DEENDAYAL PORT AUTHORITY
(Erstwhile : Deendayal Port Trust)

दीनदयाल पत्तन प्राधिकरण
DEENDAYAL PORT AUTHORITY

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www.deendayalport.gov.in

EG/WK/4751/Part (CCA Renewal) /348 Dated 07/08/2023

Shri T C Patel
Unit Head, Kachchh,
Gujarat Pollution Control Board,
Paryavaran Bhavan,
Sector 10A, Gandhinagar- 382 010.

Sub: Consolidated Consent & Authorization (Renewal) order no AWH-110594 date of issue 22/01/2021 (GPCB ID 28494) - **Submission of compliance report of stipulated conditions mentioned in the CCA Order issued by the GPCB reg.**

Ref.: 1. CCA issued by the GPCB vide Letter No.: PC/CCA·Kutch·811/GPCB10 28494/93560, Dated: 05/10/2011.
2. CCA (renewal) issued by the GPCB Letter No.:GPCB/CCA·Kutch-812/(2)GPCB ID 28494/327172, dated :11/09/2015.
3. Amendment in CCA order dated 11/9/15 issued by the GPCB vide no. AWH 101662 dated 6/8/2019.
4. **CCA (renewal) (CCA Order No. AWH-110594) issued by the GPCB issued vide no. PC/CA-KUTCH-812 (5)/GPCB ID 28494/581914 dated 22/1/2021 and correction in CCA Order issued vide letter no. PC/CCAS-KUTCH-812(5)/GPCB ID 28494/588116 dated 9/4/2021.**
5. Compliance report submitted by DPA vide letter no. EG/WK/4751(CCA Renewal)/142 dated 11/07/2022.
6. Certified Compliance report of CCA order issued by MoEF&CC, IRO, Gandhinagar dated 14/11/2022
7. Action Taken report submitted by DPA to IRO, MoEF&CC,GoI, Gandhinagar dated 21/12/2022.

Sir,

It is requested to kindly refer above cited references for the said subject.

In this regard, it is state that, the GPCB had issued CCA (renewal) **(CCA Order No. AWH-110594 - Validity up to 21/7/2025)** vide no. PC/CA-KUTCH-812 (5)/GPCB ID 28494/581914 dated 22/1/2021 and subsequently, issued correction in CCA Order vide letter no. PC/CCAS-KUTCH-812(5)/GPCB ID 28494/588116 dated 9/4/2021.

.....Cont.....

It is also relevant to submit here that, the Deendayal Port Authority had from time to time submitted compliance report of the stipulated conditions mentioned in the CCA Order (as mentioned above in the reference).

Further to above, it is submitted that, based on the request made by DPA, after site inspection, the Integrated Regional Office, MoEF&CC,GoI had issued certified compliance report to Deendayal Port Authority dated 14/11/2022. As directed therein, DPA had also submitted Action taken report w.r.t. partially complied conditions to the IRO, MoEF&CC,Gandhinagar dated 21/12/2022.

Now, please find enclosed herewith compliance report of conditions stipulated in CCA Order (period up to July - 2023) (incorporating updated status w.r.t. observations mentioned in certified compliance report) along with necessary enclosures as **Annexure I (soft copy in CD as well as through email),** for kind information & record please.

Additionally, the copies of certified compliance report dated 14/11/2022 and action taken report submitted by DPA dated 21/12/2022, are also attached herewith as **Annexure II & III**, respectively.

This has the approval of the Chief Engineer, Deendayal Port Authority.

Yours faithfully,

Encl.: As above

Manager (Environment)
Deendayal Port Authority

Copy to: 1) Dr. Yogesh Kumar, Deputy Director (S)/Scientist C,
Integrated Regional Office, MoEF&CC,
Office : A - 407 & A-409 , "ARANYA BHAWAN",
Near CH- 3 Circle, Sector – 10 A,
Gandhinagar – 382 010.
Email ID : iro.gandhingr-mefcc@gov.in

2) The Regional Officer,
Gujarat Pollution Control Board,
Regional office,
East Kutch, Gandhidham-370201.
Email Id. ro-gpcb-kute@gujarat.gov.in

ANNEXURE – I

Compliance report of Conditions Stipulated in CCA order no. AWH – 110594 date of issue 22/01/2021 (PCB ID 28494)

Compliance Report Up to July, 2023

Subject: Point wise compliance report of stipulated conditions mentioned in the Consolidated Consent& Authorization order no AWH-110594 dated 22/01/2021 to Deendayal Port Trust, (New Name) PCB ID -28494

Reference: CCA issued vide consent order no. GPCB/CCA-Kutch-812(5)/GPCB ID-28494 dated 22/01/2021

Sr. No	Conditions	Compliance Status
1	**Specific Conditions**	
1	Unit shall strictly adhere to compliance ministry in its letter file no. 11-82/2011-IA-III, dated 2016	The compliance reports of stipulated conditions mentioned in the EC & CRZ Clearance accorded by the MoEF&CC,GoI vide File no. 11-82/2011-IA-III dated 19/12/20216, are being submitted regularly, to the concerned authorities viz. Regional Office, MoEF&CC,GoI, Gandhinagar with a copy to the MoEF&CC,GoI, New Delhi, RO,CPCB, Vadodara, GPCB, Gandhinagar as well as GPCB Regional Office, Gandhidham. Last compliance report submitted on 20/04/2023 is attached herewith as **Annexure-A.**
2	Unit shall strictly adhere to all conditions of Environment and CRZ clearance issued by MoEF vide letter no. F.No. 11-70/2006-IA-III	The compliance reports of stipulated conditions mentioned in the EC & CRZ Clearance accorded by the MoEFCC,GoI vide File no. 11-70/2006-IA.III dated September, 2008, are being submitted regularly, to the concerned authorities viz. Regional Office, MoEF&CC,GoI, Gandhinagar with a copy to the MoEF&CC,GoI, New Delhi, RO,CPCB, Vadodara, GPCB, Gandhinagar as well as GPCB Regional Office, Gandhidham. Last compliance report submitted on 02/02/2023 is attached herewith as **Annexure-B.**
3	Applicant shall comply with Manufacture, storage and import of Hazardous Chemicals Rules-1989 (MSIHC) as amended time to time.	As per the Lease deed all the statutory clearance and its compliance needs to be done by the plot allotee/BOT operator. All plot allotees/BOT operators are complying with the said rules.
4	Applicant shall ensure that all storage terminal located within DPT area shall strictly comply with MSIHC rules including site notification & submit details periodically to board with relevant details.	As per the Lease deed all the statutory clearance and its compliance needs to be done by the plot allotee/BOT operator. All plot allotees/BOT operators are complying with the said rules.
5	Applicant shall renew Public Liability Insurance time to time & submit a copy to this Board.	The copy of Public Liability Insurance is kept at **Annexure-C**, which is valid till 23/07/2024. Further.
6	Unit shall notify site under MSIHC Rule – 1989 from component authority as mentioned in Schedule – 5 of MSIHC notification.	As per the Lease deed all the statutory clearance and its compliance needs to be done by the plot allotee/BOT operator. All plot allotees/BOT operators are complying with the said rules.

7.	Industry shall not withdraw groundwater without prior NOC from CGWA as per Hon. National Green tribunal order.	Point noted. The Water requirement is being met through GWSSB (Narmada Pipeline) & through private tankers.
8.	Industry shall manage Solid waste generated from Industrial activities as per Solid Waste Management Rules-2016 (Solid waste as defined in Rule -3 (46))	Garbage facility is provided as per MARPOL Act 73/78 to the vessel berthed at Deendayal Port Trust. A copy of "Grant of Permission / License for removal of Dry Solid Waste(Non-Hazardous) from Vessels calling at Deendayal Port" is attached herewith as **Annexure-D.** Companies authorized by Central Pollution Control Board(CPCB) and State Pollution Control Board (SPCB) have been awarded the work of collection, transporting and disposal of solid waste by the Deendayal Port Trust. In additional to the above, DPA has awarded work for "Preparation of Plan for Management of Plastic Wastes, Solid waste including C&D wastes, E-wastes, Hazardous wastes including Biomedical", to Gujarat Environment Management Institute (GEMI), Gandhinagar vide work order dated 24/01/2023. The said work is in process.
9.	Industry shall comply with Plastic Waste Management Rules – 2016 and amendments made therein	DPA is managing its plastic waste as per Plastic Waste Management Rules – 2016 and amendments made therein. In order to strictly implement the said rules, DPA had issued a circular regarding plastic waste minimization, source segregation, recycling etc. vide its Circular no. EG/WK/4751/Part 243(A) dated 03/09/2021. In additional to the above, DPA has accorded work for "Preparation of Plan for Management of Plastic Wastes, Solid waste including C&D wastes, E-wastes, Hazardous wastes including Biomedical". To Gujarat Environment Management Institute (GEMI), Gandhinagar vide work order dated 24/01/2023. The said work is in process.
10.	Industry shall strictly comply with coal handling guidelines of this board.	Deendayal Port Authority issued a Circular (SOP) to the trade with regard to control of dust pollution arising out of coal handling and ensuring safety in coal handling (circular no. TF/SH/Circulars/2019/1256 dated 10/10/2019). A copy of circular is attached herewith as **Annexure-E.** It is submitted that, the continuous steps are being taken by DPA to control/minimize dust pollution within Port area, which are enumerated as under: DPA already installed Sprinkling system inside Cargo Jetty area for Coal Dust Suppression in Coal Yard (40 Ha. area) at the cost of Rs. 14.44 crores.

		Continues water sprinkling is being carried out on the heap of coal, at regular intervals to prevent dusting, fire and smoke. For the newly developed area of 34 hectares for coal storage, the work of installation of sprinkling is completed. Two Road sweeper machines with compressor have been deployed along with two mist cannon machine for a contract period of 3 years, which are being operated continuously. The work for protection wall along with wind screen at the periphery of coal storage yard is completed. Most of the roads and plots inside Port area are paved in order to prevent dusting The directions have already been issued from time to time to all the traders in order to ensure that all trucks before leaving the storage yards will be covered with tarpaulin, no overloading of trucks are allowed and there should not be spillage of cargo during transportation. DPA has appointed Gujarat Institute of Desert Ecology (GUIDE) for "Green belt development in Deendayal Port Authority and its Surrounding Areas, Charcoal site' (Phase-l)" vide Work Order No.EG/WK/4757/Part [Greenbelt GUIDE, dated 31st May, 2022. The work completed. Further DPA has accorded the work of "Green belt development in DPA and its surrounding area (Phase II) to Gujarat Institute of Desert Ecology (GUIDE), Bhuj for the plantation of 10000 saplings of suitable species vide work order dated 23/06/2023. The same is in process. It is once again relevant to submit here that, DPA appointed M/s Detox Corporation, Surat (NABL Accredited laboratory) for regular Monitoring of environmental parameters since the year 2016 in continuation of this DPA appointed M/s Gujarat Environment Management Institute (GEMI), Gandhinagar (NABL Accredited laboratory) for regular Monitoring of environmental parameters vide work order dated 15/02/2023. The work is in progress & DPA is submitting the monitoring data regularly to all the concerned authorities along with compliance reports submitted. The Environmental Monitoring Reports are attached herewith as **Annexure F**

11.	Industry shall provide dedicated storage facility for dry cargo and ensure to take adequate measure to prevent dusting.	DPA has provided dedicated storage facilities for all type of Cargo including 33 warehouse and 67 open storage space. DPA vide its circular no. TF/SH/Circulars/2019/1256 dated 10/10/2019 had issued a circular for "controlling of Dust pollution arising out of Coal Handling". The same is already attached at **Annexure-E**. It is relevant to mention here that DPT has installed Mist Canon at the Port area to minimize the coal dust. The work related to construction **of protection wall with wind screen to prevent coal dust** deposition in building has already been completed during the year 2011-2012. Continues water sprinkling is being carried out on the top of the heap of coal, at regular intervals to prevent dusting, fire and smoke. DPT already installed Sprinkling system inside Cargo Jetty area for Coal Dust Suppression in Coal Yard (40 Ha. area) at the cost of Rs. 14.44 crores. The DPA is taking all the required measures to reduce coal dust by implementing the Coal Handling Guidelines through Port users. DPA appointed M/s Detox Corporation, Surat (NABL Accredited laboratory) for regular Monitoring of environmental parameters since the year 2016 in continuation of this DPA appointed M/s Gujarat Environment Management Institute (GEMI), Gandhinagar (NABL Accredited laboratory) for regular Monitoring of environmental parameters vide work order dated 15/02/2023. The work is in progress & DPA is submitting the monitoring data regularly to all the concerned authorities along with compliance reports submitted.
12.	The applicant shall ensure that there shall be no damage to the existing mangrove patches near site and also ensure the free flow of water to avoid damage to the mangroves.	It is assured that necessary steps are being taken , to protect existing mangrove patches and for maintaining free flow of water to avoid damage to the mangroves. Further, as per the directions of the GCZMA and MoEF&CC,GoI, till date, DPA had already undertaken Mangrove Plantation in an area of 1600 Ha. till date since the year 2005. A statement showing details of mangrove plantation at various locations with cost incurred is placed at **Annexure G.** It is also relevant to submit here that, as per the direction of the Gujarat Coastal Zone Management Authority, DPA had already prepared & submitted a report on mangrove conservation and management plan formulated by Gujarat Institute of Desert

		Ecology during the study period of Jan-April, 2015 (Report attached as **Annexure H**). In addition to the above, DPA appointed M/s GUIDE,Bhuj vide work order dated 1/9/2017 & subsequently, vide work order dated 3/5/2021, for "Monitoring of Mangrove Plantation carried out by DPA". A copy of report prepared by M/s GUIDE, Bhuj (period May, 2021 to May, 2022) is attached herewith as **Annexure I.**
13.	Applicant shall ensure as per EC condition that no creeks or rivers are blocked due to any activities at the site and free flow of water is maintained.	Due care is being taken so that no creeks or rivers are blocked, due to any activities undertaken at the project site and free flow of water is maintained.
14.	Applicant shall provide proper system for collection, storage and treatment and disposal of waste water generated by vessel as per MARPOL & maintain records.	DPA has a dedicated Sewage Treatment Plant (STP)at Deendayal Port, Kandla Township, Gandhidham for treatment of waste water. The water is being stored at underground tanks at various locations at Kandla.
15.	Applicant shall install storm drainage catch basin to avoid directly discharge into surface water.	Point Noted. Necessary surface drainage system including storm water network has already been provided for proper drainage.
16.	Waste effluent accumulated with port activities including storm water & sewage from port operation including sewage ballast water, bilge water & clean waste from ships shall be as per MARPOL norms.	Point Noted for compliance. A copy of Grant of License/Permission to carry out the work of collection and disposal of "Hazardous Waste/Sludge/ Waste Oil" from Vessels calling at Deendayal Port" is already attached at **Annexure-J.**
17.	Applicant shall make separate records regarding generation, collection, transportation and disposal of waste generation from ship & maintain its records.	Point noted for the compliance.
18.	Applicant shall made necessary arrangement for plastic waste, solid waste or other waste generation due to port activities & for facilitation of reception facilities under MARPOL & Environment (Protection) Act – 1986 rules etc.	Complied with the condition. A copy of "Grant of Permission / License for removal of Dry Solid Waste (Non Hazardous) from Vessels calling at Deendayal Port" is attached herewith as **Annexure-D.** It is relevant to mention here, that DPA has invited tender for Appointment of Advisor for "Preparation of Plan for Management of Plastic Wastes, Solid waste including C&D wastes, E-wastes, Hazardous wastes including Biomedical". The tender is under evaluation.
19.	Ports shall obtain approval of their oil spill contingency plan (OSCP) as required under national oil spill disaster contingency plan (NOS-DCP) of coast guard. Ministry of defense, govt. of India.	DPA is already having Oil Spill Contingency Plan Copy placed at **Annexure-K.**
20.	Best environmental practices by ports may be uploaded on "Indian ports Association" as well as the same may be linked to websites of CPCB and respective SPCBs.	DPA is ISO 14001:2015 certified port for ***"Providing port facility and related maritime services for vessel and Cargo handling including storage"*** (Certificate copy placed at **Annexure-L**).

		As per the directions of the GCZMA and MoEF&CC,GoI, till date, DPA had already undertaken Mangrove Plantation in an area of 1600 Ha. till date since the year 2005. A statement showing details of mangrove plantation at various locations with cost incurred is placed at **Annexure G.** DPA has appointed M/s GEMI, Gandhinagar for the work "Making Deendayal Port a Green Port–Intended Sustainable Development under the Green Port Initiatives". M/s GEMI, Gandhinagar had submitted the Final Report on 10/03/2021. In addition to the above, DPA has been submitting regularly the compliance of the conditions stipulated in Environmental & CRZ Clearance, CRZ recommendation and CTE to MoEF&CC along with all statutory bodies. The same is being uploaded in MoEF&CC parivesh portal on regular basis. DPA also has been regularly submitting Annual Return of Hazardous waste in Form IV and Environmental Statement in Form V for the entire port area and uploading the same in GPCB site on regular basis. Form IV and V for the year 2022-23 is attached herewith as **Annexure-M & N , respectively.**
21.	Manually handling of cargo should be converted into mechanized system, in time bound manner.	Mechanization has been planned for handling of fertilizer and other clean cargo at Cargo Berth no. 13 to 16.
3.	**Conditions Under Water Act – 1974**	
3.1	Source of Water – GWIL	Point noted
3.2	There shall be no industrial water consumption and waste water generation from manufacturing process and other ancillary operations.	Not applicable. No manufacturing process or any other ancillary operations involved.
3.3	The quantity of the fresh water consumption for domestic purpose shall not exceed 1300 KLD	Considering the actual average fresh water consumption quantity more than the 1300 KLD, DPA has applied for the amendment in the quantity of fresh water consumption from 1300 KLD to 3000 KLD vide Inward no. 277270 dated 25/03/2023 copy of same is attached herewith as **Annexure O.**
3.4	The quantity of domestic waste water shall not exceed 800 KLD.	Point noted for compliance. DPA has been regularly submitting Environmental Statement in Form V for the entire port area and uploading the same in GPCB site on regular basis. Form V for the year 2022-23 which includes total Domestic Waste Water Generation is attached herewith as **Annexure N.**
2.5	Domestic effluent shall be treated effluent conforming to following norms shall be	DPA appointed M/s Detox Corporation, Surat (NABL Accredited laboratory) for regular Monitoring of

<table>
<tr><td></td><td>discharged on land within premises strictly for gardening and plantation & no sewage shall be disposed outside premises in any manner.
<table><tr><td>Parameters</td><td>Permissible Limit</td></tr><tr><td>pH</td><td>6.5 to 8.5</td></tr><tr><td>BOD(5 days at 20 ^{0}C)</td><td>30 mg/lit</td></tr><tr><td>Suspended Solid</td><td>100 mg/lit</td></tr><tr><td>Fecal coli form</td><td>< 1000 MPN/100 ml</td></tr></table></td><td>environmental parameters since the year 2016 in continuation of this DPA appointed M/s Gujarat Environment Management Institute (GEMI), Gandhinagar (NABL Accredited laboratory) for regular Monitoring of environmental parameters vide work order dated 15/02/2023. The work is in progress & DPA is submitting the monitoring data regularly to all the concerned authorities along with compliance reports submitted

The Environmental Monitoring Reports for the month of May 2023 is attached herewith as Annexure F.</td></tr>
<tr><td>3.6</td><td>Treated domestic effluent confirming to above norms shall be discharged on land only for gardening & plantation within premises.</td><td>Sewage is treated in the STP of Kandla Residential Colony. The treated effluent from STP is utilized for gardening & plantation purpose.</td></tr>
<tr><td>3.7</td><td>Unit shall provide flow meter at inlet & outlet of STP & maintain its record.</td><td>DPA has appointed M/s Patel construction for Operation and maintenance of the STP at Kandla.
Sewage Treatment Plants at Kandla is equipped with flow meters at inlet and outlet and record is being maintained.</td></tr>
<tr><td>3.8</td><td>Disposal system for storm water shall be provided separately, in no case storm water and sewage from port facilities shall not be discharged into surface water.</td><td>Point Noted. Necessary surface drainage system including storm water network has been provided for proper drainage.</td></tr>
<tr><td>4.</td><td colspan="2">Conditions under air act 1981:</td></tr>
<tr><td>4.1</td><td>The following shall be used as a fuel in D.G sets
<table><tr><td>Sr.No.</td><td>Utility</td><td>Fuel</td><td>Quantity</td></tr><tr><td>1.</td><td>D.G Set</td><td>HSD</td><td>500 Ltr/Hr</td></tr></table></td><td>Noted for compliance.

Total consumption of HSD is as below: -

D.G -1 and 2 1530 L Up to July 2023.</td></tr>
<tr><td>4.2</td><td>The applicant shall install & operate air pollution control system efficiently in order to achieve prescribed norms.</td><td>DPT is taking measures for mitigation of air pollution: -

- Regular sprinkling of water is being done to suppress the fugitive dust. In addition, DPT has installed Mist canon at various strategic locations to suppress dust from Port Operations.
- DPA is in process for mechanization of dry cargo handling. In this regard, Tender has been invited for “Appointment of consultant for the study & preparation of techno economic feasibility report for mechanized handling of cargo at DPT”. The same is under evaluation.
- Deendayal Port Trust had taken up massive greenbelt development activities in and around Kandla, Residential colony, Administrative building etc.
- DPT had entrusted the work to Forest Department, Gujarat for developing green belt in and around Port area at a cost of Rs. 352 lakhs in an area of about 32 hectares and the work is completed.</td></tr>
</table>

<table>
<tr>
<td>4.3</td>
<td>The flue gas emission through stack attached to D.G sets shall confirm to the following standards
<table>
<tr><th>Sr. No.</th><th>Stack attached to</th><th>Stack height in meter</th><th>APCM</th><th>Parameter</th><th>Permissible limit</th></tr>
<tr><td>1.</td><td>D.G sets (2 No.s) (1010 KVA)</td><td>15 each</td><td>--</td><td>PM
SO2
NOx</td><td>150 mg/NM3
100 ppm
50 ppm</td></tr>
</table>
</td>
<td>DPA appointed M/s Detox Corporation, Surat (NABL Accredited laboratory) for regular Monitoring of environmental parameters since the year 2016 in continuation of this DPA appointed M/s Gujarat Environment Management Institute (GEMI), Gandhinagar (NABL Accredited laboratory) for regular Monitoring of environmental parameters vide work order dated 15/02/2023. The work is in progress & DPA is submitting 0the monitoring data regularly to all the concerned authorities along with compliance reports submitted

The Environmental Monitoring Reports is attached herewith as Annexure F.</td>
</tr>
<tr>
<td>4.4</td>
<td>There shall be no process gas emission from manufacturing in the ambient air within the premises of the industry and a distance of 10 meters form the source other than the stack/vent shall not exceed the following levels.</td>
<td>Not applicable.

No manufacturing process is involved.</td>
</tr>
<tr>
<td>4.5</td>
<td>The concentration of the following parameters in the ambient air within the premises of the industry and a distance of 10 meters from the source other than the stack/vent shall not exceed the following levels.
<table>
<tr><th>Sr. no.</th><th>Pollutant</th><th>Time weighted Average</th><th>Concentration in ambient air in µg/m^3</th></tr>
<tr><td>1.</td><td>Sulphur Dioxide (SO_2)</td><td>Annual
24 Hour</td><td>50
80</td></tr>
<tr><td>2.</td><td>Nitrogen Dioxide (NO_2)</td><td>Annual
24 Hour</td><td>40
80</td></tr>
<tr><td>3.</td><td>Particulate matter (size less than 10 µm) or PM_{10}</td><td>Annual
24 Hour</td><td>60
100</td></tr>
<tr><td>4.</td><td>Particulate matter (size less than 2.5 µm) or $PM_{2.5}$</td><td>Annual
24 Hour</td><td>40
60</td></tr>
</table>
</td>
<td>Point noted for compliance.

DPA appointed M/s Detox Corporation, Surat (NABL Accredited laboratory) for regular Monitoring of environmental parameters since the year 2016 in continuation of this DPA appointed M/s Gujarat Environment Management Institute (GEMI), Gandhinagar (NABL Accredited laboratory) for regular Monitoring of environmental parameters vide work order dated 15/02/2023. The work is in progress & DPA is submitting the monitoring data regularly to all the concerned authorities along with compliance reports submitted

The Environmental Monitoring Reports is attached herewith as Annexure F.

Further, DPA already invited tender for ‘Online Continuous Ambient Air Quality Monitoring (CAAQM) For the Period of Three Years at Deendayal Port Trust’. The same is under evaluation stage.

Deendayal Port Authority had taken up massive greenbelt development activities in and around Kandla, Residential colony, Administrative building etc.

DPT had entrusted the work to Forest Department, Gujarat for developing green belt in and around Port area at a cost of Rs. 352 lakhs in an area of about 32 hectares and the work is completed.</td>
</tr>
<tr>
<td>4.6</td>
<td>The applicant shall provide portholes, ladder, platform etc at chimney (s) for monitoring the air emissions and the same</td>
<td>Point noted for compliance.</td>
</tr>
</table>

<table>
<tr><td></td><td>shall be open for inspection to/and for use of Board's staff. The chimney(s) vents attached to various sources of emission shall be designated by number such as S-1, S-2, etc and these shall be painted/displayed to facilitate identification.</td><td></td></tr>
<tr><td>4.7</td><td>The industry shall take adequate measures for control of noise levels from its own sources within the premises so as to maintain ambient air quality standards in respect of noise to less than 75 dB(A) during day time and 70 dB(A) during night time. Daytime is reckoned in between 6:00 am and 10:00 pm and night time is reckoned between 10:00 pm and 6:00 am</td><td>Point noted for compliance.
DPA appointed M/s Detox Corporation, Surat (NABL Accredited laboratory) for regular Monitoring of environmental parameters since the year 2016 in continuation of this DPA appointed M/s Gujarat Environment Management Institute (GEMI), Gandhinagar (NABL Accredited laboratory) for regular Monitoring of environmental parameters vide work order dated 15/02/2023. The work is in progress & DPA is submitting the monitoring data regularly to all the concerned authorities along with compliance reports submitted

The Environmental Monitoring Reports is enclosed herewith as Annexure F.</td></tr>
<tr><td>5.</td><td colspan="2">Authorization as per Hazardous And Other Waste (Management and Transboundary) Rules, 2016 form -2 [see rule 6 (2)]</td></tr>
<tr><td>5.1</td><td>Authorization order no. AWH-110594 date of issue: 08/12/2020</td><td>--</td></tr>
<tr><td>5.2</td><td>M/s. Kandla Port Trust is hereby granted an authorization to operate facilities for following hazardous waste on the premises situated at Kandla, A.O building Gandhidham Tal.: Gandhidham, Dist: Kutch
<table>
<tr><th>Sr. No</th><th>Waste</th><th>Quantity/ Year</th><th>Schedule & Category</th><th>Facility</th></tr>
<tr><td>1.</td><td>Used spent oil</td><td>1125 MT</td><td>1-5.1</td><td>Collection, Storage, transportation And disposal by selling to Authorized Recycler</td></tr>
<tr><td>2.</td><td>Waste Residue Containing oil</td><td>3344.43 MT</td><td>1-5.2</td><td>Collection, Storage, transportation And disposal by selling to Authorized Recycler</td></tr>
</table></td><td>DPA has been regularly submitting Annual Return of Hazardous waste in Form IV for the entire port area to the GPCB on regular basis. Form IV for the year 2022-23 was submitted dated 19/06/2023 and is attached herewith as Annexure-M.

Further Considering 10% increase each year in the quantity of hazardous waste generation DPA has submitted CCA amendment application vide Inward no. 277270 dated 25/03/2023 for the increase in hazardous waste copy of same is attached herewith as Annexure O.</td></tr>
<tr><td>5.3</td><td>The authorization shall be valid up to 21/07/2025</td><td>Point noted.</td></tr>
</table>

5.4	The authorization is subject to the conditions stated below and such other conditions as may be specified in the rules from time to time under the Environment (Protection) Act – 1986.	Point noted.
5.5	The authorization is granted to operate a facility for collection, storage within factory premises transportation and ultimate disposal of hazardous wastes as per conditions no. 5.2 to the industry having valid CCA of this board.	Point noted.
5.6	**Terms and Condition of Authorization**	
1.	The applicant shall comply with the provision of the Environment (Protection) Act-1986 and the rules made there under	Agreed with the condition.
2.	The authorization or its renewal shall be produced for inspection at the request of an officer authorized by the Gujarat pollution Control Board.	Agreed with the condition.
3.	The person authorized shall not rent, lend, sell, and transfer or otherwise transport the hazardous wastes without obtaining prior permission of the Gujarat Pollution Control Board.	Agreed with the condition.
4.	Any unauthorized change in personnel, equipment or working conditions as mentioned in the authorized order by the persons authorized shall constitute a beach of this authorization	Agreed with the condition.
5.	The person authorized shall implement Emergency Response Procedure (ERP) for which this authorization is being granted considering all site-specific possible scenarios such as spillages, leakages, fire etc, and their possible impact and also carry out mock drill in this regard at regular interval of time.	DPA is already having Disaster management plan (Attached as **Annexure-P**) considering all site-specific possible scenarios such as spillages, leakages, fire etc., and their possible impact. In addition to the above mock drills are also carried out regularly for effective implementation of the same.
6.	The person authorized shall comply with the provisions outlined in the Central Pollution Control Board guidelines on "Implementing Liabilities for Environmental damages due to handling and disposal of Hazardous waste and penalty."	Agreed with the condition.
7.	It is the duty of the authorized person to take prior permission of the Gujarat Pollution Control Board to close down the facility.	Agreed with the condition.
8.	An application for the renewal of an authorization shall be made as laid down in rules 6 (2) under Hazardous and other wastes rules, 2016	Agreed with the condition.
9.	The imported hazardous and other wastes shall be fully insured for transit as well as for any accidental occurrence and its clean-up operation.	Not applicable. DPA is not involved in import of any kind of hazardous waste.

10.	The record of consumption and fate of the imported hazardous and other wastes shall be maintained.	Not applicable. DPA is not involved in import of any kind of hazardous waste.
11.	The hazardous and other wastes which gets generated during recycling or reuse or recovery or pre-processing or utilization of imported hazardous or other wastes shall be treated and disposed of as per specific conditions of authorization.	Not applicable.
12.	The importer or exporter shall bear the cost of import or export and mitigation of damage if any.	Point noted.
13.	Any other conditions for compliance as per the guidelines issued by the ministry of Environment, Forest and climate change or Central Pollution Control Board from time to time.	Point noted.
14.	The waste generator shall be totally responsible for (i.e collection, storage, transportation and ultimate disposal) the wastes generated.	Agreed with the condition.
15.	Record of waste generation, its management and annual return shall be submitted to Gujarat Pollution Control board in form -4 by 30th day of June of every year for the preceding period April to March.	DPA has been regularly submitting Annual Return of Hazardous waste in Form IV for the entire port area and uploading the same in GPCB site on regular basis. Form IV for the year 2022-23 was submitted dated 19/06/2023 and is attached herewith as **Annexure-M**.
16.	In case of any accidents, details of the same shall be submitted on Form-11 to Gujarat Pollution Control Board.	Agreed with the condition.
17.	As per "Public Liability Insurance Act – 91" company shall get Insurance policy, if applicable.	Public Liability Insurance is renewed time to time as required. The Public Liability Insurance was last renewed on 22/07/2023 and is valid till 23/07/2024 The same is attached herewith as **Annexure-C.**
18.	Empty drums and containers of toxic and hazardous material shall be treated as per guidelines published for "Management and Handling of discharged containers" records of the same shall be maintained and forwarded to Gujarat Pollution Control Board regularly.	Point Noted.
19.	In case of transport of hazardous waste to a facility for (i.e treatment, storage and disposal) existing in a state other than the state where hazardous wastes generated, the occupier shall obtain "No Objection Certificate" from the State Pollution Control Board or Committee of the concerned state of Union Territory Administration where facility exists.	Not Applicable. DPA has appointed GPCB approved vendors for collection and disposal of "Hazardous Waste/Sludge/ Waste Oil". A copy of Grant of License/Permission to carry out the work of collection and disposal of "Hazardous Waste/Sludge/ Waste Oil" from Vessels calling at Deendayal Port" is attached herewith as **Annexure-K.**
20.	Unit shall all concrete measures to show tangible results in waste generation, reduction, avoidance, reuse and recycle. Actions taken in this regard shall be	Point noted.

	submitted within three months and also along with form -4	
21.	Industry shall have to display the relevant information with regards to hazardous waste as indicated in the Hon. Supreme Court's Order in WP No. 657 of 1995 dated 14th October 2003.	Agreed with the condition.
22.	Industry shall have to display on-line data outside the main factory gate with regard to quantity and nature of hazardous chemicals being handled in the plant, including wastewater and air emissions and solid hazardous wastes generated within the factory premises.	Agreed with the condition.
6.	**Specific Conditions: -**	
6.1	The authorized actual user of hazardous and other waste shall maintain records of hazardous and other wastes purchased in a passbook issued by the State Pollution Control Board along with the authorization.	Not Applicable. To be complied by the Authorized recycler.
6.2	Handling over of the hazardous and other wastes to the authorized actual user shall be only after making the entry in the passbook of the actual user.	DPA is keeping the details of hazardous waste handed over to the authorized recycler. DPA has been regularly submitting Annual Return of Hazardous waste in Form IV for the entire port area and uploading the same in GPCB site on regular basis. Form IV for the year 2022-23 was submitted dated 19/06/2023 and is attached herewith as **Annexure-M**.
6.3	In case of renewal of authorization, a self-certified compliance report in respect of effluent, emission standards and the conditions specified in the authorization for hazardous and other wastes shall be submitted SPCB.	Point noted for compliance.
6.4	The occupier of the facility shall comply standard operating procedure/guidelines published by MoEF&CC or CPCB or GPCB from time to time.	Agreed with the condition.
6.5	Unit shall comply provisions of E-waste management Rules - 2016	Point noted for compliance. It is relevant to mention here, that DPA has Appointed GEMI, Gandhinagar for the "Preparation of Plan for Management of Plastic Wastes, Solid waste including C&D wastes, E-wastes, Hazardous wastes including Biomedical". The work is in process.
6.6	The disposal of hazardous waste shall be carried out as per the waste management hierarchy.	Waste Management Hierarchy i.e. Prevent, Reduce, Reuse, Recycle, Recover and Disposal is being strictly followed in order by the CPCB approved vendors appointed for the collection of hazardous waste.
6.7	The occupier of facilities shall not store the hazardous and other wastes for a period not exceeding ninety days. Prior permission of	DPA appointed GPCB approved vendors for collection of hazardous waste and they are collecting it regularly.

	the board shall be obtained for extension of the storage period.	
6.8	The occupier shall maintain the records of generation, sale, storage, transport, recycling, co-processing and disposal of hazardous waste and make available during the inspection.	DPA maintains the record of all hazardous waste collected and sold to the GPCB authorized vendors for recycling. Further, DPA is regularly submitting the Hazardous waste return in form IV for the entire port area and uploading the same in GPCB site on regular basis. Form IV for the year 2022-23 is attached herewith as Annexure-P
6.9	The transportation of the hazardous waste shall be carried out in GPS mounted dedicated vehicles.	DPA has appointed GPCB authorized vendors for collection and transportation of Hazardous waste.
7.	**General Conditions: -**	
7.1	Any change in personnel, equipment or working conditions as mentioned in the consents from order should immediately be intimated to this Board.	Point noted for compliance.
7.2	Applicant shall also comply with the general conditions given in Annexure 1	Agreed with the condition.
7.3	Wherever due to accident or other unforeseen act or ever, such emissions occur or apprehend to occur in excess of standards laid down such information shall the forthwith reported to board, concerned police station office of Directorate of Health Service, Department of explosive, Inspectorate of Factories and local body.	Agreed with the condition.
7.4	In case failure of pollution control equipment's, the production process connected to it shall be stopped. Remedial actions/measures shall be implemented immediately to bring entire situation normal.	Not applicable. No production activity is involved.
7.5	The Environment management Unit/cell shall be setup to ensure implementation on and monitoring of Environmental safeguards and other conditions stipulated by statutory authorities. The Environment management Cell/Unit shall directly report to the Chief executive of the organization and shall work as a focal point for internalizing environmental issues. These cells/units also coordinate the exercise of environmental audit and preparation of environmental statements.	DPA is already having Environment Management cell. Further, DPT has also appointed expert agency for providing Environmental Experts from time to time. DPT appointed M/s Precitech Laboratories, Vapi for providing Environmental Experts vide work order dated 5/2/2021. A copy of Work order is attached herewith as **Annexure-Q.** Further, DPA has appointed manager Environment on contractual basis for the period of 3+2 years. A copy of office order is attached herewith as **Annexure R.** **Further, a copy of organigram of EMC is also attached herewith as Annexure S.**
7.6	The environmental audit shall be carried out yearly and the environmental statements pertaining to the previous year shall be submitted to this State Board latest by 30th September every year.	Not applicable. As per Environment Audit Scheme, DPA is not covered under Schedule 1 or Schedule 2 industry.

7.7	The Board reserves the right to review and/or revoke the consent and/or make variation in the conditions, which the Board deems, fit in accordance with section 27 of the Act.	Point noted.
7.8	In case of change of ownership/management the name and address of the new owners/partners/directors/proprietor should immediately be intimated to the Board.	Point Noted
7.9	Industry shall have to display relevant information with regard to hazardous waste as indicated in the Hon. Supreme order in w.p no. 657 of 1995 dated 14th October 8	Point Noted

ANNEXURE – A

Compliance report of EC and Clearance accorded by the MoEF&CC,GoI vide File no. 11-82/2011-IA-III dated 19/12/20216

DEENDAYAL PORT AUTHORITY
(Erstwhile: DEENDAYAL PORT TRUST)

Administrative Office Building
Post Box NO. 50
GANDHIDHAM (Kutch).
Gujarat: 370 201.
Fax: (02836) 220050
Ph.: (02836) 220038

www.deendayalport.gov.in

EG/WK/4751/Part (Comp. 1)/ 286 Dated: 20/04/2023

To,
The Deputy Director General of Forests (C),
Ministry of Environment, Forest & Climate Change,
Integrated Regional Office,
Gandhinagar, A wing-407 & 409,
Aranya Bhavan Near CH-3 Circle,
Sector 10 A, Gandhinagar -382010
Email : ecompliance-guj@gov.in

Sub: "Development of 7 Integrated facilities (Stage I) within the existing Kandla Port Trust limit at District Kutch (Gujarat) by M/s Kandla Port Trust Limited" – Environmental & CRZ Clearance – **Pointwise Compliances of the conditions stipulated in the EC&CRZ Clearance and Monitoring Report in Datasheet reg.**

Ref.:
1) MoEF&CC, GoI letter F. No. 11-82/2011-IA.III dated 19/12/2016
2) Ministry's letter vide F.No. 6-1/2017 (ENV) dated 1/5/2017.
3) KPT letter no. EG/WK/4751/Part (Compliance)/77 dated 3/6/2017.
4) DPT letter no. EG/WK/4751/part(Compliance)/610 dated 13/12/2017- Submission of Six Monthly Compliance Report (June, 2017 to Nov., 2017).
5) DPT letter no. EG/WK/4751/part (Compliance)/315 dated 14(21)/6/2018- Submission of Six Monthly Compliance Report (Dec, 2017 to May, 2018).
6) DPT letter no. EG/WK/4751/part (Compliance)/115 dated 30(2)/3(4)/2019- Submission of Six Monthly Compliance Report (up to March, 2019).
7) DPT letter no. EG/WK/4751/part (Compliance 1)/155 dated 14/11/2019- Submission of Compliance Report (up to October, 2019).
8) DPT letter no. EG/WK/4751/part (Compliance 1) dated 29/12/2020- Submission of Compliance Report (up to November, 2020).
9) DPT letter no. EG/WK/4751/part (Comp. 1)/95 dated 07/10/2021- Submission of Compliance Report (up to May, 2021).
10) DPA letter no. EG/WK/4751/part (Comp. 1)/221 dated 30/01/2023- Submission of Compliance Report (up to May, 2022).

Sir,

It is requested to kindly refer above cited references for the said subject.

In this regard, it is to state that, Ministry of Environment, Forest and Climate Change (MoEF&CC), GoI vide F. No. 11-82/2011-IA.III dated 19/12/2016 has accorded Environmental and CRZ Clearance for the 7 project activities of Deendayal Port Authority.

.....cont...

Subsequently, DPA vide above referred letter dated 3/6/2017 had submitted details/information (including point-wise compliance of stipulated conditions & duly filled in data sheet) asked by the Regional Office, MoEF&CC, GoI, Bhopal in connection with the EC & CRZ Clearance granted by the MoEF&CC, GoI dated 19/12/2016 for the subject mentioned above. Further, DPA vide above referred letters had submitted compliance report of stipulated conditions.

Now, as directed in above referred letter dated 1/5/2017 of the Regional Office, MoEF&CC, GoI, Bhopal, please find enclosed herewith compliance report of stipulated conditions mentioned in the EC & CRZ Clearance granted by the MoEF&CC, GoI dated 19/12/2016 **(Annexure 1)** & Monitoring Report in Data Sheet **(Annexure 2)** (for the period up to November, 2022) for kind information and record please.

Further, as per the MoEF&CC, Notification S.O.5845 (E) dated 26.11.2018, stated that "**In the said notification, in paragraph 10, in sub-paragraph (ii), for the words "hard and soft copies" the words "soft copy" shall be substituted"**. Accordingly, we are submitting herewith soft copy of the same in CD as well as through e-mail in ID rowz.bpl-mef@nic.in & eccompliance-guj@gov.in.

This has the approval of Chief Engineer, Deendayal Port Authority.

Thanking You.

Yours faithfully,

Encl.: As above

Manager (Env.)
Deendayal Port Authority

Copy along with point wise compliance of stipulated conditions, to:

1) Shri Amardeep Raju,
Scientist E, Ministry of Environment,
Forest and Climate Change,
& Member Secretary (EAC-Infra.1),
Indira Paryavaran Bhawan,
3rd Floor, Vayu Wing, Jor Bagh Road,
Aliganj,
New Delhi- 110 003;
E-mail:ad.raju@nic.in

2) Shri Prasoon Gargava,
Scientist E &Regional Director,
Central Pollution Control Board,
Parivesh Bhawan,
Opp. VMC Ward Office No.10,
Subhanpura,
Vadodara – 390 023.
Email Id.Prasoon.cpcb@nic.in

3) The Unit Head,
Kachchh,
Gujarat Pollution Control Board,
Paryavaran Bhavan,
Sector 10A,
Gandhinagar- 382 010.
Email-kut-uh-gpcb@gujarat.gov.in

4) The Regional Officer,
Gujarat Pollution Control Board,
Regional Office (East Kutch)
Administrative Office Building,
Deendayal Port Authority,
Gandhidham 370201
Email Id. ro-gpcb-kute@gujarat.gov.in

Annexure -I

Annexure 1

CURRENT STATUS OF WORK (up to November, 2022)

Subject: **Development of 7 integrated facilities (Stage I) within existing Deendayal Authority at Kandla**.

Reference: Environmental and CRZ Clearance granted by MoEF&CC, GoI vide letter F. No. 11-82/2011-IA-III dated 19/12/2016.

Name of Project	Status
1. Development of oil jetty to handle liquid cargo and ship bunkering terminal at old Kandla under PP mode (jetty: 300m x 15m, approach 450 m X 10 m, back up area 5.5 HA, capacity – 3.39 MMTPA, capital dredging 1,73,660 m^3 maintenance dredging 1,56,294 m^3 (Estimated cost: 276.53 Cr.).	The Concession Agreement was executed between DPA and M/s KOTPL on 16/11/2013 to implement the project on Built, Transfer & Operate (BOT- PPP) Basis by M/s KOTPL. The award of concession was issued on 11/12/2020 to M/s KOTPL by DPA. **The Project is under construction phase.**
2. Multipurpose Cargo Terminal at Tekra off Tuna on BOT basis (T shape jetty 600m X 80 m Capacity 18MMTPA, back up area 101 Ha capital dredging 1,26,57,175 m3 maintenance dredging 18,98,576. 25 m^3 Estimated cost: 1686.66 Cr.	The Board of DPA approved the Feasibility Report in its meeting on 19.02.2021. The MoPSW,GoI vide communication dated 21/10/2022 has conveyed approval granted by the Cabinet Committee on Economic Affairs to the project. Accordingly, DPA already invited RFQ and RFP which is currently under bidding stage **No construction activity has started yet.**
3. Up gradation of Barge handling capacity at Bundar basis at Kandla capacity 3.33 MMTA back-up area 5 Ha, Estimated cost: 109.59 Cr.	The up-gradation work was completed.
4. Construction of Rail over Bridge at NH 8 A near Nakti Bridge (crossing of NH 8 A Estimated cost: 32.17 Cr.	**Construction activity has not yet started.**
5. Mechanization of Dry Cargo handling capacity at Kandla Port (Berth 7 and 8 capacity 7.35 MMTPA estimated cost 80.61 Cr.	Mechanization work already completed.
6. Strengthening of Oil jetty 1 (Estimated cost: 7.5 Cr.	The strengthening work completed.
7. Modification and strengthening of Cargo berth No. 6 at Kandla Port Estimated cost: 11.5 Cr.	The modification & strengthening work completed.

Out of a total of 7 project activities, construction activities of 4 projects (i.e. Sr. No. 3, 5, 6 & 7 mentioned in the EC & CRZ Clearance) have already been completed. Whereas construction activity of the project at Sr. No. 2 & 4 have not yet started.

For the current compliance period up to November, 2022, construction activity related to project No. 1 is ongoing. The compliance report submitted by the Concessionaire M/s KOTPL is attached herewith as Annexure A.

COMPLIANCE REPORT (for the period up to November, 2022)

Subject: Compliance of conditions stipulated by the Ministry of Environment, Forests & Climate Change (MoEF&CC), GoI in Environmental & CRZ Clearance granted for "**Development of 7 integrated facilities (Stage I) within existing Deendayal Authority at Kandla**".

Reference: Environmental and CRZ Clearance granted by MoEF&CC, GoI vide letter F. No. 11-82/2011-IA-III dated 19/12/2016.

Sr. No	EC Conditions	Compliance status
	A. Specific conditions	
I.	Construction activity shall be carried out strictly according to the provisions of CRZ Notification, 2011. No construction work other than those permitted in Costal Regulation Notification shall be carried out in coastal regulation zone area.	a) For Project at Sr. No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at **Annexure A**. b) Further, w.r.t. project at Sr. No. 2 & 4 (construction not yet started), it is assured that no activity other than those permissible in Coastal Regulation Notification shall be carried out in the CRZ area.
II.	The Project Proponent shall ensure that there shall be no damage to the existing mangrove patches near site and also ensure the free flow of water to avoid damage to the mangroves.	a) For Project at Sr. No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at **Annexure A.** b) Further, w.r.t. project at sr.no. 2 & 4 (construction not yet started), it is assured that due care shall be taken to protect existing mangrove patches near the site and also the free flow of water to avoid damage to the mangroves.
III.	The Project Proponent shall ensure that no creeks or rivers are blocked due to any activities at the project site and free flow of water is maintained.	a) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at **Annexure A.** b) Further, w.r.t. project at sr.no. 2 & 4 (construction not yet started), it is assured that no creeks or rivers shall be blocked due to any activities at the project site, and the free flow of water shall be maintained.
IV.	Shoreline should not be disturbed due to dumping. Periodical study on shore line changes shall be conducted and mitigation carried out, if necessary. The	Deendayal Port Authority (Erstwhile, Deendayal Port Trust) vide Work order no. EG/WK/4751/Part (EC–Shoreline study)/98 dated 12/10/2021 had appointed NCSCM,

	detail shall be submitted along with the six monthly monitoring report.	Chennai for carrying out the work "**Shoreline Change Study for Deendayal Port Trust, Kandla, Kachchh District, Gujarat, to Study the Effect of Dumping, if any**". The study is completed and the final report submitted by NCSCM, Chennai has already been communicated to the MoEF&CC, GoI, Gandhinagar with six monthly compliance report submitted vide letter dated 30/1/2023.
V.	The foreshore facilities shall be set up in the stable / low or medium eroding site as demarcated in the shoreline change map by NCSCM. Further, NCSCM shall be authorized to monitor the project during construction and operation phases so as to ensure that the foreshore facilities cause minimum or no impact to the geomorphological systems.	Necessary CRZ recommendation from the Gujarat Coastal Zone Management Authority had already been obtained for establishment of 7 project facilities dated 1/7/2015 **(Copy submitted along with earlier compliance report submitted)** and accordingly, the MoEF&CC, GoI had accorded EC & CRZ Clearance dated 19/12/2016 for the proposed 7 project facilities. Further, DPA has already given assurance in the earlier compliance report submitted regarding authorizing NCSCM.
VI.	The PP should take measures to ensure that construction materials / debris (Mortar, cementing materials etc.) do not fall into the water. Construction materials including labour camps should be located at adequate distance from CRZ areas.	a) No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at **Annexure A**. b) Further, w.r.t. project at sr.no. 2 & 4 (construction not yet started), it is assured that, the construction activities shall be carried out, with due care so that construction material /debris do not fall into the water. Further, it is also assured that, construction materials including labour camps will be located outside CRZ areas.
VII.	Dredged materials should be analyzed for presence of contaminants and also to decide the disposal options. Monitoring of dredging activities should be conducted and the findings should be shared with the Gujarat SPCB and regional office of the ministry.	Dredged Material will be disposed of at designated location as identified by the CWPRS, Pune. DPA assigned work to M/s GUIDE, Bhuj for analysis of dredged material since the year 2017 and the reports are being submitted from time to time along with compliance reports submitted. The second season report submitted by M/s GUIDE, Bhuj for the period 2021-2022 is attached herewith as **Annexure- B.**
VIII.	PP in consultation with GCZMA should	DPA has already informed in the earlier

	prepare a regional strategic Impact Assessment Report with a special focus on region where the PP started construction without permission. The cost towards the study should be borne by the PP.	compliance report submitted regarding the appointment of M/s Gujarat Institute of Desert Ecology, Bhuj (work order dated 1/9/2017) for preparation of Regional Strategic Impact Assessment Report and status of approval from GCZMA for approval of Terms of Reference for preparation of RSIA Report. The revised ToR has been approved by GCZMA in the 61st Meeting held on 20/06/2022 and Formal approval letter in this regard has been issued by the Director (Environment) & MS, GCZMA vide letter dated 13/10/2022 **(Copy – Annexure C).** The RSIA Report is under finalization by M/s GUIDE, Bhuj as per approved TOR issued by the GCZMA. DPA will submit RSIA Report to the Regional Office, MoEF&CC, GoI and to the GCZMA, after receipt of the same from M/s GUIDE, Bhuj.
IX.	A comprehensive and integrated conservation plan including detailed Bathymetry Study and protection of Creeks / Mangrove area including buffer zone, mapping of coordinates, running length, HTL, CRZ boundary should be put in place. The plan should take note of all the conditions of approvals granted to all the project Proponents in this area, and the reported cases of disappearance of Mangroves near project site. The preservation of entire area to maintain the fragile ecological conditions should be a part of the plan in relation to the creek and Mangrove conservation.	The final report submitted by M/s GUIDE, Bhuj (vide letter dated 21/5/2018) had already been communicated to the MoEF&CC, GoI, Bhopal & copy to the MoEF&CC, GoI, New Delhi, along with six monthly compliance report submitted vide letter dated 21/06/2018.
X.	The commitments made during the Public Hearing and recorded in the minutes shall be complied with letter and spirit. A hard copy of the action taken shall be submitted to the	The commitments made during the Public Hearing are being complied with letter & spirit. In this regard, the details of CSR Activities implemented as well as proposed are enclosed herewith as **Annexure D.**

	ministry.	
XI.	All the conditions stipulated in the earlier clearance including the recommendations of Environment Management Plan, Disaster Management Plan shall be strictly complied with.	a) DPA has already taken necessary steps for compliance with all the conditions stipulated in the earlier clearance, including the recommendations of the Environment Management Plan, Disaster Management Plan. DPA already has an updated Disaster Management Plan. Further, DPA appointed M/s Detox Corporation, Surat (NABL Accredited laboratory) for regular Monitoring of environmental parameters since the year 2016. The work is in progress & DPA submitted monitoring data regularly to all the concerned authorities along with compliance reports submitted. The Environmental Monitoring Reports, as submitted by M/s Detox Corporation, is enclosed herewith as **Annexure E**. b) Further, w.r.t. Project at Sr.No.1, kindly refer to the Monitoring reports submitted by M/s KOTPL along with compliance report placed at **Annexure A**.
XII.	Disposal sites for excavated materials should be so designed that the revised land use after dumping and changes in the land use pattern do not interfere with the natural drainage.	a) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at **Annexure A**. b) For the remaining projects Sr.No 2 & 4 (construction not yet started), it is assured that the land use pattern will not interfere with the natural drainage.
XIII.	PP shall install a continuous automatic ambient air quality monitoring system (24 x 7) for all relevant parameters at two locations to monitor the ambient air quality status of the project area. Data should be transferred online to CPCB and SPCB websites.	a) For regular monitoring of Air quality and other environmental parameters, DPA appointed M/s Detox Corporation, Surat (NABL Accredited laboratory) since the year 2016. The work is in progress & DPA submitted monitoring data regularly to all the concerned authorities along with compliance reports submitted from time to time.

		The Environmental Monitoring Reports, as submitted by M/s Detox Corporation, is enclosed herewith as **Annexure E.** DPA has already initiated the action for inviting the tenders for carrying out online ambient air quality monitoring system (24 X 7). b) Further, w.r.t. Project at Sr.No.1, kindly refer to the Monitoring reports submitted by M/s KOTPL along with compliance report placed at **Annexure A**.
XIV.	The ground water shall not be tapped within the CRZ areas by the PP to meet with the water requirement in any case.	a) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at **Annexure A.** b) Further, w.r.t. Project at Sr. no.2 & 4 (construction not yet started), Water requirement will be met through procurement from GWSSB or private tankers. No ground water shall be tapped.
XV.	Necessary arrangements for the treatment of the effluents and solid wastes must be made and it must be ensured that they confirm to the standards laid down by competent authorities including the state or Central Pollution Control Board and under the Environmental (Protection) Act, 1986.	a) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at **Annexure A.** b) Further, it is also relevant to submit here that, w.r.t. completed projects (modification/ strengthening/ up-gradation of existing facilities), Sewage is being treated in the STP of Kandla (1.5 MLD). The treated sewages from STP of DPA are utilized for plantation / Gardening. DPA has entered into 'Selling Agency' agreement with M/s. MSTC (Govt. of India Entreprise), Vadodara on 04/01/2022 for collection, transporting and disposal of scrap, surplus items, unserviceable equipment etc.
XVI.	All the operational areas will be connected with the network of liquid waste collection corridor comprising of	The 4 projects completed are of modification/strengthening/up-gradation of existing facilities, having already developed

	storm water, oily waste and sewage collection pipelines.	network of storm water drainage & other facilities. Further, oil wastes are being disposed of by selling to the authorized vendor of GPCB/CPCB, as per norms. However, for the operational phase of the ongoing as well as the remaining projects, DPA/BOT operator will provide the necessary facilities.
XVII.	Automatic/Online monitoring system (24 x 7 monitoring devices) for water pollution in respect of flow measurement and relevant pollutants in the treatment system to be installed. The data to be made available to the respective SPCB and in the company's website.	DPA appointed M/s Detox Corporation, Surat (NABL Accredited laboratory) for regular Monitoring of environmental parameters since the year 2016. The work is in progress & DPA submitted monitoring data regularly to all the concerned authorities along with compliance reports submitted. The Environmental Monitoring Reports, as submitted by M/s Detox Corporation, is enclosed herewith as **Annexure E.**
XVIII.	Marine ecology shall also be monitored regularly in terms of sea weeds, grasses, mudflats, sand dunes, fisheries, echinoderms, shrimps, turtles, corals, coastal vegetation, mangroves and other marine bio diversity components as part of the management plan. Marine ecology shall be monitored regularly also in terms of all micro, macro and mega floral and faunal components of marine biodiversity.	DPA assigned work to M/s GUIDE, Bhuj, for regular monitoring of Marine Ecology since the year 2017 (From 2017 – 2021), and reports of the same are being submitted regularly to the Regional Office, MoEF&CC, GoI, Gandhinagar as well as to the MoEF&CC, GoI, New Delhi along with compliance reports submitted. The final report for the Holistic Marine Ecological Monitoring for the period up to May 2021 was submitted on 22.05.2021. Copy of the report was communicated vide earlier compliance report submitted vide letter dated 29/6/2021. Further, it is again to submit that DPA issued a work order to M/s GUIDE vide its letter no. EG/WK/ 4751 /Part (Marine Ecology Monitoring) /11 dated 03/05/2021 for Regular monitoring of Marine Ecology in and around Deendayal Port Authority (Erstwhile Deendayal Port Trust) and continuous Monitoring Program covering all seasons on various aspects of the Coastal Environs for the period 2021-24. The first season report for the year 2022-2023 submitted is attached herewith as **Annexure F.**
XIX.	Measure should be taken to contain, control and recover the accidental spills	DPA already having Oil Spill Contingency Plan. An adequate control measure has already been

	of fuel and cargo handle.	taken to control and recover accidental fuel and cargo handle spills.
XX.	All the mitigation measures submitted in the EIA report shall be prepared in a matrix format and the compliance for each mitigation plan shall be submitted to RO, MoEF&CC along with half yearly compliance report.	Compliance of mitigation measures suggested in the EIA report in the matrix format is attached herewith as **Annexure G.**
XXI.	Ship/barges shall not be allowed to release any oily bilge waste or ballast water in the sea. Any effluent from the jetty which have leachable characteristics shall be segregated and recycled/disposed as per SPCB guideline.	It is assured that Ships/barges shall not be allowed to release any oily bilge waste or ballast water in the sea. It is assured that any effluent from the jetty which has leachable characteristics shall be segregated, treated and recycled/disposed of as per SPCB guidelines. DPA issued a Grant of License/Permission to collect and dispose of "Hazardous Waste/Sludge/ Waste Oil" from Vessels calling at Deendayal Port" through DPA contractors. Further, it is to state that, all ships are required to follow DG Shipping circulars regarding the reception facilities at Swachch Sagar portal.
XXII.	Location of DG sets and other emission generating equipment shall be decided keeping in view the predominant wind direction so that emission do not effect nearby resident areas. Installation and operation of DG Sets shall comply with the guideline of CPCB	a) DG sets will be installed keeping in view the predominant wind direction; as per prescribed guidelines, DG sets shall be used in case of power failure only. b) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at **Annexure A**.
XXIII.	All the mechanized handling systems and other associated equipments such as hoppers, belt conveyors, stacker cum reclaimers shall have integrated dust suppression system. Dust suppression system shall be provided at all transfer point.	a) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at **Annexure A.** b) Further, w.r.t. Project at Sr.No.2 (construction not yet started), BOT operator will take the necessary step to provide all the mechanised handling systems and other associated equipment, such as hoppers, belt conveyors, and stacker cum reclaimers with integrated dust suppression systems. DPA/BOT operator will provide a Dust suppression system at all transfer points. DPA has already installed

		a water sprinkling system in the Port area for coal handling areas.
XXIV.	No products other than permitted under the CRZ Notification, 2011 shall be stored in the CRZ area.	It is hereby assured that only products permitted under the CRZ Notification, 2011 shall be stored in the CRZ area.
XXV.	It shall be ensured by the Project Proponent that the activities does not cause disturbance to the fishing activity, movement of fishing boats and destruction to mangroves during the construction and operation phase.	a) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at **Annexure A.** b) Further, it is assured that, due care is being taken so that the activities do not cause disturbance to the fishing activity, movement of fishing boats and destruction to mangroves.
XXVI.	As proposed, green belt over an area of 36.8 ha shall be developed with at least 10 meter wide green belt on all sides along the periphery of the project area, in downward direction and along road side etc. Selection of plant species shall be as per the CPCB guidelines in consultation with the DFO.	a) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at **Annexure A.** b) As already informed, DPA entrusted work of green belt development in and around the Port area to the Forest Department, Gujarat at Rs. 352 lakhs (Area 32 hectares). The work is completed. Further, DPA has appointed the Gujarat Institute of Desert Ecology (GUIDE) for "Green belt development in Deendayal Port Authority and its Surrounding Areas, Charcoal site' (Phase-I)" vide Work Order No.EG/WK/4757/Part [Greenbelt GUIDE, dated 31st May 2022 **(Annexure H).**
XVII.	Mangrove plantation in an area of 100ha shall be carried out by KPT within 2 years in a time bound manner. Action taken report shall be submitted to the Regional Office of MoEF&CC.	DPA had already undertaken Mangrove Plantation in an area of 1500 Ha. till date since the year 2005. A statement showing details of the mangrove plantation and the cost incurred is again placed in **Annexure I**. Further, DPA is carrying out an additional mangrove plantation of 100 ha. with the consultation of the Gujarat Ecology Commission vide Work Order No. DD/WK/3050/Pt-I/GIM/PC-44 dated 02/06/2022 (**Annexure J**).
XVIII.	Municipal Solid Waste and Hazardous wastes shall be managed as per Municipal Solid Waste Rule, 2016 and Hazardous Waste Management Rules	Municipal solid waste and hazardous waste management by DPA are undertaken by appointing GPCB authorized vendor per the Municipal solid waste Rule, 2016 and Hazardous waste management Rules, 2016, for further

	2016	treatment.
XXIX.	The project Proponent shall take up and earmark adequate fund for socio-economic development and welfare measure as proposed under the CSR programmed. This shall be taken up on priority.	a) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at **Annexure A**. b) The details of the fund earmarked under CSR activities and CSR activities undertaken by DPA to date & proposed activities are placed at **Annexure D.**
XXX.	The Project Proponent shall set up separate Environmental Management Cell for effective implementation of the stipulated environmental safeguards under the supervision of a senior executive	a) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at **Annexure A**. b) DPA already has an Environment Management cell. Further, DPA has also appointed an expert agency to provide Environmental Experts from time to time. Recently, DPA appointed M/s Precitech Laboratories Pvt. Ltd., Vapi, for three years vide work order dated 5/2/2021 **(Annexure K)**. Further, DPA has appointed a Manager Environment on a contractual basis for 3+2 years. A copy of the office order is attached herewith as **Annexure L**.
XXXI.	The funds earmarked for environmental management plan shall be included in the budget and this shall not be diverted for any other purpose.	a) The allocation made under the "Environmental Services & Clearance of other related Expenditure" scheme during BE 2021-22 is Rs. 266 Lakhs. and BE 2022-2023 is Rs. 345 Lakhs. b) The funds earmarked for EMP by the Concessionaire M/s KOTPL w.r.t. project at Sr.No. 1 are delineated in the compliance report submitted (**Annexure A**).
XXII.	The proponent shall abide by all the commitments and recommendations made in the EIA/EMP reports so also during their presentation to the EAC.	a) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at **Annexure A**. b) DPA has installed Mist Canon at the Port area to minimize the dust. Further, DPA has already installed continuous sprinkling system in coal stack yard in DPA (40 ha. area) for to prevent dust pollution. Further, to

		control dust pollution in other area, regular sprinkling through tankers on roads and other staking yards is being done. Regular sweeping of spilled cargo from roads is done by parties on regular basis. DPA appointed M/s Detox Corporation, Surat (NABL Accredited laboratory) for regular Monitoring of environmental parameters since the year 2016. DPA submitted monitoring data regularly to all the concerned authorities along with compliance reports submitted. The Environmental Monitoring Reports as submitted by M/s Detox Corporation is enclosed herewith as **Annexure E.** For ship waste management, DPA issued Grant of License/Permission to carry out the work of collection and disposal of "Hazardous Waste/Sludge/ Waste Oil" and "Dry Solid Waste (Non- Hazardous)" from Vessels calling at Deendayal Port" through DPA contractors. Further, it is to state that, all ships are required to follow DG Shipping circulars regarding the reception facilities at Swachch Sagar portal. DPA assigned work to M/s GUIDE, Bhuj, for regular monitoring of Marine Ecology since the year 2017 (From 2017 – 2021), and reports of the same are being submitted regularly to the Regional Office, MoEF&CC, GoI, Gandhinagar as well as to the MoEF&CC, GoI, New Delhi along with compliance reports submitted. The final report for the Holistic Marine Ecological Monitoring for the period up to May 2021 was submitted on 22.05.2021. Copy of the report was communicated vide earlier compliance report submitted vide letter dated 29/6/2021. Further, it is to submit that DPA issued a work order to M/s GUIDE vide its letter no. EG/WK/ 4751 /Part (Marine Ecology Monitoring) /11 dated 03/05/2021 for Regular monitoring of Marine Ecology in and around Deendayal Port Authority (Erstwhile Deendayal Port Trust) and continuous Monitoring Program covering all seasons on various aspects of the Coastal Environs for the period 2021-24. The first season report for the year 2022-2023 submitted is attached herewith as **Annexure F**. As already informed, DPA entrusted work of green belt development in and around the Port area to

		the Forest Department, Gujarat at Rs. 352 lakhs (Area 32 hectares). The work is completed. Further, DPA has appointed the Gujarat Institute of Desert Ecology (GUIDE) for "Green belt development in Deendayal Port Authority and its Surrounding Areas, Charcoal site' (Phase-l)" vide Work Order No.EG/WK/4757/Part [Greenbelt GUIDE, dated 31st May 2022 (**Annexure H**). For dredged material management, DPA assigned work to M/s GUIDE, Bhuj for analysis of dredged material since the year 2017 and the reports are being submitted from time to time along with compliance reports submitted. The Second Season Report submitted by M/s GUIDE, Bhuj for the period 2021-2022 is attached herewith as **Annexure B.** Further, Dredged Material will be disposed of at designated location as identified by the CWPRS, Pune. For energy conservation measures, DPA is already generating 20 MW of Wind energy. In addition to it, DPA has commissioned a 45 kWP Solar Plant at Gandhidham. Further, it is relevant to mention that, two out of four Nos. of Harbour Mobile Crane (HMC) made electric operated. Balance 02 Nos. shall be made electric operated by 2023-2024. Four Nos. of Deisel operated RTGs converted to e-RTGs. Retrofitting of hydrogen fuel cell in Tug Kalinga and Pilot Boat Niharika to be done as a pilot project under the guidance of MoPSW. Also, 14 Nos. of EV cars to be hired in this year and 03 Nos. EV Bus to be procured by the year 2023-24. Further, for Oil Spill Management, DPA is already having Oil Spill Contingency Plan in place and Oil Response System as per the NOS-DCP guidelines.
XXIII.	Company shall prepare operating manual in respect of all activities. It shall cover all safety & environment related issues and system. Measure to be taken for protection. One set of environmental manual shall be made available at the project site. Awareness shall be created at each level of the management. All the schedules and results of environmental monitoring shall be available at the project site	The operating manual plan in respect of all activities has already been communicated along with the compliance report submitted vide letter dated 2/4/2019.

	office.	
XXIV.	Corporate Social Responsibility a. The company shall have a well laid down Environmental Policy approved by the Board of Directors b. The Environmental policy shall prescribe for standard operating process/procedure to bring into focus any infringements / deviation/violation of the environmental or forest norms c. The system or Administrative order of the hierarchical company to deal with environmental issues and for ensuring compliance with the environmental clearance conditions shall be furnished. d. To have proper checks and balances, the company shall have a well laid down system of reporting of non compliances / violations of environmental norms to the board of directors of the company and/or share holders or stake holders at large.	The DPA has an Environmental Policy approved by the Board of Directors. The Environmental policy has already prescribed standard operating processes/procedures, bringing into focus any infringements/deviations/violations of the environmental or forest norms. DPA already has a well-established environmental Cell for ensuring proper checks on non-compliances/violations of Environmental norms. The organogram is attached herewith as **Annexure M**.
B. <u>General Condition</u>		
i.	The Project Authorities must strictly adhere to the stipulations made by the State Pollution Control Board (SPCB), State Govt. and any other statutory authority.	a) Point Noted. b) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at **Annexure A**.
ii.	Full support shall be extended to the officers of this ministry/regional office at Bhopal by the project Proponent during inspection of the project for monitoring purposes by furnishing full details and action plan including action taken reports. In respect of mitigation measures and other environmental protection activities.	a) Point Noted. b) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at **Annexure A**.

iii.	A six monthly monitoring report shall need to be submitted by the project proponents to the regional office of this ministry at Bhopal regarding the implementation of the stipulated conditions.	a) Point Noted. b) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at **Annexure A**.
iv	Ministry of Environment Forest and Climate Change or any other competent authority may stipulate any other additional conditions or modify the existing one, if necessary in the interest of environment and the same shall be complied with.	a) Point Noted. b) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at **Annexure A**.
v	The ministry reserves the right to revoke this clearance if any of the condition stipulated are not complied with the satisfaction of the ministry	a) Point Noted. b) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at **Annexure A**.
vi	In the event of a change in project profile or change in the implementation agency, a fresh reference shall be made to the ministry of Environment, Forest and Climate Change.	a) Point Noted. b) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at **Annexure A**.
vii	The Project Proponents shall inform the regional office as well as the ministry, the date of the financial closure and final approval of the project by the concerned authorities and the date of start of Land Development work.	DPA vide letter dated 14/12/2020 w.r.t. project No.1, i.e***. "Development of Oil Jetty to Handle Liquid Cargo and Ship Bunkering Terminal at Old Kandla under PPP Mode"***, has already informed the Regional Office, MoEF&CC, GoI, Bhopal & copy to MoEF&CC, GoI, New Delhi about the award of the concession granted to the Concessionaire M/s Kandla Oil Terminal Limited dated 11/12/2020, and the project implementation work has commissioned.
viii	A copy of the clearance letter shall be marked to concerned panchayat / local NGO, if any, from whom any suggestion/representation has been made received while processing the proposal	DPA vide letter dated 29/12/2016 had already informed to Conservation Action Trust & Paryavaran Mitra (from whom KPT received the representation during the Public Hearing).
ix	A copy of the environmental clearance letter shall also be displayed on the website of the concerned State	Point Noted.

	Pollution Control Board. The EC letter shall also be displayed at the Regional Office, District Industries Centre and Collector's Office / Tehsildar's office for30 days.	
11	The stipulations would be enforced among others under the provisions of water (Prevention and Control of Pollution) Act 1974, the Air (Prevention and control of Pollution) Act 1981, the environment (Protection) Act, 1986, the Public Liability (Insurance) Act, 1991 and EIA Notification 1994, including the amendments and rules made thereafter.	DPA appointed M/s Detox Corporation, Surat (NABL Accredited laboratory) for regular Monitoring of environmental parameters since the year 2016. The work is in progress & DPA submitted monitoring data regularly to all the concerned authorities along with compliance reports submitted. The Environmental Monitoring Reports, as submitted by M/s Detox Corporation, is enclosed herewith as **Annexure E.** For Project at Sr.No. 1 which is under construction, kindly refer monitoring data submitted by M/s KOTPL along with compliance submitted placed at **Annexure A.**
12	All other statutory clearance such as the approvals for storage of diesel from Chief Controller of Explosives, Fire Department, Civil Aviation Department, Forest Conservation Act, 1980 and Wildlife (Protection) Act, 1972 etc. shall be obtained, as applicable by project proponents from the respective competent authorities.	DPA/BOT Operator will obtain all other statutory clearance applicable as per the condition stipulated.
13	The project proponent shall advertise in at least two local Newspapers widely circulated in the region, one of which shall be in the vernacular language informing that the project has been accorded Environmental and CRZ Clearance and copies of clearance letters are available with the state Pollution Control Board and may also be seen on the website of the Ministry of Environment and Forests at http://www.envfor.nic.in. the advertisement should be made within 10 days from the date if receipt of the clearance letter and a copy of the same should be forwarded to the Regional Office of this Ministry at Bhopal.	Deendayal Port had already given advertisement in two newspapers, i.e., in KUTCHMITRA (Gujarati) & in The Indian Express (Ahmedabad Edition) (English) dated 20/12/2016. Further, DPA forwarded the copies to the Regional Office, MoEF&CC, GoI, Gandhinagar vide letter dated 22/12/2016.
14	This Clearance is subject to final order of the Hon'ble Supreme Court of India	a) Point Noted.

	in the matter of Goa Foundation Vs. Union of India in Writ Petition (Civil) No. 460 of 2004 as may be applicable to this project.	b) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at **Annexure A.**
15	Status of compliance to the various stipulated Environmental conditions and environmental safeguards will be uploaded by the project proponent in its website.	Status of compliance with the various stipulated Environmental conditions being uploaded on the website of DPA. The present compliance report has already been uploaded to the website www.deendayalport.gov.in.
16	Any appeal against this clearance shall be lie with the National Green Tribunal, if preferred, within a period of 30 days as prescribed under Section 16 of the National Green Tribunal Act, 2010.	a) Point Noted. b) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at **Annexure A**.
17	A copy of the clearance letter shall be sent by the proponent to concerned Panchayat, Zilla Parisad / Municipal Corporation, Urban Local Body and the Local NGO, if any, from whom suggestions / representations, if any, were received while processing the proposal. The clearance letter shall also be put on the website of the company by the proponent.	DPA vide letter dated 29/12/2016 had already informed to Conservation Action Trust & Paryavaran Mitra (from whom KPT received the representation during the Public Hearing).
18	The Proponent shall upload the status of compliance of the stipulated Clearance conditions, including results of monitored data on their website and shall update the same periodically. It shall simultaneously be sent to the Regional Office of MoEF, the respective Zonal Office of CPCB and the SPCB.	The status of compliance with the various stipulated Environmental conditions is being uploaded on the website of DPA. The present compliance report has already been uploaded to the website www.deenbdayalport.gov.in. Copy of the compliance report has also been marked to the Regional Office of MoEF&CC, GoI, the respective Zonal Office of CPCB and the SPCB.
19	The environmental statement for each financial year ending 31st March in Form – V as is mandated to be submitted by the project proponent to the concerned State Pollution Control Board as prescribed under the Environment (Protection) Rules, 1986, as amended subsequently, shall also be put on the website of the company along with the status of compliance of clearance conditions and shall also be sent to the respective Regional Office of MoEF by e – Mail.	a) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at **Annexure A.** b) As informed earlier, out of 7 projects, the projects mentioned at Sr. No. 3, 5, 6 & 7 in the EC Letter dated 19/12/2016 are not new projects (strengthening/ upgradation work). These projects are already covered und er consent to operate granted by the GPCB for the whole DPA area (GPCB ID 28494 –Renewed Consent Order no-AWH-110594 dated issue-8/12/2020- Valid up to 21/7/2025) and for which DPA regularly submitted the Environmental statement in Form V to the GPCB.

		A copy of the last Environmental Statement submitted to the GPCB (the year 2021-22) for the entire DPA area is enclosed herewith as **Annexure N**. Further, DPA also uploaded the said Environmental statement in Form V in the website www.deendayalport.gov.in.

ANNEXURE – B

Compliance report of EC and Clearance accorded by the MoEF&CC,GoI vide File no. 11-70/2006-IA.III dated September, 2008

DEENDAYAL PORT AUTHORITY
(Erstwhile: DEENDAYAL PORT TRUST)

दीनदयाल पत्तन प्राधिकरण
DEENDAYAL PORT AUTHORITY

Administrative Office Building
Post Box NO. 50
GANDHIDHAM (Kutch).
Gujarat: 370 201.
Fax: (02836) 220050
Ph.: (02836) 220038

www.deendayalport.gov.in

EG/WK/4660(EC) Part -V/ 230

Date: /01/2023
02/02/2023

To,
The Deputy Director General of Forests,
Ministry of Environment, Forest & Climate Change
Integrated Regional Office,
Gandhinagar, A wing-407 & 409
Aranya Bhavan Near CH-3 Circle
Sector 10A, Gandhinagar - 382010
Email :eccomplaince-guj@gov.in

Sub: "Construction of 13th to 16th Cargo Berths at Kandla" by M/s Deendayal Port Authority (Erstwhile Deendayal Port Trust) – Compliance Report of conditions stipulated in **Environmental & CRZ Clearance and Monitoring Report in Data Sheet reg.**

Ref.: 1) EC & CRZ Clearance granted vide MoEF F.No. 11-70/2006-IA-III dated 1/10/2008.
2) KPT letter no.EG/WK/4660 (EC)/654 dated 6/10/2010.
3) KPT letter no.EG/WK/4660 (EC)/ 112 dated 4/2/2012.
4) KPT letter no. EG/WK/4660(EC)/223 dated 4/9/2012.
5) KPT letter no. EG/WK/4660(EC)/144 dated 16 (17) /5/2013.
6) KPT letter no. EG/WK/4660 (EC)/Part 111/1087 dated 9/12/2013.
7) KPT letter no. EG/WK/4660 (EC)/Part 111/250 dated 17/05/2014.
8) KPT letter no. EG/WK/4660 (EC)/Part 111/198 dated 14/11/2014.
9) KPT letter no. EG/WK/4660 (EC)/Part 111/256 dated 11/05/2015.
10) KPT letter no. EG/WK/4660 (EC)/Part 111/162 dated 15/10/2015.
11) KPT letter no. EG/WK/4660 (EC)/Part 111/133 dated 09/05/2016.
12) KPT letter no. EG/WK/4660 (EC)/Part IV/167 dated 26/12/2016.
13) DPT letter no. EG/WK/4660 (EC)/Part IV/325 dated 26/06/2018.
14) DPT letter no. EG/WK/4660 (EC)/Part V/53 dated 14(16)/2/2019.
15) DPT letter no. EG/WK/4660(EC)/PartV/205 dated 30(6)/11 (12)/2019.
16) DPT letter no. EG/WK/4660 (EC)/Part V dated 15/01/2021.
17) DPT letter no. EG/WK/4660 (EC)/Part V/92 dated 30(07)/9(10)/2021.
18) DPT letter no. EG/WK/4660 (EC)/Part V dated 28/03/2022
19) DPA letter no. EG/WK/4660 (EC)/Part V/149 dated 19/07/2022

Sir,

It is requested to kindly refer above cited references for the said subject.

In this connection, it is to state that, as directed under above referred letter dated 5/8/2009 of MoEF, Regional Office, Gandhinagar, Deendayal Port Authority (Erstwhile Deendayal Port Trust) vide above referred letters had regularly submitted Six Monthly compliance report of stipulated conditions and Monitoring report in Data Sheet, in connection with subject project.

.....cont.....

Now, as directed in above referred letter dated 5/8/2009 of MoEF, GoI, please find enclosed herewith point wise compliance to various stipulation in Environmental & CRZ Clearance granted by MoEF, GoI vide letter 11-70/2006-IA.III dated Sept, 2008 (**Annexure 1**) & Monitoring Report in Data Sheet (**Annexure 2**), for the period from June, 2022 to November, 2022 for kind information and record please.

Further, as per the MoEF&CC, Notification S.O.5845 (E) dated 26.11.2018, stated that ***"In the said notification, in paragraph 10, in sub-paragraph (ii), for the words "hard and soft copies" the words "soft copy" shall be substituted".*** Accordingly, we are submitting herewith soft copy of the same via e-mail ID rowz.bpl-mef@nic.in & eccompliance-guj@gov.in.

This has the approval of the Chief Engineer, Deendayal Port Authority.

Thanking You.

Yours faithfully,

Manager (Env.)
Deendayal Port Authority

Copy along with point wise compliance of stipulated conditions, to:

1) Shri Amardeep Raju, MoEF&CC,GoI and Member Secretary (EAC-Infra.1),
Indira Paryavaran Bhavan,
Ministry of Environment, Forest and Climate Change
Jor Bagh Road, Aliganj,
New Delhi-110003.
Email: ad.raju@nic.in

2) Shri Prasoon Gargav,
Scientist E & Regional Director,
Central Pollution Control Board,
Parivesh Bhawan, Opp. VMC Ward Office No.10, Subhanpura,
Vadodara – 390 023.
Email: prasoon.cpcb@nic.in

3) Smt. Urvashi Upadhyay,
Environment Engineer,
Unit Head, Kachchh,
Gujarat Pollution Control Board,
Paryavaran Bhavan,
Sector 10A, Gandhinagar- 382 010.
Email-kut-uh-gpcb@gujarat.gov.in

4) The Regional Officer,
Gujarat Pollution Control Board,
Regional Office (East Kutch),
Administrative Office Building,
Deendayal Port Trust, Gandhidham.
Email Id. ro-gpcb-kute@gujarat.gov.in

Annexure -1

Annexure 1

Compliance Report for the period upto November, 2022

Subject: - Compliance of conditions stipulated in Environmental & CRZ Clearance granted by the MoEF&CC, GoI for "Construction of 13th to 16th Cargo Berths at Deendayal Port Authority (Erstwhile: Deendayal Port Trust)".

- The MoEF, GoI granted Environmental & CRZ Clearance for the subject project vide no. F.No. 11-70/2006-IA-III dated Sep 2008.

- 7/2/2014 – The MoEF&CC, GoI extended the validity period of Environmental & CRZ Clearance for a further period of 5 years i.e. up to 30/9/2018.

STATUS OF Berths:

13thCargo Berth: Under operation since 18/2/2013.
15thCargo Berth:Under Operation since 16/11/2013.
14th Cargo Berth: Under Operation since 8/4/2019.
16th Cargo Berth: Under Operation since 10/3/2019.

CONSENT TO OPERATE:

Consolidated Consent & Authorization (CC&A) issued by the GPCB (Consent Order no-AWH-110594 dated of issue-8/12/2020, with a validity period upto 21/7/2025)– Detailed Order issued by the GPCB vide outward no. 581914 dated 22/1/2021 & subsequently, issued Correction in CC&A order vide letter no. PC/CCA-KUTCH-812(5)/GPCB ID 28494/588116 dated 9/4/2021.

Sr. No.	Conditions	Remarks
A	**Specific Condition**	
1	All measures indicated in the letter dated 4/8/2008 shall be strictly complied with.	Compliance Report of conditions stipulated in the CRZ recommendation granted by Forest & Environment Department, GoG vide letter dated 14/02/2008 is placed at **Annexure A.**
2	Necessary clearances from the Gujarat State Pollution Control Board shall be obtained before initiating the project.	GPCB vide order no. PCC/CCA-BHUJ-179(3)/575 dated 9/1/2009 granted No Objection Certificate to the said project. Currently, all the 4 berths are under operation. Further, GPCB vide order dated 22/1/2021 has issued Consolidated Consent & Authorization. Subsequently, GPCB issued Correction in CC&A order vide letter no. PC/CCA-KUTCH-812(5)/GPCB ID 28494/ 588116 dated 9/4/2021. The copy of the same is enclosed herewith as **Annexure B.**
3	The project proponent shall not undertake any destruction of mangroves during construction and operation of project.	All the 4 berths are under operation. As a part of mangrove conservation, DPA has undertaken Mangrove Plantaion in an area of 1500 Hectares at various locations **(Annexure C)** till date under the directions of the GCZMA and MoEF&CC,GoI. In addition to it, DPA is carrying out additional mangrove plantation of 100 ha. in consultation with Gujarat Ecology Comission vide Work Order No. DD/WK/3050/Pt-I/GIM/PC-44 dated 02/06/2022 (**Annexure D**). It is also relavent to mention here that, as per the direction of the Gujarat Coastal Zone Management Authority, DPA has already prepared & submitted a report on mangrove conservation and management plan formulated by Gujarat Institute of Desert Ecology during the study period of Jan-April, 2015 (Report already submitted along with earlier compliance reports submitted). For regular monitoring, DPA vide work order dated 3/5/2021 has assigned work to M/s GUIDE, Bhuj for Monitoring of mangrove plantation carried out by DPA (Period from 24/5/2021 to 23/5/2022). The final report submitted by M/s GUIDE is attached

		herewith as **Annexure E.**
4	Sewage arising in the Port area shall be treated to conform to the standards stipulated by Gujarat State Pollution Control Board and shall be utilized/ recycled or gardening, plantation and irrigation.	The sewage generated in the port area is treated in the existing STP of 1.5 MLD capacity at Kandla. The treated wastewater is utilized for gardening and plantation purposes. In addition to that, it also has septic tanks at places where STP is inaccessible. For monitoring of environmental parameters including the STP, DPA appointed M/s Detox Corporation (NABL Accredited laboratory), Surat and reports are being submitted from time to time to the Regional Office as well as to the MoEF&CC, GoI, New Delhi. The monitoring report is attached herewith as **Annexure F.**
5	Project proponent shall prepare Disaster Management Plan covering emergency evacuation mechanisms etc.deal with natural disaster events and regularly update from time to time.	DPA is already having a Disaster Management Plan. The copy of the same has been communicated with earlier compliance reports submitted.
6	There shall be no withdrawal of ground water in COASTAL REGULATION ZONE area, for this project. The proponent shall ensure that as a result of the proposed constructions, ingress of saline water into ground water does not take place. Piezometers shall be installed for regular monitoring for this purpose at appropriate locations on the project site.	All the 4 berths are currently under operation.
7	The facilities to be constructed in the COASTAL REGULATION ZONE area as part of this project shall be strictly in conformity with the provisions of the COASTAL REGULATION ZONE Notification, 1991 as amended subsequently.	All the 4 berths are currently under operation.
8	Green belt area shall be developed along the project and budget earmarked.	DPA had entrusted the work to Forest Department, Gujarat for developing green belt in and around Port area at a cost of Rs. 352 lakhs in an area of about 32 hectares and the work is already completed. Further, DPA has appointed Gujarat Institute

		of Desert Ecology (GUIDE) for "Green belt development in Deendayal Port Authority and its Surrounding Areas, Charcoal site' (Phase-I)" vide Work Order No.EG/WK/4757/Part [Greenbelt GUIDE], dated 31st May, 2022 **(Annexure G)**.
9	No product other than those permissible in the COASTAL REGULATION ZONE Notification, 1991 shall be stored in the COASTAL REGULATION ZONE area.	Point Noted. Cargo is being stored at back-up area of berths viz. 13th to 16th CB, as per the EC & CRZ Clearance accorded by the MoEF&CC, GoI.
B	**General Conditions**	
I	Construction of the proposed structures shall be undertaken meticulously conforming to the existing Central/Local rules and regulations including COASTAL REGULATION ZONE Notification, 1991 & its amendments. All the construction design/drawings relating to the proposed construction activities must have approvals of the concerned State Government Department/Agencies.	Currently, all the 4 berths are under operation.
II	Adequate provisions for infrastructure facilities such as water supply, fuel, sanitation etc. shall be ensured for construction workers during the construction phase of the project so as to avoid feeling of trees / mangroves and pollution of water and surroundings.	All the 4 berths are currently under operation.
iii	The project authorities must make necessary arrangement for disposal of solid wastes and for the treatment of Effluents by providing a proper wastewater treatment plant outside the COASTAL REGULATION ZONE area. The quality of treated effluents, solid wastes and noise level etc. must conform to the standards laid down by the competent authorities including the Central/State Pollution Control Board and the Union Ministry of Environment and Forests	Companies authorized by Central Pollution Control Board (CPCB) and State Pollution Control Board (SPCB) have been awarded the work of collection, transporting and disposal of solid waste by the Deendayal Port Authority. Generated sewage is treated in the existing STP (1.5 MLD capacity) of DPA. In addition to that, it also has septic tanks at places where STP is inaccessible. DPA appointed M/s Detox Corporation (NABL Accredited laboratory), Surat for monitoring of Environmental parameters viz. Air, Water, Noise etc. and reports are being submitted

	under the Environment (Protection) Act, 1986, whichever are more stringent.	from time to time to the Regional Office as well as to the MoEF&CC, GoI, New Delhi. The monitoring report is attached herewith as **Annexure F**.
Iv	The proponents shall provide for a regular monitoring mechanism as to ensure that the treated effluents conform to the prescribed standards. The records of analysis reports must be properly maintained and made available for inspection to the concerned State/Central officials during their visits.	For monitoring of treated sewage, DPA appointed M/s Detox Corporation (NABL Accredited laboratory), Surat and reports are being submitted from time to time to the Regional Office as well as to the MoEF&CC, GoI, New Delhi. The monitoring report is attached herewith as **Annexure F**.
V	In order to carry out the environmental monitoring during the operational phase of the project, the project authorities shall provide an environmental laboratory well equipped with standard equipment and facilities and qualified manpower to carry out the testing of various environmental parameters.	DPA appointed M/s Detox Corporation, Surat (NABL Accredited laboratory) for regular Monitoring of environmental parameters. For the purpose, well equipped laboratory has already been established by M/s Detox Corporation at DPA. The work is in progress & DPA submitted monitoring data regularly to all the concerned authorities along with compliance reports submitted (**Annexure F).**
vi	The sand dunes if any on the site shall not be disturbed in any way.	No sand dunes at project site prevail.
Vii	A copy of the clearance letter will be marked to the concerned Panchayat/local NGO, if any from whom any suggestion/ representation has been received while processing the proposal.	No suggestion/ representation has been received while processing the proposal.
Viii	The Gujarat Pollution Control Board shall display a copy of the clearance letter at the Regional Office, District Industries Centre and Controller's Office/Tehsildar's Office for 30 days.	-------
ix	The funds earmarked for environment protection measures shall be maintained, in a separate account and there shall be no diversion of these funds for any other purpose. A year-wise expenditure on environmental safeguards shall be reported to this Ministry's Regional Office at Bhopal and the State Pollution Control Board.	Point noted. The allocation made under the scheme of "Environmental Services & Clearance thereof other related Expenditure" during BE 2021-22 is Rs. 266 Lakhs & BE 2022-23 is Rs. 345 Lakhs. The expenditure made under the scheme of "Environmental Services & Clearance thereof other related Expenditure" is Rs. 275.36 lakhs for period up to November, 2022.

		The year wise expenditure on environmental safeguards is regularly submitted in the monitoring datasheet to Ministry's Regional Office at Bhopal (Now Gandhinagar).
X	Full support shall be extended to the officers of this Ministry's Regional Office at Bhopal and the officers of the central and State Pollution Control Board by the project proponents during their inspection for monitoring purpose, by furnishing full details and action plans including the action taken reports in respect of mitigate measures and other environment protection activities.	Point Noted.
xi	In case of deviation of alteration in the project including the implementing agency, a fresh reference shall be made to this Ministry for modification in the clearance conditions or imposition of new ones for ensuring environment protection.	Point Noted.
Xii	This ministry reserves the right to revoke this clearance, if any of the conditions stipulated are not complied with to satisfaction of this ministry.	Point Noted.
Xiii	This Ministry or any other competent authority may stipulate any other additional conditions subsequently, if deemed necessary, for environment protection, which shall be complied with.	Point Noted.
Xiv	The project proponent shall advertise in at least two local newspapers widely circulated in the region around the project, one of which shall be in the vernacular language of the locality Concerned, informing that the project has been accrued environment clearance and copies of clearance letters are available with the State Pollution Control Board and may also be seen at website of the Ministry of Environment & Forests at http;//www.envfornic.in. The advertisement shall be made	Advertisement had already been made in Kutch Mitra on 21/10/2008 and Kutch Uday on 22/10/2008. Further, Newspaper cuttings had already been sent to Regional office, MoEF, Bhopal vide DPA letter No.: EG/WK/4660(EC)/01 dated 31/10/2008.

	within 7 days from the date of issue of the clearance letter and a copy of the sameshall be forwarded to the Regional office of this Ministry at Bangalore.	
xv	The project proponent shall inform the Regional office at Bhopal as well as the Ministry the date of financial closer and final approval of the Project by the concerned authorities and the date of Start of Land Development work.	The necessary details have already been provided by the DPA from time to time along with the earlier compliance reports submitted. Now, all the 4 berths are under operation.
10	The above-mentioned stipulations will be enforced among others under the water (Prevention and Control of Pollution) Act, 1974, the Air (Prevention and Control of Pollution) Act, 1981, the Environment (Protection) Act 1986, the Hazardous Chemicals (Manufactures, storage and Import) Rules, 1989, the Coastal Regulation Zone Notification, 1991 and its subsequent amendments and the Public Liability Insurance Act, 1991 and the Rules made there under from time to time. The project proponents shall also ensure that the proposal complies with the provisions of the approved Coastal Zone Management Plan of Gujarat State.	DPA has obtained consolidated consent and authorization vide GPCB (Consent Order no-AWH-110594 dated of issue-8/12/2020, with a validity period upto 21/7/2025)– Detailed Order issued by the GPCB vide outward no. 581914 dated 22/1/2021 & subsequently, issued Correction in CC&A order vide letter no. PC/CCA-KUTCH-812(5)/GPCB ID 28494/588116 dated 9/4/2021. The copy of the same is enclosed herewith as **Annexure B.** Moreover, DPA retained M/s Detox Corporation for regular environmental monitoring and the report is enclosed at **Annexure F**. Public Liability Insurance is renewed time to time as required. The Public Liability Insurance has been renewed and is valid till 23/07/2023. The same is attached herewith as **Annexure H.** Deendayal Port Authority had already obtained Coastal Regulation Zone Recommendations dated 14/02/2008 from State Forest &Environment Department, Government of Gujarat for the project. All the 4 berths are under operation.

ANNEXURE – C

Public Liability Insurance valid upto 23/07/2024

RISK DETAILS

TYPE: MARINE PORT PACKAGE INSURANCE POLICY

INSURED: **DEENDAYAL PORT AUTHORITY,** (hereinafter referred as DPA) and/ or associated and/ or affiliated and/ or interrelated and/ or subsidiary companies and/ or corporations as they now are or may hereafter be created and/ or constituted and/ or for whom the Assured receive instructions to insure and/ or for whom the Assured have or assume a responsibility to arrange insurance, whether contractually or otherwise, as their respective rights and interests may appear hereinafter known as the Assured and/ or as original

PRINCIPAL ADDRESS:

Address of the Original Insured
Administrative Office Building, Near Madhuban Hotel, Gandhidham, Kutch, Gujarat.

INSURANCE INTERMEDIARY: Marsh India Insurance Brokers Pvt. Ltd.

PERIOD: 12 months with effect from 24th July 2023 till 23rd July 2024, both days included

INTEREST:

Section 1
Port Authority Liabilities including liability of contractor and subcontractors and wreck removal.

Section 2
Real and Personal Property - In respect of all properties, owned by / under custody of Insured(s) hereunder including adjacent warehouses associate structures.

Section 3
Port Equipment including all Cargo Handling Equipment /Vehicles, Machineries and spares

Section 4
Business Interruption consequent upon Property damage (including cargo handling equipment, machineries etc.) -

For Business interruption of the Port operation (wholly or partly) due to/consequent upon or arising out of:

(a) Interruption of electric supply to insured properties Or insured handling equipment, which is beyond the control of the assured.

(b) Blockage of Channel/ Waterways due to any cause

(c)Blockage of any land access within the immediate Vicinity* of the Port/ Terminals.
*(immediate vicinity will mean at least 8 km radii from main entrance of Port's operational area applicable for both Kandla as well as for Vadinar)

LIMIT OF LIABILITY

Section 1
Overall Limit of Liability: INR 40,00,00,000 any one accident or occurrence and in the aggregate
Sublimit for liability arising out of wreck removal: INR 5,00,00,000

Sections 2, 3 & 4

Loss Limit: INR 673,00,00,000 any one accident or occurrence and in the aggregate

TOTAL SUM INSURED FOR PROPERTIES (excludes owned vessels): INR 57,304,306,727.

Sections 4

Indemnity Period: 2 Months
Annual Revenue – INR 23,478,594,000
Annual Gross Profit – INR 22,159,394,000
Loss limit – INR 100,00,00,000

Combined Single Limit for PD /BI / Liability across all sections is INR 713,00,00,000

LOCATION:

Insured Location addresses as under:

1. Administrative Office Buildng, Near Madhuban Hotel, Gandhidham, Kutch, Gujarat -370201
2. Custom Bounded Area Port of Kandla – 370210.
3. Port Colony, KDLB colony, FCI colony, Residential quarters-400 quarters, Gopalpuri, Gandhidham -370201.

4. Office Buildings and Residential Quarters outside port area, Kandla – 370210
5. Dispensary at Adipur-370205
6. Baba Saheb Ambedkar Convention Centre Gandhidham
7. Jetty Area, Vadinar-361010 – Latitude : 220 44' N ; Longitude : 690 67' E
8. Port Colony, Vadinar-361010 – Latitude : 230 01' N ; Longitude : 700 13' E

POLICY CONDITIONS:

Section 1

Ports and Terminals Consortium Section 1 – Liability Wording Amended.
Clause 2.3 (Insuring Clause) amended.

Ports and Terminals Consortium Fire Extension (Liability).
Ports and Terminals Consortium Advice and Information Extension (Liability).

Ports and Terminals Consortium Fines and Duty Extension (Liability).
Ports and Terminals Consortium Infringement of Personal Rights Extension (Liability).
Ports and Terminals Consortium Wrongful Delivery of Cargo Extension (Liability).

Subject to Joint Liability Committee War and Terrorism Exclusion Clause JL2002/02 17/01/02 plus Joint Liability Committee

Deductible:
For Liability (including environmental pollution): Flat: INR 5,00,000

Section 2

Ports and Terminals Consortium Section 2 – Property Damage Wording Amended.
Clause 2.1 (Insuring Clause) amended to include electrical and machinery breakdown.
Exclusion 4.8 (Safe working load) amended.
Exclusion 5.2 (Road) deleted.
Exclusion 5.4 (Stock) does not apply to stock of spare parts.
Exclusion 4.9 (Communication Equipment) deleted.
Clause 5.1 amended to include land development cost
Clause 8.1 (Automatic Acquisition) amended to 90 days.
Clause 8.2 (Automatic Acquisition) amended to 10%.

Ports and Terminals Consortium Earthquake Extension Clause

(Property) Amended, 1/04 LSW1517.
Clause A amended to include Tsunami.
Clause B amended to include Tsunami.
48 hours amended to 72 hours.

Deductible:
(A) Other than AOG peril & Vessel Impact: 2% of claim amount subject to Minimum **INR 3,00,000 each and every claim**

(B) AOG Peril: 2% of claim amount subject to **Minimum INR 20,00,000 each and every claim (including losses affecting breakwater)**

(C) Vessel impact: 2% of claim amount subject to **Minimum INR 20,00,000 each and every claim (including losses affecting breakwater)**

Section 3
Ports and Terminals Consortium Section 3 – Handling Equipment Wording Amended.
Clause 2.1 (Insuring Clause) amended to include electrical and machinery breakdown.
Clause 2.4 (Removal of Wreck/Debris) included
Exclusion 4.7 (Communication Equipment) deleted.
Exclusion 4.9 (Safe working load) amended.

Exclusion 4.15 (Mechanical or Electrical Breakdown) deleted.
Clause 8 (Protective Maintenance) amended.
Clause 9.1 (Automatic Acquisition) amended to 90 days Clause 9.2 (Automatic Acquisition) amended to 10%

Ports and Terminals Consortium Earthquake Extension Clause (Handling Equipment) Amended 1/04 LSW1520. Clause A amended to include Tsunami.
Clause B amended to include Tsunami.
48 hours amended to 72 hours.

Deductible: 2% of claim subject to **Minimum INR 3,00,000**

Section 4
Ports and Terminals Consortium Section 4 Business Interruption Wording Amended 1/04 LSW1522.
Clause 2.3 (Interruption to Utility Supply) amended to include gas, fuel or water supply.
Additional Clause 2.4 interruption due to damage and/or blockage of pipeline.

Deductible: 7days

Applicable to Sections 2, 3 & 4
Subject to Expediting Expenses Clause

Subject to Architects, Surveyors', Legal and Consulting Engineers' Fees Clause

Subject to Minor Works Clause

Subject to Public Authority Clause

Subject to Reinstatement Clause

Subject to Temporary Removal Clause

Subject to Additional Increased Cost of Working Clause.

Subject to Prevention of Ingress/Egress Clause.

Subject to Professional Accountants Fees Clause

Subject to Average Clause (85%)
Pollution Clean-up Costs Clause
Claims Preparation Costs Clause
Minimization of Loss Clause
Designation of Property Clause
Listed Perils resulting from seepage and/or pollution and/or contamination clause

Limited seepage &/or pollution &/or contamination resulting from physical damage caused by listed perils clause

Waiver of under-insurance upto 15% of Sum Insured under property damage and BI Sum Insured
Marine Impact Insurance Clause
Specialized / Heavy Lift/ Oversize Lifting clause
Toxic Mould Exclusion Clause
Claims Control Clause
NMA 2919 War and Civil War and Terrorism Exclusion Clause

Applicable to All Sections

General Policy Provisions LSW1524 01/04 Amended.

Marsh

Clause 5 (Radioactive Contamination, etc) deleted
Clause 6.1 B. amended to delete 'strike, lock-out, labour disturbance, riot, civil commotion'.
Clause 11 (Notice of Potential Claims) amended.
Clause 18 (Premium Payment Clause) deleted.
Clause 21 (Governing Law) amended to India.
Clause 10 (Electronic Exclusion Clause) deleted.
Employment Practices Clause
Simultaneous Payment Clause (Losses)
Waiver of Subrogation and Additional Assured Clause
Special Termination Clause.
Continuity Clause

Subject to Institute Radioactive Contamination, Chemical, Biological, Bio-chemical and Electromagnetic Weapons Exclusion

Clause CL.370 10/11/03, and Marine Cyber Exclusion LMA5402 and Marine Cyber Endorsement LMA5403.

Subject to Sanction Limitation and Exclusion Clause LMA3100 15th September 2010.

Subject to Unintentional Errors and Omission Clause.

Notwithstanding anything contained elsewhere, insurance shall be governed by and construed in accordance with the laws of India and the exclusive jurisdiction of India.

Payment on account clause - Payment on account of any loss recoverable under this insurance will be promptly made by the insurers to the insured if so desired , provided that such payment are deducted from the finally agreed claim settlement figures.

Paneled surveyor clause: In the event of a claim, the surveyors shall be appointed only from the panel of agreed surveyors as mentioned below:
a) Proclaim Insurance Surveyors and Loss Assessors Private Limited

b) McLarens Insurance Surveyors And Loss Assessors India Pvt. Ltd

c) Alex Stewart International (India) Private Limited

In case above surveyors are not available, the appointment of alternate surveyor by insurance company will be done in agreement

and after consent of the assured.

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EXPRESS WARRANTIES: None

CONDITIONS PRECEDENT: None

SUBJECTIVITIES: None

PREMIUM: Total Premium inclusive of sections 1,2,3 &4:

INR 119,589,903/- plus GST of INR 21,526,183/-

Total premium of INR <u>141,116,086/-</u>

Paid in full prior to inception

Terrorism Cover

Insured: **DEENDAYAL PORT AUTHORITY,** (hereinafter referred as MPT) and/ or associated and/ or affiliated and/ or interrelated and/ or subsidiary companies and/ orcorporations as they now are or may hereafter be created and/ or constituted and/ or for whom the Assured receive instructions to insure and/ or for whom the Assured have or assume a responsibility to arrange insurance, whether contractually or otherwise, as their respective rights and interests may appear hereinafter known as the Assured and/ or as original

Insurance Intermediary: Marsh India Insurance Brokers Pvt. Ltd.

Risk Location:

Insured Location addresses as under:

1. Administrative Office Buildng, Near Madhuban Hotel, Gandhidham, Kutch, Gujarat -370201

2. Custom Bounded Area Port of Kandla – 370210.
3. Port Colony, Gopalpuri, Gandhidham - 370201.
4. Office Buildings and Residential Quarters outside port area, Kandla – 370210
5. Dispensary at Adipur-370205
6. Baba Saheb Ambedkar Convention Centre Gandhidham
7. Jetty Area, Vadinar-361010 – Latitude : 220 44' N ; Longitude : 690 67' E
8. Port Colony, Vadinar-361010 – Latitude : 230 01' N ; Longitude : 700 13' E

Occupancy: **Marine Port**

Cover: Terrorism and Sabotage with third party liability limit

Period: 24th July 2023 to 23rd July 2024

Total Insured Values: Property Damage and handling equipment- INR 57,304,306,727.

Sections 4

Indemnity Period: 2 Months
Annual Revenue – INR 23,478,594,000
Annual Gross Profit – INR 22,159,394,000
Loss limit – INR 100,00,00,000

Limit: Combined Single Limit for Property Damage, handling equipment and Business Interruption – INR 673,00,00,000

Third party liability limit of INR 40,00,00,000

Combined Single Limit for Property Damage, handling equipment and Business Interruption and liability – INR 713,00,00,000

Deductibles: Material damage – 2% claim amount subject to minimum of INR 300,000

Business Interruption – 7 days

Third Party Liability – INR 500,000 any one accident / occurrence

दि न्यू इन्डिया एश्योरन्स कं. लि.
(भारत सरकार का उपक्रम)
बृहत कॉर्पोरेट एवं ब्रोकर्स कार्यालय : 920000
न्यू इन्डिया सेंटर, 11वीं मंजिल, 17/ए, कूपरेज रोड,
डॉ. बी.आर. आंबेडकर चौक, मुंबई - 400 001.
फोन : 022-22044973 / 2204 4976 / 2204 4977 / 2204 4974

THE NEW INDIA ASSURANCE CO. LTD.
(A Govt. of India Undertaking)
Large Corporate & Broker's Office : 920000
New India Centre, 11th Floor, 17/A, Cooperage Road,
Dr. B.R. Ambedkar Chowk, Mumbai - 400 001
Phone : 022 - 2204 4973 / 2204 4976 /2204 4977 / 2204 4974

Marsh

Total Premium: INR 1,720,634/- plus GST of INR 309,714/- totaling to

<u>INR 2,030,348/-</u>

Thanking you,

The New India Assurance Co. Ltd.

K Chaan

दि न्यू इन्डिया एश्योरन्स कंपनी लिमिटेड
बृहत कॉर्पोरेट एवं ब्रोकर्स कार्यालय 920000
Large Corporate & Brokers' Office 920000
The New India Assurance Co. Ltd.

Authorized Signatory

ANNEXURE – D

Grant of Permission / License for removal of Dry Solid Waste(Non-Hazardous) from Vessels calling at Deendayal Port

GPCB

GUJARAT POLLUTION CONTROL BOARD

PARYAVARAN BHAVAN
Sector-10-A, **Gandhinagar**-382 010
Phone : (079) 23226295
Fax : (079) 23232156
Website : www.gpcb.gov.in

By R.P.A.D

One Time Authorization as importer for importing Non-Hazardous waste under Part – D of Schedule – III on behalf of actual users.

(See Rule-13)(2)(C)

The authorization is hereby granted to **V. K. Enterprise** having **IEC No. ACAPN6790N** Located at **2, Plot No.16, Sector 1/A, Shakti Nagar Road, Gandhidham, Kutch-370201** for import of the following waste listed in part D of schedule III of Hazardous and Other Waste (M&TM) Rules-2016.

Sr.No.	Description of Non Hazardous waste to be imported.
1.	Iron and Steel Scrap, Brass Scrap, Aluminium Scrap, Copper Scrap, Zinc Scrap-500MTPA(Under B-1010, Part-D of Schedule – III of Hazardous and Other Waste (M&TM) Rules-2016)

Specific condition;

1. Unit shall strictly comply with all the conditions mentioned in Memorandum of Understanding No.KC0000733176 dated 01/04/2021.
2. The Applicant / Importer shall have to submit Performa Invoice within 30 days from the date of issue of this letter.

The authorization is subjected to following conditions:

1 The import is permitted only for sale to actual users/manufactures who are registered & have valid consent & Authorization of the State Pollution Control Board/Pollution Control Committee

2 In case of illegal import or import other than mentioned in Part-D of Schedule-III of the Hazardous and Other Waste (M&TM) Rules-2016, the waste has to be **re-exported by the importer** at his own cost within a period of 90 days from the date of its arrival in India.

3 The importer of the hazardous and other wastes shall maintain records of the hazardous and other waste imported by him in Form 3 and the record so maintained shall be made available for inspection.

4 The importer of the hazardous and other wastes shall file an annual return in **Form 4** to the State Pollution Control Board on or before the **30th day of June** following the financial year to which that return relates.

5 The Board reserves right to cancel/amend/Revoke the authorization at any point of time as per the provision of Hazardous and Other Waste (M&TM) Rules-2016 and subsequent amendment thereof.

6 The importers shall have to comply with the provisions of the Environment protection Act, 1986 and the Rules made therein.

7 The Importer shall [illegible] of Hazardous and Other Waste (M&TM) Rules-2016 in line with EPA-1986.

For and on behalf of
Gujarat Pollution Control Board

D. M. Thaker 18/9/2021

(D. M. Thaker)
Environment Engineer
Unit Head Hazardous Waste Cell

No GPCB/HAZ-R-Kutch-332/ 60|158/ 18 SEP 2021

Issued to:
V. K. Enterprise
2, Plot No 16, Sector 1/A
Shakti Nagar Road, Gandhidham
Kutch 370 201

GPCB

GUJARAT POLLUTION CONTROL BOARD

PARYAVARAN BHAVAN
Sector-10-A, Gandhinagar-382 010
Phone : (079) 23226295
Fax : (079) 23232156
Website : www.gpcb.gov.in

TRUE COPY

By R.P.A.D

One Time Authorization as importer for importing Non-Hazardous waste under Part – D of Schedule – III on behalf of actual users.

(See Rule-13)(2)(C)

The authorization is hereby granted to **Green Earth Marine Solutions** having **IEC No. CIOPS1894Q** Located at **Office No.202, Plot No.578, Ward 12/c, Second Floor, Shakti Avenue, Gandhidham, Kutch-370201** for import of the following waste listed in part D of schedule III of Hazardous and Other Waste (M&TM) Rules-2016.

Sr. No.	Name and Basel No. of Other Waste as per the SCHEDULE-III, Part-D of Hazardous and Other Waste (Management and Transboundary Movement) Rules, 2016	Quantity (Ton/ Annum)	List and detailed address of actual or prospective users
1.	Iron and Steel Scrap [B-1010]	600 MTPA	V M Industries (GPCB ID 13236) Plot No.210/3, Shramjivi Vasahat, Opp. Rajendra Park, Rakhiyal, Ahmedabad
2.	Copper Scrap [B-1010]	1000 MTPA	Jayshree Agro Industries (GPCB ID 11910), Plot No.1211, GIDC Dholka, Ahmedabad

This authorization is granted as per the provisions of clause (c) of sub-rule (2) of rule 13, of Hazardous and Other Waste (Management and Transboundary Movement) Rules, 2016.

This authorization is subject to the following general and specific conditions:-

1. Unit shall strictly comply with all the conditions mentioned in Memorandum of Understanding No.KC0031050896-897 dated 25/01/2022.
2. The Applicant / Importer shall have to submit Performa Invoice within 30 days from the date of issue of this letter.
3. The authorized person shall comply with the provisions of the Environment (Protection) Act, 1986 (29 of 1986), and the rules made there under.
4. This authorization shall be produced for inspection at the request of an officer authorized by the State Pollution Control Board.
5. The person authorized shall not import, store and trade in the imported other wastes other than those wastes permitted through this authorization.
6. Authorized person shall intimate the State Pollution Control Board regarding change in the storage location or closure of storage facility.

NOTARY SAPNA D. DADLANI Area Gandhidham-Kutch Regd. No. 7910/2010 GUJARAT INDIA Expiry Date 12-05-2025 GOVT. OF INDIA

TRUE COPY

7. The waste which gets generated during storage and trading of imported other wastes shall be treated and disposed of as per prevailing regulations.
8. The importer shall bear the cost of import and mitigation of damages if any caused during the process of import, storage and trading.
9. Any other conditions for compliance as per the Guidelines issued by the Ministry of Environment, Forest and Climate Change or the Central Pollution Control Board, as the case may be, from time to time.
10. Annual return as per FORM 4 shall be filed by June 30th for the period ensuring 31st March of the year.
11. The Authorized Trader shall be responsible to obtain other statutory permissions as may be required.
12. The import is permitted only for sale to actual users/manufactures who are registered & have valid consent & Authorization of the State Pollution Control Board/Pollution Control Committee.
13. In case of illegal import or import other than mentioned in Part-D of Schedule-III of the Hazardous and Other Waste (M&TM) Rules-2016, the waste has to be re-exported by the importer at his own cost within a period of 90 days from the date of its arrival in India.
14. The importer of the hazardous and other wastes shall maintain records of the hazardous and other waste imported by him in Form 3 and the record so maintained shall be made available for inspection.
15. The Board reserves right to cancel/amend/Revoke the authorization at any point of time as per the provision of Hazardous and Other Waste (M&TM) Rules-2016 and subsequent amendment thereof.

For and on behalf of
Gujarat Pollution Control Board

D. M. Thaker 2/2/2022
(D. M. Thaker)
Environment Engineer
Unit Head Hazardous Waste Cell

No.GPCB/HAZ-R-Kutch-366/ 622193

02 FEB 2022

Issued to:
Green Earth Marine Solutions
Office No.202, Plot No.578, Ward 12/c,
Second Floor, Shakti Avenue, Gandhidham,
Kutch-370201

COLOUR XEROX
- 9 FEB 2022
TRUE COPY
(SAPNA D. DADLANI)
ADVOCATE & NOTARY
Gandhidham-Kutch

NOTARY
SAPNA D. DADLANI
Area Gandhidham-Kutch
Regd. No. 7918/2010
GUJARAT, INDIA
Expiry Date 12-05-2025
GOVT. OF INDIA

GPCB

GUJARAT POLLUTION CONTROL BOARD
PARYAVARAN BHAVAN
Sector 10-A, Gandhinagar 382 010
Phone : (079) 23226295
Fax : (079) 23232156
Website : www.gpcb.gov.in

By R.P.A.D

One Time Registration as importer for importing Non-Hazardous waste under Part – D of Schedule – III on behalf of actual users.

(See Rule-16)

The registration is hereby granted to **Chitrakut Trading and Industries** having **IEC No. 3714001654** Located at **Ranko, Ward-29, Navawas, Madhapar, Bhuj, Kutch-370020** for import of the following waste listed in part D of schedule III of Hazardous waste (Management, Handling & Transboundary Movement) Rules-2008 read with third amendment dated 30/3/2010.

Sr. No.	Description of Non Hazardous waste to be imported.
1.	Aluminum Scrap, Iron & Steel Scrap, Copper Scrap, Zinc Scrap, Brass Scrap @ 80000 MTPA Under B-1010, Part-D of Schedule - III

The registration is subjected to following conditions:

1 The import is permitted only for sale to actual users/manufactures who are registered &have valid consent& Authorization of the State Pollution Control Board/Pollution Control Committee.

2 The registered trader shall have to submit the details of such import and particulars of actual users along with quantities to this Board on a **quarterly basis** as per prescribed format enclosed herewith as Annexure – A and registration would be liable for cancellation on failure to furnish these details/quarterly report to this Board.

3 In case of illegal import or import other than mentioned in Part-D of Schedule-III of the Hazardous waste (Management, Handling & Transboundary Movement),Third Amendment Rules 2010, the waste has to be **re-exported by the importer** at his own cost within a period of 90 days from the date of its arrival in India.

4 The Board reserves right to cancel/amend/Revoke the registration at any point of time as per the provision of Hazardous waste (M,H&TM) Rules – 2008 and subsequent amendment thereof.

28 OCT 2022

TRUE COPY

(MADHUKANT J. SHAH)
B.Com., LL.B.(Sp.)
ADVOCATE & NOTARY
Gandhidham (Kutch) 370201, India

NOTARY Madhukant J. Shah Area Dist. Kutch. REG. No. 324/2002 Expiry Date 24-08-2027 GOVT. OF GUJARAT

5 The importers shall have to comply with the provisions of the Environment protection Act, 1986 and the Rules made therein.

6. The Importer shall strictly adhere with Environmental stipulation of Hazardous Waste (Management & Handling) Rules, 2008 in line with EPA-1986.

For and on behalf of
Gujarat Pollution Control Board

(V. R. Ghadge)
Senior Environmental Engineer

No.GPCB/HAZ-R-Kutch-171/ 230610 14 NOV 2014

Issued to:
Chitrakut Trading and Industries
Ranko, Ward-29, Navawas,
Madhapar, Bhuj,
Kutch-370020

TRUE COPY
28 OCT 2022
(MADHUKANT J. SHAH)
B.Com., LL.B.(Sp.)
ADVOCATE & NOTARY
Gandhidham (Kutch) 370201, India

NOTARY
Madhukant J. Shah
Area: Dist. Kutch.
Reg. No. 924/2002
Expiry Date 24-06-2027
GOVT. OF GUJARAT

GUJARAT POLLUTION CONTROL BOARD

Paryavaran Bhavan,
Sector-10-A,
Gandhinagar- 382 010
Phone : (079) 23226295 Fax (079) 23232156
Website: www.gpcb.gov.in

By R.P.A.D

One Time Authorization as importer for importing Non-Hazardous waste under Part – D of Schedule – III on behalf of actual users.

(See Rule-13)(2)(C)

The authorization is hereby granted to **Golden Shipping Services** having **IEC No. 3716500208** Located at **Kidana Nirmal Nagar, Survey No.133, Plot No.83, Kidana, Kutch-370205** for import of the following waste listed in part D of schedule III of Hazardous and Other Waste (M&TM) Rules-2016.

Sr. No.	Name and Basel No. of Other Waste as per the SCHEDULE-III, Part-D of Hazardous and Other Waste (Management and Transboundary Movement) Rules, 2016	Quantity (Ton/ Annum)	List and detailed address of actual or prospective users
1.	Iron and Steel Scrap [B-1010]	600 MTPA	Vega Alloys (GPCB ID 44804) S.No.22/1 & 2, Maglana-364240, Tal: Sihor, Dist: Bhavnagar

This authorization is granted as per the provisions of clause (c) of sub-rule (2) of rule 13, of Hazardous and Other Waste (Management and Transboundary Movement) Rules, 2016.

This authorization is subject to the following general and specific conditions:-

1. Unit shall strictly comply with all the conditions mentioned in Memorandum of Understanding No.KC0033840599 dated 07/05/2022.
2. The Applicant / Importer shall have to submit Performa Invoice within 30 days from the date of issue of this letter.
3. The authorized person shall comply with the provisions of the Environment (Protection) Act, 1986 (29 of 1986), and the rules made there under.
4. This authorization shall be produced for inspection at the request of an officer authorized by the State Pollution Control Board.
5. The person authorized shall not import, store and trade in the imported other wastes other than those wastes permitted through this authorization.
6. Authorized person shall intimate the State Pollution Control Board regarding change in the storage location or closure of storage facility.
7. The waste which gets generated during storage and trading of imported other wastes shall be treated and disposed of as per prevailing regulations.
8. The importer shall bear the cost of import and mitigation of damages if any caused during the process of import, storage and trading.

NOTARY Madhukant J. Shah Area: Dist. Kutch. REG. No. 394/2002 Expiry Date 24-08-2027 GOVT. OF GUJARAT

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30 MAY 2022
(MADHUKANT J. SHAH)
B.Com., LL.B.(Sp.)
ADVOCATE & NOTARY
Gandhidham (Kutch) 370201, India.

9. Any other conditions for compliance as per the Guidelines issued by the Ministry of Environment, Forest and Climate Change or the Central Pollution Control Board, as the case may be, from time to time.
10. Annual return as per FORM 4 shall be filed by June 30th for the period ensuring 31st March of the year.
11. The Authorized Trader shall be responsible to obtain other statutory permissions as may be required.
12. The import is permitted only for sale to actual users/manufactures who are registered & have valid consent & Authorization of the State Pollution Control Board/Pollution Control Committee.
13. In case of illegal import or import other than mentioned in Part-D of Schedule-III of the Hazardous and Other Waste (M&TM) Rules-2016, the waste has to be re-exported by the importer at his own cost within a period of 90 days from the date of its arrival in India.
14. The importer of the hazardous and other wastes shall maintain records of the hazardous and other waste imported by him in Form 3 and the record so maintained shall be made available for inspection.
15. The Board reserves right to cancel/amend/Revoke the authorization at any point of time as per the provision of Hazardous and Other Waste (M&TM) Rules-2016 and subsequent amendment thereof.

For and on behalf of
Gujarat Pollution Control Board

D. M. Thaker 17/5/2022

(D. M. Thaker)
Environment Engineer
Unit Head Hazardous Waste Cell

No.GPCB/HAZ-R-Kutch-374/ 672663

Issued to:
Golden Shipping Services
Kidana Nirmal Nagar, Survey No.133,
Plot No.83, Kidana,
Kutch-370205

18 MAY 2022.

TRUE COPY
30 MAY 2022
(MADHUKANT J. SHAH)
B.Com., LL.B.(Sp.)
ADVOCATE & NOTARY
Gandhidham (Kutch) 370201, India.

NOTARY
Madhukant J. Shah
Area : Dist. Kutch.
REG. No. 324/2002
Expiry Date 24-06-2027
GOVT. OF GUJARAT

GUJARAT POLLUTION CONTROL BOARD
Paryavaran Bhavan
Sector-10-A, Gandhinagar-382 010.
Phone : (079) 23226295
Fax : (079) 23232156
Website : www.gpcb.gov.in

RPAD

Registration as importer for importing on behalf of actual users.

(See Rule-16)

The registration is hereby granted to M/s. **Harish A. Pandya** having IEC No.3700000260 Located at Office No.15,Brahm Samaj Building,Plot No.106, Sector-08,B/H-Oslo Cinema,Gandhidham For import of the following waste listed in part-B of Schedule III of Hazardous waste (Management, Handling & Transboundary Movement) Rules, 2008.

Description of waste	Quantity of Waste to be Imported
All kind of ferrous & & non ferrous scrap under B-1010 Of Schedule-III **Alluminium Scrap** **Stainless steel scrap** **Copper scrap –** **Zink scrap –** **Brass Scrap**	**80,000MT/Annum**

The registration is subjected to following conditions:

1 The import is permitted only on behalf of actual users, registered traders who have valid consent & Authorization of the Gujarat Pollution Control Board.

2 The importer shall submit the quarterly report stating the details of import including the names of actual users and quantity of waste to the Board.

3 In case of illegal import or import other than mentioned in Part-B of Schedule-III of the Hazardous waste (Management, Handling & Tran boundary Movement) Rules, 2008, the waste has to be re-exported by the importer at his own cost within a period of 90 days from the date of its arrival in India.

NOTARY Madhukant J. Shah Area Dist. Kutch. REC No. 324/2002 Expiry Date 24-06-2027 GOVT. OF GUJARAT

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11 JAN 2023
(MADHUKANT J. SHAH)
B.Com., LL.B.(Sp.)
ADVOCATE & NOTARY
Gandhidham (Kutch) 370201, India.

GUJARAT POLLUTION CONTROL BOARD
Paryavaran Bhavan
Sector-10-A, Gandhinagar-382 010.
Phone : (079) 23226295
Fax : (079) 23232156
Website : www.gpcb.gov.in

4 The Board reserves right to cancel/amend/Revoke the registration/Authorization at any time as per the policy of the Board/ Government

5 The importers shall comply with the provisions of the Environment protection Act, 1986 and the Rules made there under.

For and on behalf of
Gujarat Pollution Control Board

(R. C. Tamboli)
Environment Engineer

GPCB/Haz/R/Kutch-39/ 6562 /2010

1 APR 2010

Issued to:
M/s **Harish A. Pandya**
Office No.15,Brahm Samaj Building,
Plot No.106, Sector-08,
B/H-Oslo Cinema,
Gandhidham

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11 JAN 2023
(MADHUKANT J. SHAH)
B.Com., LL.B.(Sp.)
ADVOCATE & NOTARY
Gandhidham (Kutch) 370201, India

NOTARY
Madhukant J. Shah
Area: Dist. Kutch.
REG. No. 224/2002
Expiry Date 24-09-2027
GOVT. OF GUJARAT

GUJARAT POLLUTION CONTROL BOARD

Paryavaran Bhavan,
Sector-10-A,
Gandhinagar- 382 010
Phone : (079) 23226295 Fax (079) 23232156
Website: www.gpcb.gov.in

By R.P.A.D

One Time Authorization as importer for importing Non-Hazardous waste under Part – D of Schedule – III on behalf of actual users.

(See Rule-13)(2)(C)

The authorization is hereby granted to **New India Marine Works** having **IEC No. 3712001673** Located at **Plot No.378, Ward 11-A, Bharat Nagar, Gandhidham, Kutch-370201** for import of the following waste listed in part D of schedule III of Hazardous and Other Waste (M&TM) Rules-2016.

Sr.No.	Name and Basel No. of Other Waste as per the SCHEDULE-III, Part-D of Hazardous and Other Waste (Management and Transboundary Movement) Rules, 2016	List and detailed address of actual or prospective users	Quantity (Ton/ Annum)
1.	Aluminium Scrap [B-1010]	Pyramid Industries, Survey No.322 paiki 1, NR B.V. Oil Mill,Chhatral Kadi Road, Vill:Indrad, Tal: Kadi, Dist: Mehsana	3000MTPA
2.	Zinc Scrap [B-1010]		3000MTPA
3.	Brass Scrap [B-1010]	Indu Extrusion & Alloys Pvt Ltd, Plot No.3657/58, GIDC Phase-III, Dared, Jamnagar	1000MTPA
4.	Copper Scrap [B-1010]		1000MTPA
5.	Iron and Steel Scrap [B-1010]	Sardar Casting Pvt Ltd, 15, Plot No.6,7,8, Kangasiyali Road, Gondal Road, Vavdi, Rajkot	1000MTPA

This authorization is granted as per the provisions of clause (c) of sub-rule (2) of rule 13, of Hazardous and Other Waste (Management and Transboundary Movement) Rules, 2016.

This authorization is subject to the following general and specific conditions:-

1. Unit shall strictly comply with all the conditions mentioned in Memorandum of Understanding No.KC0019531774, KC0017892708-709 dated 05/01/2022, 17/01/2022.
2. The authorized person shall comply with the provisions of the Environment (Protection) Act, 1986 (29 of 1986), and the rules made there under.
3. This authorization shall be produced for inspection at the request of an officer authorized by the State Pollution Control Board.

4. The person authorized shall not import, store and trade in the imported other wastes other than those wastes permitted through this authorization.
5. Authorized person shall intimate the State Pollution Control Board regarding change in the storage location or closure of storage facility.
6. The waste which gets generated during storage and trading of imported other wastes shall be treated and disposed of as per prevailing regulations.
7. The importer shall bear the cost of import and mitigation of damages if any caused during the process of import, storage and trading.
8. Any other conditions for compliance as per the Guidelines issued by the Ministry of Environment, Forest and Climate Change or the Central Pollution Control Board, as the case may be, from time to time.
9. Annual return as per FORM 4 shall be filed by June 30th for the period ensuring 31st March of the year.
10. The Authorized Trader shall be responsible to obtain other statutory permissions as may be required.
11. The import is permitted only for sale to actual users/manufactures who are registered & have valid consent & Authorization of the State Pollution Control Board/Pollution Control Committee.
12. In case of illegal import or import other than mentioned in Part-D of Schedule-III of the Hazardous and Other Waste (M&TM) Rules-2016, the waste has to be re-exported by the importer at his own cost within a period of 90 days from the date of its arrival in India.
13. The importer of the hazardous and other wastes shall maintain records of the hazardous and other waste imported by him in Form 3 and the record so maintained shall be made available for inspection.
14. The Board reserves right to cancel/amend/Revoke the authorization at any point of time as per the provision of Hazardous and Other Waste (M&TM) Rules-2016 and subsequent amendment thereof.

For and on behalf of
Gujarat Pollution Control Board

D. M. Thaker 19/01/2022

(D. M. Thaker)
Environment Engineer
Unit Head Hazardous Waste Cell

No.GPCB/HAZ-R-Kutch-363621336

19 JAN 2022

Issued to:
New India Marine Works
Plot No.378, Ward 11-A, Bharat Nagar,
Gandhidham. Kutch-370201

GPCB

GUJARAT POLLUTION CONTROL BOARD

PARYAVARAN BHAVAN
Sector-10-A, Gandhinagar-382 010
Phone : (079) 23226295
Fax : (079) 23232156
Website : www.gpcb.gov.in

By R.P.A.D

One Time Authorization as importer for importing Non-Hazardous waste under Part – D of Schedule – III on behalf of actual users.

(See Rule-13(2)(C))

The authorization is hereby granted to **K M Enterprise** having **IEC No. BGJPH6692D** Located at **Plot No.63, Ward-3B, Adipur, Gandhidham, Kutch-370201** for import of the following waste listed in part D of schedule III of Hazardous and Other Waste (M&TM) Rules-2016.

Sr.No.	Description of Non Hazardous waste to be imported.
1.	Iron and Steel Scrap, Brass Scrap, Aluminium Scrap, Copper Scrap, Zinc Scrap-200MTPA [Under B-1010, Part-D of Schedule-III of Hazardous and Other Waste (M&TM) Rules-2016]

Specific condition;

1. Unit shall strictly comply with all the conditions mentioned in Memorandum of Understanding No.KC0001032237 dated 06/03/2021.
2. The Applicant / Importer shall have to submit Performa Invoice within 30 days from the date of issue of this letter.

The authorization is subjected to following conditions:

1 The import is permitted only for sale to actual users/manufactures who are registered & have valid consent & Authorization of the State Pollution Control Board/Pollution Control Committee.

2 In case of illegal import or import other than mentioned in Part-D of Schedule-III of the Hazardous and Other Waste (M&TM) Rules-2016, the waste has to be **re-exported by the importer** at his own cost within a period of 90 days from the date of its arrival in India.

3 The importer of the hazardous and other wastes shall maintain records of the hazardous and other waste imported by him in Form 3 and the record so maintained shall be made available for inspection.

4 The importer of the hazardous and other wastes shall file an annual return in **Form 4** to the State Pollution Control Board on or before the **30th day of June** following the financial year to which that return relates.

TRUE COPY
(U. K. JOSHI)
NOTARY
DIST. KUTCH- (GUJARAT)
Reg. No 5848

NOTARY
UMED K. JOSHI
GOVT. OF INDIA

5 The Board reserves right to cancel/amend/Revoke the authorization at any point of time as per the provision of Hazardous and Other Waste (M&TM) Rules-2016 and subsequent amendment thereof.

6 The importers shall have to comply with the provisions of the Environment protection Act, 1986 and the Rules made therein.

7 The Importer shall strictly adhere with Environmental stipulation of Hazardous and Other Waste (M&TM) Rules-2016 in line with EPA-1986.

For and on behalf of
Gujarat Pollution Control Board

D.M. Thaker 10/3/2021

(D. M. Thaker)
Environment Engineer
Unit Head Hazardous Waste Cell

No.GPCB/HAZ-R-Kutch-327/58557

10 MAR 2021

Issued to:
K M Enterprise
Plot No.63, Ward-3B,
Adipur, Gandhidham,
Kutch-370201

Copy to:
1. Regional Officer,
Kutch (East)

TRUE COPY
(U. K. JOSHI)
NOTARY
DIST. KUTCH- (GUJARAT)
Reg. No.5848

NOTARY
UMED K. JOSHI
Area: Dist Kutch
Regd. No. 5848
GUJARAT STATE
(INDIA)
GOVT. OF INDIA

GUJARAT POLLUTION CONTROL BOARD
PARYAVARAN BHAVAN
Sector 10-A, Gandhinagar 382010
Phone : (079) 23226295
Fax : (079) 23232156
website : www.gpcb.gov.in

By R.P.A.D

One Time Registration as importer for importing Non-Hazardous waste under Part – D of Schedule -III on behalf of actual users.

(See Rule-16)

The registration is hereby granted to **Naaz Shipping Services Enterprise** having **IEC No. 3707001466** Located at **Off.No-35, 1st Floor, Grain Merchant Assn. Building, Plot No-297, Ward 12/B, Gandhidham Kutch 370201** for import of the following waste listed in part D of schedule III of Hazardous waste (Management, Handling & Trans boundary Movement) Rules-2008 read with third amendment dated 30/3/2010.

Sr.No.	Description of Non Hazardous waste to be imported.
1.	Iron & Steel Scrap @ 50,000 MTA Under B-1010, Part-D of Schedule - III

Specific condition;

The Applicant / Importer shall have to submit the following details within 7(seven) days or else registration shall be treated as cancelled without prior intimation.

1. Copy of ID proof of the Proprietor of the Company, I.e. copy of Pancard etc.

The registration is subjected to following conditions:

1 The import is permitted only for sale to actual users/manufacturers who are registered & have valid consent & Authorization of the Gujarat Pollution Control Board.

2 The registered trader shall have to submit the details of such import and particulars of actual users along with quantities to this Board on a **quarterly basis** as per prescribed format enclosed herewith as Annexure – A and registration would be liable for cancellation on failure to furnish these details/quarterly report to this Board.

3 In case of illegal import or import other than mentioned in Part-D of Schedule-III of the Hazardous waste (Management, Handling &

NOTARY R.L.GADHVI Area Gandhidham Taluka Regd. No. 1323/2010 Gujarat State Expiry Date 09/02/2025 Govt. of Gujarat

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R.L.GADHVI
ADVOCATE & NOTARY
Gandhidham-Kutch

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Transboundary Movement), Third Amendment Rules 2010, the waste has to be **re-exported by the importer** at his own cost within a period of 90 days from the date of its arrival in India.

4. The Board reserves right to cancel/amend/Revoke the registration at any point of time as per the provision of Hazardous waste (M,H&TM) Rules – 2008 and subsequent amendment thereof.
5. The importers shall have to comply with the provisions of the Environment protection Act, 1986 and the Rules made therein.
6. The Importer shall strictly adhere with Environmental stipulation of Hazardous Waste (Management & Handling) Rules, 2008 in line with EPA-1986.

For and on behalf of
Gujarat Pollution Control Board

(V. R. Patel)
Senior Environment Engineer

GPCB/HAZ-R-KUTCH-124/ 130332 17 NOV 2012

Issued to:
Naaz Shipping Services Enterprise
Off.No-35, 1st Floor, Grain Merchant Assn. Building,
Plot No-297, Ward 12/B, Gandhidham
Kutch-370201

TRUE COPY
R.L.GADHVI
ADVOCATE & NOTARY
Gandhidham-Kutch

NOTARY
R.L. GADHVI
Area: Gandhidham
Taluka
Regd. No. 1323/2010
Gujarat State
Expiry Date
09/02/2024
Govt. of Gujarat

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GUJARAT POLLUTION CONTROL BOARD
PARYAVARAN BHAVAN
Sector-10-A, Gandhinagar 382 010
Phone : (079) 23222425
(079) 23232152
Fax : (079) 23232156
Website : www.gpcb.gov.in

GPCB

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By R.P.A.D

One Time Authorization as importer for importing Non-Hazardous waste under Part – D of Schedule – III on behalf of actual users.

(See Rule-13)(2)(C)

The authorization is hereby granted to **Omega Marine Services** having **IEC No. 3713001812** Located at **Office No.2, Bhraham Samaj Building, Plot No.106, Sector-8, Gandhidham, Kutch-370201** for import of the following waste listed in part D of schedule III of Hazardous and Other Waste (M&TM) Rules-2016.

Sr.No.	Description of Non Hazardous waste to be imported.
1.	Iron and Steel Scrap-50000MTPA [Under B-1010, Part-D of Schedule – III of Hazardous and Other Waste (M&TM) Rules-2016]

Specific condition;

1. Unit shall strictly comply with all the conditions mentioned in Memorandum of Understanding No.86029169441 dated 06/08/2020.
2. The Applicant / Importer shall have to submit Performa Invoice within 30 days from the date of issue of this letter.

The authorization is subjected to following conditions:

1 The import is permitted only for sale to actual users/manufactures who are registered & have valid consent & Authorization of the State Pollution Control Board/Pollution Control Committee.

2 In case of illegal import or import other than mentioned in Part-D of Schedule-III of the Hazardous and Other Waste (M&TM) Rules-2016, the waste has to be **re-exported by the importer** at his own cost within a period of 90 days from the date of its arrival in India.

3 The importer of the hazardous and other wastes shall maintain records of the hazardous and other waste imported by him in Form 3 and the record so maintained shall be made available for inspection.

4 The importer of the hazardous and other wastes shall file an annual return in **Form 4** to the State Pollution Control Board on or before the **30th day of June** following the financial year to which that return relates.

NOTARY PANKAJ J. JOSHI Arun Gandhidham Tahsil Regd. No. 1907/2022 GUJARAT STATE Expiry Date 31-1-2025 Govt. of India

Clean Gujarat Green Gujarat
ISO-9001-2008 & ISO-14001 - 2004 Certified Organisation

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(PANKAJ J. JOSHI)
NOTARY (Gandhidham-Kutch)

OMEGA MARINE SERVICES Gujarat India

TRUE COPY

5 The Board reserves right to cancel/amend/Revoke the authorization at any point of time as per the provision of Hazardous and Other Waste (M&TM) Rules-2016 and subsequent amendment thereof.

6 The importers shall have to comply with the provisions of the Environment protection Act, 1986 and the Rules made therein.

7 The Importer shall strictly adhere with Environmental stipulation of Hazardous and Other Waste (M&TM) Rules-2016 in line with EPA-1986.

For and on behalf of
Gujarat Pollution Control Board

D. M. Thaker 13/8/2020

(D. M. Thaker)
Environment Engineer
Unit Head Hazardous Waste Cell

No.GPCB/HAZ-R-Kutch-305/ 565808 | 13 AUG 2020

Issued to:
Omega Marine Services
Office No.2, Bhraham Samaj Building,
Plot No.106, Sector-8, Gandhidham,
Kutch-370201

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(PANKAJ J. JOSHI)
NOTARY (Gandhidham-Kutch)

OMEGA MARINE SERVICES Gujarat India

NOTARY GOVT. OF INDIA

ANNEXURE – E

Coal Handling Circular -
TF/SH/Circulars/2019/1256 dated 10/10/2019

DEENDAYAL PORT TRUST
(AN ISO 9001:2008 & ISO 14001:2004 CERTIFIED PORT)
(आईएसओ9001:2008 एवआईएसओ14001:2004प्रमाणितपोर्ट)

SAGARMALA

Telegram : PORT TRUST
तार : पोर्टट्रस्ट
टेलीफोन : 02836-270625
फैक्स : 02836-270475

SIPC KANDLA

यातायात प्रबंधक का कार्यालय
कंडलापोर्टट्रस्ट
पीएंडसीबिल्डिंग
नयाकंडला (कच्छ) 370210

TF/SH/Circulars/2019/1256 Date: 10/10/2019

CIRCULAR

In supersession of earlier Circulars notably No.TF/SH/2019/5362 dtd.23-24/01/2019 and No.TF/SH/Circulars/2019/1004 dtd. 18/09/2019 issued with regard to controlling the dust pollution arising out of coal handling as also ensuring safety in cargo handling so as to avoid damage to port infrastructure, in consultation with Port Users the following Standard Operating Procedures (SOPs) is formulated for due compliance :

1. During the course of discharging coal from the vessels at berth, the grab should invariably be opened at a lower height at Wharf.
2. Trucks/Dumpers are transporting coal from wharf to storage yard, storage yard to railway siding/for final delivery by road, as the case may be, should load coal below the brim/body level to avoid spillage enroute.Trucks, dumpers loaded for delivery of coal while moving from plot to weighbridge or weighbridge to plot and moving out should be covered by tarpaulin.
3. Storage of coal at yard shall not exceed above 5Mtrs height.
4. Water sprinkling on Indonesian coal heaps at plots at regular intervals to be undertaken by respective Port Users.
5. Sweeping machines should be deployed by the Port Users for their respective vessels at wharf and on roads during Coal handling operations.Spillage cargo on road/s should be cleaned immediately.
6. The residual cargo at wharf should be swept immediately on completion of dischargeof vessel to ensure the wharf is clean for next incoming vessel.
7. The internal roads at coal storage yard should be cleaned by the respective Port Users adjacent to their plots.

Further, damages are reportedly being caused to Port properties due to deployment of chain mounted heavy equipments by port users. To avoid such damages and adhering to safety norms, it has been decided not to permit deployment of such chain mounted heavy equipments / vehicles to come into direct contact with the surface on following areas:

1. Chain mounted equipments shall not be allowed to come into direct contact with the surface at wharfs neither for cargo loading nor barge unloading including Bunder area.Such equipments are permittedto be used/moved at Wharfs only on rubber mats/Steel plate and/or on cargo heaps of one meter height and above.
2. At no point of time,the Chain/ Crawler mounted equipments are allowed tocome into direct contact with Concrete/Bitumen surfaceeither whilemoving, loading, unloadingof such equipments, except on rubber mats/steel plates or directly on to cargo heaps of minimum one meter height and above.
3. While cleaning coal spillage on Railway Tracks, equipments like Pay Loaders/Escavators (Hitachis) are not to be used.

4. Dumping and/or Storage of cargo within three meters distance from Cable Ducts, Highmast Light Towers, Drainages, Railway Lines, Waterspringling system, Fire fighting installations is not permitted / allowed.

5. While handling of coal and other bulk cargoes, especially with Ship's Cranes, a temporary precautionary barrier should be made available to avoid spillage of cargo into the sea.

6. Plying of Vehicles, Equipments other than at designated places/areas is not permitted.

All Port Users/stake holders are requested to take note of the above and strictly adhere to the aforestated SOPs. CHA's are requested to inform their respective transporters of these SOP's and give wide publicity amongst them.

Any violation of above circular with regard to non adherence of precautions to be taken whilst deploying chain mounted equipment/s, a penalty of Rs. 25000/- and for any other violationsa penalty of Rs 10000/- shall be imposed for each violation of above rules. If the violation is repeated thrice, it could lead to suspension of licence/authorization for a period 10 days. Repeated and habitual violations could lead to cancellation of licence/ authorization. Road Trafffic, parking, covering of coal by Tarpauling and other safety related violations will be delt with as per Circular of life saving Rules and other Safety Rules DPT and procedure for traffic Safety Management in DPT. Any damage to port property by port user a penality of two times of assessed cost will be recorved from the port users.

This will come into effect from 10/10/2019. The same will be reviewed after three months.

The stakeholder's kind co-operation is solicited.

The Circular is issued with approval of competent authority.

Traffic Manager (I/c)
Deendayal Port Trust

To:

All Port Users/Trade Associations

Copy to :

1. **Sr.PS to Chairman – for kind information of Chairman**
2. **PS to Dy.Chairman – for kind information of Dy.Chairman**
3. **Chief Engineer**
4. **Chief Mechanical Engineer**
5. **ALL Officers of Traffic Department - for implementation**
6. **Sr.DD(EDP) - for uploading on website**

ANNEXURE – F

Environmental Monitoring Reports

ENVIRONMENTAL MONITORING REPORT FOR DEENDAYAL PORT TRUST

REPORT	**:**	**DCPL/DPT/20-21/21**
Mont	**:**	**January**
Issue	**:**	**01**
Revision	**:**	**00**
Prepare	**:**	**DETOX CORPORATION PVT. LTD., SURAT**

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Introduction

Monitoring of various environmental aspects of the Deendayal port by M/s Detox Corporation Pvt. Ltd. has been carried out through collection of samples, analysis of the same, comparing results with respect to the national standards and any other relevant standards by GBCB/CPCB/MoEF to identify non conformity in the Environment of the Deendayal Port. The results shall address the identified impacts and suggest measures to minimize the environmental impact due to various operations at Deendayal Port.

The environmental monitoring is carried out as per the Environment Management and Monitoring Plan submitted by Detox Corporation Pvt. Ltd.

1. Ambient Air Quality Monitoring

As per the Environmental Monitoring Plan of Deendayal Port Trust, Air monitoring was carried out at six identified locations at Deendayal Port and two locations at Vadinar Port.

1.1 Air Quality Monitoring Methodology

Air quality is measured in all the stations, for 24 hour for Total Suspended Particulate Matter (TSPM), PM_{10}, $PM_{2.5}$, SO_2, NO_X, NH_3 & Benzene, and Grab-sampling for CO & CO_2 measurements. The Air samplers are operated for a period of 24 hours and after a continuous operation of 8 hours of the sampler, the reagents were replaced to obtain 3 samples per day for each parameter namely, SO_2, NO_X. The EPM 2000 filter paper and PTFE Membrane bound filter paper are used for a period of 24 hours to obtain one sample each of TSPM, PM_{10} & $PM_{2.5}$. The AAQ samples are collected twice a week from all the eight locations as per the EMP.

1.2 Results

The ambient air quality monitoring data for six stations, viz. Marine Bhavan, Oil Jetty, Port Colony,Gopalpuri Hospital,Tuna Port and Nr. Coal Storage Area for the month of January 2022 are given in Tables 1A to 6B. The ambient air quality monitoring data for two stations at Vadinar (Nr. Admin Building &Nr. Signal Building) are given in Tables 7A to 8B.

Location 1: Marine Bhavan (AL1)

Location 1: Marine Bhavan (AL1)Table 1 : Results of Air Pollutant Concentration at Marine Bhavan										
Parameter		**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period	**Date**	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit		**NS**	**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL1 – 1	04.01.2022	314	209	84	6.00 6.43 6.86	6.43	20.30 19.60 21.00	20.30	11.74 11.60 11.88	11.74
AL1 – 2	07.01.2022	378	198	87	4.84 5.28 6.15	5.42	15.88 18.42 19.05	17.78	8.42 10.98 12.25	10.55
AL1 – 3	11.01.2022	463	204	96	4.84 3.96 2.20	3.66	26.04 16.51 15.88	19.48	7.66 7.15 6.89	7.23
AL1 – 4	12.01.2022	466	247	100	3.52 2.20 1.32	2.34	15.88 14.61 15.24	15.24	12.76 11.74 10.47	11.66
AL1 – 5	19.01.2022	434	239	98	3.08 4.84 3.96	3.96	19.05 17.78 13.34	16.73	7.40 7.91 7.40	7.57
AL1 - 6	21.01.2022	485	286	101	2.64 3.52 2.64	2.93	14.61 19.69 12.07	15.46	10.21 9.19 7.40	8.93
AL1 - 7	24.01.2022	396	217	98	3.52 3.96 1.76	3.08	14.61 19.69 17.15	17.15	12.76 11.49 10.21	11.49
AL1 – 8	28.01.2022	398	221	96	5.28 5.71 3.52	4.84	22.23 19.05 18.42	19.90	10.47 10.98 9.96	10.47
Monthly Average		417	227	95		4.08		17.75		9.96
Standard Deviation		57	29	6		1.38		1.97		1.82

NS -Not Specified

Table 1 : Results of Air Pollutant Concentration at Marine Bhavan					
Parameter	**Date**	**C_6H_6 [µg/m³]**	**HC* ppm**	**CO [mg/m³]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m³**	**NS**	**4.0 mg/m³**	**NS**
AL1 – 1	04.01.2022	1	BQL	1.8	506
AL1 – 2	07.01.2022	1.15	BQL	1.8	1005
AL1 – 3	11.01.2022	1.39	BQL	1.8	568
AL1 – 4	12.01.2022	1.19	BQL	1.9	579
AL1 – 5	19.01.2022	1.24	BQL	1.8	652
AL1 - 6	21.01.2022	1.154	BQL	1.82	587
AL1 - 7	24.01.2022	1.163	BQL	1.83	665
AL1 - 8	28.01.2022	1.171	BQL	1.96	665
Monthly Average		**1.18**	**-**	**1.84**	**653**
Standard Deviation		**0.11**	**-**	**0.06**	**153**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)
NS -Not Specified

At Marine Bhavan, the overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_X and NH_3 is attributed mainly by motor vehicle emission produced from various types of automobiles (both diesel and petrol driven). Moreover, the loading and unloading of Food Grains and Timber at Jetty no. 1 and 2 also contributes to the high levels of TSPM and PM_{10}. The mean TSPM value at Marine Bhavan was 417µg/m³, The mean PM_{10} values were 227.0 µg/m³, which is above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean 95.0 µg/m³). The average values of SO_2, NO_x and NH_3 were within the permissible limit. The average values of SO_2, NO_x and NH3 were 4.08 µg/ m³, 17.75 µg/ m³ & 9.96 µg/ m³ respectively. These were within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Marine Bhavan. The mean Benzene concentration was 1.18 µg/m³, well below the permissible limit of 5.0 µg/m³. HC's were below the detectable limit and Carbon Monoxide concentration was 1.84 mg/m³, well below the permissible limit of 4.0 mg/m³.

Location 2: Oil Jetty (AL2)

Table 2 : Results of Air Pollutant Concentration at Oil Jetty

Parameters	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit		NS	100 µg/m3	60 µg/m3	-	80 µg/m3	-	80 µg/m3	-	400 µg/m3
AL2 – 1	04.01.2022	378	121	78	2.64 4.40 4.84	3.96	13.34 12.07 18.42	14.61	6.38 10.21 12.76	9.79
AL2 – 2	07.01.2022	551	283	101	1.32 3.52 4.40	3.08	12.70 12.07 14.61	13.13	8.93 7.40 7.15	7.83
AL2 – 3	11.01.2022	486	261	89	6.59 5.28 5.71	5.86	19.69 18.42 22.23	20.11	10.21 9.96 8.68	9.62
AL2 – 4	12.01.2022	557	300	108	5.28 5.71 3.96	4.98	13.97 14.61 19.69	16.09	6.13 10.21 8.93	8.42
AL2 – 5	19.01.2022	300	185	89	3.96 1.76 2.64	2.78	19.69 22.87 20.96	21.17	7.15 9.19 8.68	8.34
AL2 – 6	21.01.2022	362	249	92	6.59 4.40 3.96	4.98	18.42 10.16 17.15	15.24	6.64 9.19 10.47	8.76
AL2 – 7	24.01.2022	392	200	84	1.32 1.76 2.20	1.76	19.69 15.24 20.96	18.63	10.21 11.49 10.47	10.72
AL2 – 8	28.01.2022	474	253	100	2.64 2.20 3.96	2.93	13.34 20.33 12.07	15.24	6.89 7.66 10.21	8.25
Monthly Average		480	437	232	93		3.79		16.78	8.97
Standard Deviation		96	93	59	10		1.39		2.86	0.98

NS: Not Specified

Table 2B : Results of Air Pollutant Concentration at Oil Jetty					
Parameter	**Date**	**C_6H_6 [µg/m³]**	**HC* ppm**	**CO [mg/m³]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m³**	**NS**	**4.0 mg/m³**	**NS**
AL2 -1	04.01.2022	1.17	BQL	1.8	451
AL2 -2	07.01.2022	1.23	BQL	1.7	1020
AL2 -3	11.01.2022	1.08	BQL	1.8	552
AL2 -4	12.01.2022	1.26	BQL	2	648
AL2 – 5	19.01.2022	1.06	BQL	1.9	550
AL2 – 6	21.01.2022	1.26	BQL	1.76	530
AL2 -7	24.01.2022	1.18	BQL	1.89	677
AL2 – 8	28.01.2022	1.26	BQL	1.75	661
Monthly Average		**1.19**	**-**	**1.83**	**636**
Standard Deviation		**0.08**	**-**	**0.10**	**173**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)
NS- Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Oil Jetty area was mainly by motor vehicle emission produced from various types of vehicles Oil Jetty Area. The mean TSPM values at Oil Jetty were 480 µg/m³ .The mean PM_{10} values were 437 µg/m³, which is above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean = 232 µg/m³).The average values of SO_2, NO_x and NH_3 were within the permissible limit, The mean concentration of SO_2, NO_x and NH3 were 3.79 µg/m³, 16.78 µg/m³ and 8.97 µg/m³ respectively.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Oil Jetty. The mean Benzene concentration was 1.19 µg/m³ .Well below the permissible limit of 5.0 µg/m³. , HC's were below the detectable limit and Carbon Monoxide concentration was 1.83 mg/m³, well below the permissible limit of 4.0 mg/m³.

Location 3: Kandla Colony – Estate Office (AL-3)

Table 3 : Results of Air Pollutant Concentration at Estate Office

Parameters	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit		NS	100 µg/m3	60 µg/m3	-	80 µg/m3	-	80 µg/m3	-	400 µg/m3
AL3 – 1	04.01.2022	259	141	85	1.76 3.08 3.96	2.93	22.23 20.96 17.78	20.33	8.93 10.72 10.98	10.21
AL3 – 2	07.01.2022	457	230	100	3.52 2.64 1.76	2.64	13.34 13.97 16.51	14.61	10.21 10.72 10.98	10.64
AL3 – 3	11.01.2022	413	180	98	4.84 4.40 3.08	4.10	13.34 18.42 22.23	18.00	8.93 8.68 4.85	7.49
AL3 – 4	12.01.2022	552	298	104	3.08 4.40 4.84	4.10	13.34 12.07 10.16	11.86	8.93 9.70 7.40	8.68
AL3 – 5	19.01.2022	440	220	99	4.40 4.84 5.28	4.84	22.23 17.78 14.61	18.21	10.47 8.17 7.40	8.68
AL3 – 6	21.01.2022	446	260	105	3.96 4.84 5.28	4.69	18.42 15.24 20.96	18.21	10.21 7.91 7.40	8.51
AL3 – 7	24.01.2022	395	193	96	3.52 4.40 4.84	4.25	12.70 13.34 19.05	15.03	10.47 11.49 9.96	10.64
AL3 – 8	28.01.2022	371	211	108	3.08 4.84 2.20	3.37	14.61 19.05 19.69	17.78	10.21 8.93 7.40	8.85
Monthly Average		417	217	99		3.86		16.75		9.21
Standard Deviation		84	48	7		0.80		2.70		1.15

NS: Not Specified

Table 3B : Results of Air Pollutant Concentration at Kandla Port Colony					
Parameter	**Date**	**C_6H_6 [µg/m³]**	**HC***	**CO [mg/m³]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m³**	**NS**	**4.0 mg/m³**	**NS**
AL3 -1	04.01.2022	1.13	BQL	1.6	487
AL3 -2	07.01.2022	1.05	BQL	1.5	1560
AL3 -3	11.01.2022	1.01	BQL	1.7	683
AL3 -4	12.01.2022	1.23	BQL	1.89	576
AL3 – 5	19.01.2022	1.07	BQL	1.9	614
AL3 – 6	21.01.2022	1.019	BQL	2	540
AL3 – 7	24.01.2022	1.127	BQL	1.89	670
AL3 – 8	28.01.2022	1	BQL	2.03	621
Monthly Average		**1.08**	**-**	**1.81**	**719**
Standard Deviation		**0.08**	**-**	**0.19**	**346**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)
NS- Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Kandla Port Colony was attributed by vehicle emission produced from trucks and heavy duty vehicles that pass through the road outside Kandla Port Colony. The mean TSPM values at Oil Jetty were 417µg/m³, The mean PM_{10} values were 217 µg/m³, which is above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean = 99.0 µg/m³). The average values of SO_2, NO_x and NH3 were 3.86µg/m³, 16.75 µg/m³ and 9.21µg/m³ respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Kandla Port Colony. The mean Benzene concentration was 1.08 µg/m³, well below the permissible limit of 5.0 µg/m³. HC's were below the detectable limit and Carbon Monoxide concentration was 1.81 mg/m³, well below the permissible limit of 4.0 mg/m³.

Location 4: Gopalpuri Hospital (AL-4)

Table 4 : Results of Air Pollutant Concentration at Gopalpuri Hospital

Parameter	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit		NS	100 µg/m3	60 µg/m3	-	80 µg/m3	-	80 µg/m3	-	400 µg/m3
AL4 -1	04.01.2022	154	87	55	2.20 1.76 3.08	2.34	11.43 12.07 13.34	12.91	9.19 7.91 7.40	8.17
AL4 -2	07.01.2022	319	182	90	2.64 2.20 3.08	2.64	9.53 11.43 10.16	12.07	10.21 8.93 8.42	9.19
AL4 -3	11.01.2022	333	197	89	2.20 3.08 1.32	2.20	12.07 8.26 9.53	9.53	5.36 6.64 7.91	6.64
AL4 -4	12.01.2022	315	197	88	3.52 2.64 1.76	2.64	13.34 12.07 8.26	11.01	7.66 6.64 5.36	6.55
AL4 – 5	19.01.2022	220	124	80	2.64 3.52 2.20	2.78	14.61 12.70 15.88	14.61	7.91 7.40 6.13	7.15
AL4 – 6	21.01.2022	217	153	62	3.08 2.64 2.20	2.64	12.07 9.53 13.34	13.97	7.40 7.66 10.47	8.51
AL4 – 7	24.01.2022	182	97	79	3.96 3.08 2.20	3.08	19.69 17.78 16.51	17.36	7.91 8.68 6.64	7.74
AL4 – 8	28.01.2022	267	165	95	2.20 3.52 3.96	3.22	13.34 15.24 12.07	13.34	7.40 8.68 7.91	8.00
Monthly Average		251	142	87.0		2.69		12.68		7.74
Standard Deviation		54	48	2		0.34		2.62		0.92

NS: Not Specified

Table 4 : Results of Air Pollutant Concentration at Gopalpuri Hospital					
Parameter	**Date**	**C_6H_6 [µg/m³]**	**HC***	**CO [mg/m³]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m³**	**NS**	**4.0 mg/m³**	**NS**
AL4 -1	04.01.2022	1.16	BQL	1.72	588
AL4 -2	07.01.2022	1.14	BQL	1.63	998
AL4 -3	11.01.2022	1.28	BQL	1.8	640
AL4 -4	12.01.2022	1.12	BQL	1.81	581
AL4 – 5	19.01.2022	1.13	BQL	1.7	552
AL4 – 6	21.01.2022	1.04	BQL	1.66	604
AL4 – 7	24.01.2022	1.27	BQL	1.67	706
AL4 – 8	28.01.2022	1.05	BQL	1.58	632
Monthly Average		**1.15**	**-**	**1.70**	**663**
Standard Deviation		**0.09**	**-**	**0.08**	**143**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)
NS-Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Gopalpuri Hospital was attributed by vehicle emission produced from light motor vehicles of the colony residents. The mean TSPM values at Oil Jetty were 251µg/m³, The mean PM_{10} values were 142 µg/m³, which is above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean= 87.0 µg/m³). The average values of SO_2, NO_x and NH_3 were 2.69µg/m³, 12.68 µg/m³ and 7.74 µg/m³ respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Gopalpuri Hospital. The mean Benzene concentration was 1.16 µg/m³, well below the permissible limit of 5.0 µg/m³. HC's were below the detectable limit and Carbon Monoxide concentration was 1.91 mg/m³, well below the permissible limit of 4.0 mg/m³.

Location 5: Coal Storage Area (AL-5)

Table 5 : Results of Air Pollutant Concentration at Coal Storage Area										
Parameters	**Date**	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period	**-**	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit	**-**	**NS**	**100 µg/m3**	**60 µg/m3**	**-**	**80 µg/m3**	**-**	**80 µg/m3**	**-**	**400 µg/m3**
AL5 – 1	04.01.2022	456	297	124	8.15 8.58 9.00	18.84	18.20 18.90 19.60	18.90	25.28 25.42 25.55	25.42
AL5 – 2	07.01.2022	424	225	108	3.96 4.40 3.08	3.81	19.69 22.23 17.78	19.90	11.49 10.21 12.76	11.49
AL5 – 3	11.01.2022	566	280	112	3.96 3.52 3.08	3.52	19.05 19.69 21.60	20.11	5.87 6.13 10.21	7.40
AL5 – 4	12.01.2022	599	256	109	2.20 3.96 3.52	3.22	16.51 19.05 20.96	18.84	9.96 10.21 10.98	10.38
AL5 – 5	19.01.2022	433	251	108	5.28 5.71 2.64	4.54	12.07 12.70 19.05	14.61	10.21 10.47 10.98	10.55
AL5 – 6	21.01.2022	502	277	123	3.52 3.08 2.20	2.93	13.34 15.88 19.05	16.09	10.72 10.98 12.76	11.49
AL5 – 7	24.01.2022	403	236	103	3.52 4.84 4.40	4.25	16.51 19.05 13.34	16.30	9.96 9.19 7.91	9.02
AL5 – 8	28.01.2022	487	293	104	3.08 3.96 4.40	3.81	16.51 12.07 11.43	13.34	10.21 11.49 11.74	11.15
Monthly Average		484	264	111		5.62		17.26		12.11
Standard Deviation		70	26	8		5.37		2.54		5.55

NS: Not Specified

Table 6 : Results of Air Pollutant Concentration at Coal Storage Area					
Parameter	**Date**	**C_6H_6 [µg/m³]**	**HC***	**CO [mg/m³]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m³**	**NS**	**4.0 mg/m³**	**NS**
AL5 – 1	04.01.2022	1.21	BQL	1.8	360
AL5 – 2	07.01.2022	1.21	BQL	1.6	1024
AL5 – 3	11.01.2022	1.23	BQL	1.9	586
AL5 – 4	12.01.2022	1.1	BQL	1.80	572
AL5 – 5	19.01.2022	1.2	BQL	1.9	556
AL5 – 6	21.01.2022	1.19	BQL	1.82	499
AL5 – 7	24.01.2022	1.2	BQL	1.77	739
AL5 – 8	28.01.2022	1.22	BQL	1.4	618
Monthly Average		**1.19**	**-**	**1.75**	**619**
Standard Deviation		**0.04**	**-**	**0.17**	**195**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)
NS-Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Coal Storage Area was comparatively highest among all the locations of Air Quality monitoring in Kandla Port. High values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_X at this location was due to lifting of coal with grab and other coal handling processes near Berth no. 6 & 7. Moreover, the traffic was also heavy around this place for transport of coal thus emissions produced from heavy vehicles. The mean TSPM values at Coal storage were 484 µg/m³. The mean PM_{10} values were 264 µg/m³, which is well above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean = 111 µg/m³). The average values of SO_2, NO_x and NH_3 were 5.62 µg/m³, 17.26 µg/m³ and 12.11 µg/m³ respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Coal Storage Area. The mean Benzene concentration was 1.19 µg/m³, well below the permissible limit of 5.0 µg/m³. HC's were below the detectable limit and Carbon Monoxide concentration was 1.75 mg/m³, well below the permissible limit of 4.0 mg/m³.

Location 6: Tuna Port (AL-6)

Table 6 : Results of Air Pollutant Concentration at Tuna Port

Parameters	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit		NS	100 µg/m3	60 µg/m3	-	80 µg/m3	-	80 µg/m3	-	400 µg/m3
AL6 -1	04.01.2022	283	132	57	2.64	2.93	15.88	15.88	10.21	9.62
					3.52		15.24		10.47	
					2.64		16.51		8.17	
AL6 – 2	07.01.2022	335	174	67	3.96	3.81	19.69	19.90	11.49	11.49
					4.40		22.23		10.21	
					3.08		17.78		12.76	
AL6 – 3	11.01.2022	338	161	72	3.96	3.52	19.05	20.11	5.87	7.40
					3.52		19.69		6.13	
					3.08		21.60		10.21	
AL6 – 4	12.01.2022	454	248	105	2.20	3.22	16.51	18.84	9.96	10.38
					3.96		19.05		10.21	
					3.52		20.96		10.98	
AL6 – 5	19.01.2022	362	204	98	5.28	4.54	12.07	14.61	10.21	10.55
					5.71		12.70		10.47	
					2.64		19.05		10.98	
AL6 – 6	21.01.2022	304	166	80	3.52	2.93	13.34	16.09	10.72	11.49
					3.08		15.88		10.98	
					2.20		19.05		12.76	
AL6 – 7	24.01.2022	310	150	62	3.52	4.25	16.51	16.30	9.96	9.02
					4.84		19.05		9.19	
					4.40		13.34		7.91	
AL6 – 8	28.01.2022	400	237	92	3.08	3.81	16.51	13.34	10.21	11.15
					3.96		12.07		11.49	
					4.40		11.43		11.74	
Monthly Average		348	184	79		3.63		16.88		10.14
Standard Deviation		70	32	9		0.59		2.48		1.41

NS: Not Specified

Table 6B : Results of Air Pollutant Concentration at Tuna Port					
Parameter	**Date**	**C_6H_6 [µg/m³]**	**HC***	**CO [mg/m³]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m³**	**NS**	**4.0 mg/m³**	**NS**
AL6 -1	04.01.2022	1.1	BQL	1.72	590
AL6 -1	04.01.2022	1.1	BQL	1.72	590
AL6 -2	07.01.2022	1.03	BQL	1.8	1063
AL6 -3	11.01.2022	BQL	BQL	1.9	569
AL6 -4	12.01.2022	1.17	BQL	1.9	574
AL6 -5	19.01.2022	1.08	BQL	1.81	542
AL6 -6	21.01.2022	1.13	BQL	1.9	669
AL6 -7	24.01.2022	1.16	BQL	1.69	759
AL6 -8	28.01.2022	1.11	BQL	1.53	670
Monthly Average		**1.11**	**-**	**1.78**	**680**
Standard Deviation		**0.05**	**-**	**0.13**	**171**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)
NS- Not Specified

The mean TSPM values at Tuna Port were 348µg/m^3, The mean PM_{10} values were 184 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean = 79 µg/m^3). The average values of SO_2, NO_x and NH_3 were 3.63 µg/m^3, 16.88 µg/m^3 and 10.14 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Tuna Port. The mean Benzene concentration was 1.11 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.78 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 7: Signal Building (Vadinar) (AL-7)

Table 7 : Results of Air Pollutant Concentration at Signal Building

Parameters	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit		NS	100 µg/m3	60 µg/m3	-	80 µg/m3	-	80 µg/m3	-	400 µg/m3
AL7 -1	04.01.2022	130	82	47	5.28 2.20 3.96	3.81	19.69 20.96 15.88	18.84	7.91 8.42 6.89	7.74
AL7 -2	07.01.2022	202	111	84	1.76 2.64 3.08	2.49	19.69 20.96 16.51	19.05	9.19 10.21 7.91	9.10
AL7 -3	11.01.2022	174	91	73	3.96 1.76 2.20	2.64	13.34 20.96 10.16	14.82	5.11 5.87 7.66	6.21
AL7 -4	12.01.2022	154	84	65	3.52 3.08 2.64	3.08	14.61 12.07 10.16	12.28	7.66 10.21 4.08	7.32
AL7 -5	19.01.2022	122	72	47	4.40 2.64 1.76	2.93	12.07 10.16 10.80	11.01	5.36 7.91 8.42	7.23
AL7 -6	21.01.2022	210	120	85	5.28 5.71 6.59	5.86	16.51 15.24 19.69	17.15	8.42 8.17 7.40	8.00
AL7 -7	24.01.2022	151	81	66	3.52 3.08 2.64	3.08	12.07 17.15 17.78	15.67	9.19 9.96 7.15	8.76
AL7 -8	28.01.2022	173	100	61	1.76 2.64 3.08	2.49	12.07 20.96 11.43	14.82	5.62 4.60 5.87	5.36
Monthly Average		164	93	66		3		15		7
Standard Deviation		31	16	15		1		3		1

NS: Not Specified

Table 7B : Results of Air Pollutant Concentration at Signal Building					
Parameter	**Date**	**C_6H_6 [µg/m³]**	**HC***	**CO [mg/m³]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m³**	**NS**	**4.0 mg/m³**	**NS**
AL7 -1	04.01.2022	1.46	BQL	1.66	403
AL7 – 2	07.01.2022	1.12	BQL	1.72	224
AL7 – 3	11.01.2022	1.26	BQL	1.57	369
AL7 – 4	12.01.2022	1.13	BQL	2.12	551
AL7 – 5	19.01.2022	1.12	BQL	2.02	607
AL7 – 6	21.01.2022	1.03	BQL	1.66	314
AL7 – 7	24.01.2022	1.03	BQL	1.77	326
AL7 – 8	28.01.2022	1.18	BQL	1.82	365
Monthly Average		**1.17**	**-**	**1.79**	**395**
Standard Deviation		**0.14**	**-**	**0.19**	**126**

*NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)
NS Not Specified

The mean TSPM values at Vadinar Port were 164 µg/m³. The mean PM_{10} values were 93 µg/m³, which is below the permissible limit. $PM_{2.5}$ values were also within the permissible limit (mean = 66 µg/m³). The average values of SO_2, NO_x and NH_3 were 3.0 µg/m³, 15.0 µg/m³ and 7.0 µg/m³ respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Vadinar Port. The mean Benzene concentration was 1.17 µg/m³, well below the permissible limit of 5.0 µg/m³. HC's were below the detectable limit and Carbon Monoxide concentration was 1.79 mg/m³, well below the permissible limit of 4.0 mg/m³.

Location 8: Admin Building (Vadinar) (AL-8)

Table 8 : Results of Air Pollutant Concentration at Admin Building

Parameters	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit		NS	100 µg/m3	60 µg/m3	-	80 µg/m3	-	80 µg/m3	-	400 µg/m3
AL8 -1	04.01.2022	163	100	58	3.52 3.96 4.40	3.96	11.43 13.34 14.61	13.13	7.91 6.64 7.40	7.32
AL8 -2	07.01.2022	172	104	61	5.28 5.71 6.59	5.86	22.87 17.78 12.07	17.57	5.87 7.91 8.93	7.57
AL8 -3	11.01.2022	192	108	78	2.64 2.20 1.32	2.05	11.43 22.87 17.15	17.15	6.38 10.47 8.42	8.42
AL8 -4	12.01.2022	153	92	54	3.52 4.84 5.28	4.54	19.69 14.61 11.43	15.24	7.91 4.08 5.36	5.79
AL8 -5	19.01.2022	144	95	46	5.71 2.20 3.08	3.66	13.34 19.69 13.97	15.67	7.91 9.19 7.40	8.17
AL8 -6	21.01.2022	162	97	55	3.08 2.64 4.84	3.52	13.34 12.70 19.05	15.03	5.36 4.85 5.87	5.36
AL8 -5	24.01.2022	186	101	76	1.76 2.64 6.15	3.52	14.61 16.51 20.96	17.36	10.21 10.47 7.66	9.45
AL8-6	28.01.2022	138	83	47	3.52 2.20 1.32	2.34	19.05 19.69 18.42	19.05	7.40 6.38 4.85	6.21
Monthly Average		164	97	60		4		16		7
Standard Deviation		19	8	12		1		2		1

NS: Not Specified

Table 8B : Results of Air Pollutant Concentration at Admin Building					
Parameter	**Date**	**C_6H_6 [µg/m³]**	**HC***	**CO [mg/m³]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m³**	**NS**	**4.0 mg/m³**	**NS**
AL8 -1	04.01.2022	1.63	BQL	1.68	452
AL8-2	07.01.2022	1.17	BQL	1.71	337
AL8 -3	11.01.2022	1.23	BQL	1.6	391
AL8-4	12.01.2022	1.01	BQL	1.94	542
AL8 -5	19.01.2022	1.23	BQL	2	530
AL8-6	21.01.2022	1.02	BQL	1.59	305
AL8-7	24.01.2022	1.14	BQL	1.91	344
AL8-8	28.01.2022	1.18	BQL	1.86	356
Monthly Average		**1.20**	**-**	**1.79**	**407**
Standard Deviation		**0.19**	**-**	**0.16**	**91**

* NMHC- Non- Methane Hydrocarbon
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)
NS-Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Admin Building Vadinar was comparatively low among all the locations of Air Quality monitoring in Kandla Port and Vadinar Port. The mean TSPM values at Vadinar Port were 164 µg/m³. The mean PM_{10} values were 97 µg/m³, which is above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean = 60.0 µg/m³). The average values of SO_2, NO_x and NH_3 were 4.0µg/m³, 16.0µg/m³ and 7.0µg/m³ respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Admin Building, Vadinar Port. The mean Benzene concentration was 1.20 µg/m³, well below the permissible limit of 5.0 µg/m³. HC's were below the detectable limit and Carbon Monoxide concentration was 1.79 mg/m³, well below the permissible limit of 4.0 mg/m³.

1.4 Observations and Conclusion

During the monitoring period, the overall Ambient Air Quality of the port area was found to be well within the desired levels for various gaseous pollutants. However, Particulate matter as PM_{10} and $PM_{2.5}$ was found to exceed the limits at locations like Near Coal storage area, Marine Bhavan, Estate Office, Tuna Port and Oil Jetty area.

2. Drinking Water Quality Monitoring

Drinking Water Quality Monitoring was carried out at twenty stations at Kandla, Vadinar & Township Area of Deendayal Port.

2.1 Drinking Water Monitoring Methodology

Drinking water samples were collected from 20 locations as prescribed in the tender document. Samples for physico-chemical analysis were collected in 1 liter carboys and samples for microbiological parameters were collected in sterilized bottles. These samples were then analyzed in laboratory for various drinking water parameters at Kandla Lab/Surat.

The Sampling and Analysis was done as per standard methods - IS 10500:2012. The water samples were analyzed for various parameters, viz. Color , Odor, Turbidity , Conductivity , pH , Chlorides , TDS, Total Hardness, Iron , Sulphate , Salinity , DO, BOD, Na, K, Ca, Mg, F, NO_3, NO_2, Mn, Cr-6, Cu, Cd, As, Hg, Pb, Zn, Bacterial Count (cfu) .

2.2 Results

The Drinking Water Quality monitoring data for 20 stations are given in below from table No. 9 to Table No. 15

Table 9: Drinking Water Quality Monitoring Parameters for Nirman Building 1, P & C building & Main Gate (North) at Kandla

Sr. No.	Parameter	Unit	Nirman Building 1	P & C building	Main Gate North	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.3	7.4	7.5	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1050	1070	1020	500	2000
3	Turbidity	NTU	0	1	1	1.0	5.0
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	1920	1956	1895	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	481.07	466.04	516.15	250.0	1000.0
9	Ca as Ca	mg/l	60.12	56.11	52.10	75.0	200.0
10	Mg as Mg	mg/l	75.33	70.47	77.76	30.0	100.0
11	Total Hardness	mg/l	460	430	450	200.0	600.0
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.42	0.49	0.35	1.0	1.5
14	Sulphate as SO4	mg/l	265.2	273.6	277.2	200.0	400
15	Nitrite as NO2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO3	mg/l	6.90	8.52	8.87	45.0	No Relaxation
17	Salinity	%	0.87	0.84	0.93	NS*	NS*
18	Sodium as Na	mg/l	302	294	302	NS*	NS*
19	Potassium as K	mg/l	4.40	4.03	4.68	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

BQL- Below Quantification Limit, (BODZinc-0.02-2.0 mg/l, Fe-0.009 mg/l, Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 10: Drinking Water Quality Monitoring Parameters for Canteen, West Gate – I &Wharf Area at Kandla

Sr. No.	Parameter	Unit	Canteen	West Gate – I	Wharf Area	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.1	7.4	7.3	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1120	950	1020	500	2000
3	Turbidity	NTU	0	1	1	1.0	5.0
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	2120	1723	1562	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	526.17	491.09	486.08	250.0	1000.0
9	Ca as Ca	mg/l	48.10	60.12	56.11	75.0	200.0
10	Mg as Mg	mg/l	72.90	63.18	72.90	30.0	100.0
11	Total Hardness	mg/l	420	410	440	200.0	600.0
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.28	0.34	0.56	1.0	1.5
14	Sulphate as SO4	mg/l	222.0	235.2	252.0	200.0	400
15	Nitrite as NO2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO3	mg/l	9.50	10.28	8.73	45.0	No Relaxation
17	Salinity	%	0.95	0.89	0.88	NS*	NS*
18	Sodium as Na	mg/l	281	293	308	NS*	NS*
19	Potassium as K	mg/l	5.15	5.04	5.49	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 11: Drinking Water Quality Monitoring Parameters for Sewa sadan – 3, Workshop I &Custom Building at Kandla

Sr. No.	Parameter	Unit	Sewa Sadan – 3	Workshop	Custom Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.4	7.2	7.4	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1010	1120	1910	500	2000
3	Turbidity	NTU	0	0	1	1.0	5.0
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	1498	2050	2630	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride	mg/l	541.20	556.24	521.16	250.0	1000.0
9	Ca as Ca	mg/l	64.13	72.14	76.15	75.0	200.0
10	Mg as Mg	mg/l	70.47	70.47	70.47	30.0	100.0
11	Total Hardness	mg/l	450	470	480	200.0	600.0
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides	mg/l	0.67	0.78	0.52	1.0	1.5
14	Sulphate	mg/l	255.6	262.8	211.2	200.0	400
15	Nitrite	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate	mg/l	12.32	11.40	12.74	45.0	No Relaxation
17	Salinity	%	0.98	1.00	0.94	NS*	NS*
18	Sodium as Na	mg/l	297	319	318	NS*	NS*
19	Potassium as K	mg/l	4.28	2.53	5.78	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	0.003
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	0.001
26	Lead	mg/l	BQL	BQL	BQL	0.01	0.01
27	Zinc	mg/l	BQL	BQL	BQL	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 12: Drinking Water Quality Monitoring Parameters for Port Colony Kandla, Hospital Kandla & A.O. Building at Gandhidham

Sr. No.	Parameter	Unit	Port Colony Kandla	Hospital Kandla	A.O. Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.6	7.3	7.4	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1020	940	950	500	2000
3	Turbidity	NTU	0	1	1	1.0	5.0
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	1920	1730	1689	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride	mg/l	511.14	496.10	526.17	250.0	1000.0
9	Ca as Ca	mg/l	64.13	48.10	52.10	75.0	200.0
10	Mg as Mg	mg/l	70.47	75.33	68.04	30.0	100.0
11	Total Hardness	mg/l	450	430	410	200.0	600.0
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides	mg/l	0.57	0.72	0.81	1.0	1.5
14	Sulphate	mg/l	219.6	231.6	283.2	200.0	400
15	Nitrite	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate	mg/l	12.60	13.52	10.28	45.0	No Relaxation
17	Salinity	%	0.92	0.90	0.95	NS*	NS*
18	Sodium as Na	mg/l	293	301	290	NS*	NS*
19	Potassium as K	mg/l	4.30	5.13	4.68	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	0.003
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	0.001
26	Lead	mg/l	BQL	BQL	BQL	0.01	0.01
27	Zinc	mg/l	BQL	BQL	BQL	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 13: Drinking Water Quality Monitoring Parameters for School Gopalpuri, Guest House &E - Type Quarter at Gopalpuri, Gandhidham

Sr. No.	Parameter	Unit	School Gopalpuri	Guest House	E - Type Quarter	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.6	7.5	7.2	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1000	1390	1410	500	2000
3	Turbidity	NTU	0	0	0	1.0	5.0
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	1860	2550	2710	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride	mg/l	536.19	491.09	561.25	250.0	1000.0
9	Ca as Ca	mg/l	56.11	60.12	64.13	75.0	200.0
10	Mg as Mg	mg/l	68.04	58.32	65.61	30.0	100.0
11	Total Hardness	mg/l	420	390	430	200.0	600.0
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides	mg/l	0.75	0.65	0.63	1.0	1.5
14	Sulphate	mg/l	268.8	289.2	219.6	200.0	400
15	Nitrite	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate	mg/l	10.63	12.04	11.62	45.0	No Relaxation
17	Salinity	%	0.97	0.89	1.01	NS*	NS*
18	Sodium as Na	mg/l	294	284	197	NS*	NS*
19	Potassium as K	mg/l	4.98	4.76	1.49	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	0.003
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	0.001
26	Lead	mg/l	BQL	BQL	BQL	0.01	0.01
27	Zinc	mg/l	BQL	BQL	BQL	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 14: Drinking Water Quality Monitoring Parameters for F - Type Quarter, Hospital Gopalpuri & Tuna Port

Sr. No.	Parameter	Unit	F - Type Quarter	Hospital Gopalpuri	Tuna Port	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.7	7.5	7.2	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1100	1200	760	500	2000
3	Turbidity	NTU	0	1	0	1.0	5.0
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Unit	Colorless	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	2130	2270	1350	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride	mg/l	516.15	571.27	546.2142 6	250.0	1000.0
9	Ca as Ca	mg/l	68.14	56.11	52.10	75.0	200.0
10	Mg as Mg	mg/l	58.32	72.90	70.47	30.0	100.0
11	Total Hardness	mg/l	410	440	420	200.0	600.0
12	Iron as Fe+3	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides	mg/l	0.56	0.79	0.84	1.0	1.5
14	Sulphate	mg/l	230.4	211.2	259.2	200.0	400
15	Nitrite	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate	mg/l	10.21	9.22	11.33	45.0	No Relaxation
17	Salinity	%	0.93	1.03	0.99	NS*	NS*
18	Sodium as Na	mg/l	294	302	292	NS*	NS*
19	Potassium as K	mg/l	4.28	4.79	4.82	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	0.003
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	0.001
26	Lead	mg/l	BQL	BQL	BQL	0.01	0.01
27	Zinc	mg/l	BQL	BQL	BQL	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 15: Drinking Water Quality Monitoring Parameters for Vadinar Jetty & Port Colony at Vadinar

Sr. No.	Parameter	Unit	Vadinar Jetty	Port Colony Vadinar	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.2	7.4	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	940	980	500	2000
3	Turbidity	NTU	0.00	1.00	1.0	5.0
4	Odor	-	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	1730	1690	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	NS*	NS*
8	Chloride	mg/l	471.05	481.07	250.0	1000.0
9	Ca as Ca	mg/l	64.13	60.12	75.0	200.0
10	Mg as Mg	mg/l	72.90	72.90	30.0	100.0
11	Total Hardness	mg/l	460	450	200.0	600.0
12	Iron as Fe+3	mg/l	BQL	BQL	0.3	No Relaxation
13	Fluorides	mg/l	0.86	0.92	1.0	1.5
14	Sulphate	mg/l	26.76	25.32	200.0	400
15	Nitrite	mg/l	BQL	BQL	NS*	NS*
16	Nitrate	mg/l	9.22	9.99	45.0	No Relaxation
17	Salinity	%	0.85	0.87	NS*	NS*
18	Sodium as Na	mg/l	54.6	42.2	NS*	NS*
19	Potassium as K	mg/l	3.2	2.8	NS*	NS*
20	Manganese	mg/l	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	0.003	0.003
24	Arsenic	mg/l	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	0.001	0.001
26	Lead	mg/l	BQL	BQL	0.01	0.01
27	Zinc	mg/l	BQL	BQL	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

2.3 Results & Discussion

The colour of all drinking water samples was <5 Hazen unit and odour of the samples was also agreeable. All parameters are found to be within the specified limit of the Drinking water Standard.

pH

The limit of pH value for drinking water is specified as 6.5 to 8.5. pH value in the studied area varied from 7.3 to 7.8 pH unit. All the sampling points showed pH values within the prescribed limit by Indian Standards.

Total Dissolved Solids (TDS)

TDS values in the studied area varied between 1020 -1850 mg/l. None of the sampling points showed higher TDS values than the prescribed limit by Indian standards.

Conductivity

Electrical Conductivity is the ability of a solution to transfer (conduct) electric current. Conductivity is used to measure the concentration of dissolved solids which have been ionized in a polar solution such as water. The conductivity in the samples collected during the month of January ranged from 2000-3670 µs/cm. Electrical conductivity standards do not appear in BIS standards for drinking water.

BOD

BOD value in the studied area was found Below Quantification Limit (2.0 mg/l). Indian standards does not show any standard values for BOD in drinking water.

Chlorides

Excessive chloride concentration increase rates of corrosion of metals in the distribution system. This can lead to increased concentration of metals in the supply. Chloride value in the studied area varied between 320.7-821.8 mg/l and is found to be within the Permissible limit of the Drinking Water Standard.

Calcium

Calcium value in the studied area varied between 40.08 - 80.1 mg/l and is found to be within the Permissible limit of the Drinking Water Standard. If calcium is present beyond the maximum acceptable limit, it causes incrustation of pipes.

Magnesium

Magnesium value in the studied area varied between 60.75-99.63 mg/l. All the locations had Magnesium within the prescribed limits of 30-100 mg/L.

Total Hardness

Hardness value in the studied area varied between 260-410 mg/l and is found to be within the Permissible limit of the Drinking Water Standard. The prescribed limit by Indian Standards is 200-600 mg/L.

Iron

Iron value in the studied area was found Below Quantification Limit (0.009 mg/l) and hence well below the permissible limit as per Indian Standards is 0.3 mg/L. The excess amount of iron causes slight toxicity; gives stringent taste to water.

Fluoride

Fluoride value in the studied area varied between 0.1 – 0.8 mg/l and hence well below the permissible limit as per Indian Standards is 1.0-1.5 mg/L. Moderate amounts lead to dental effects, but long-term ingestion of large amounts can lead to potentially severe skeletal problems.

Sulphates

Sulphate value in the studied area varied between 164.4 – 336 mg/l. All the sampling points showed sulphate values within the prescribed limits by Indian Standards (200-400 mg/L). Sulphate content in drinking water exceeding the 400 mg/L imparts bitter taste.

Nitrites (NO_2) and Nitrates (NO_3)

Nitrite values in all the water samples were found Below Quantification Limit (0.1 mg/l). There are no specified standard values for Nitrites in Drinking water. The minimum Nitrate value in drinking water of KPT was 0.0038 mg/l which is well within the permissible limit of the Drinking water Standard.

Salinity

Salinity in drinking water in the present samples collected ranged from 0.5 to 1.4%. There are no prescribed Indian standards for salinity in Drinking water**.**

Sodium and Potassium Salts

Sodium values in the samples collected ranged from 162 - 301 mg/l and Potassium salts ranged from 2.18 to 4.23 mg/l. There are no prescribed limits of Sodium and Potassium in Indian standards for Drinking water**.**

Heavy Metals in Drinking Water

In the present study period drinking water samples were analyzed for Mn, Cr, Cu, Cd, As, Hg, Pb and Zn. All these heavy metals were well Below the Quantification limits prescribed by the Indian Standards.

Bacteriological Study

Analysis of the bacteriological parameter at all location shows that Bacteria is not present and hence Bacterial count is in line with the permissible limit of drinking water. This shows that all the drinking water samples were safe from any bacteriological contamination.

2.4 Conclusions

These results are compared with acceptable limits as prescribed in IS 10500:2012 – Drinking Water Specification. It is seen from the analysis data that during the study period the water was safe for human consumption at all drinking water monitoring stations.

3. Noise Level Monitoring

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. Noise Monitoring was done at 13 stations at Kandla, Vadinar and Township area.

3.1 Method of Monitoring

Sampling was done at all stations for 24 hour period. Data was recorded using automated sound level meter. The intensity of sound was measured in sound pressure level (SPL) and common unit of measurement is decibel (dB).

3.2 Results

Table 16: Noise Monitoring data for ten locations of Deendayal Port and three locations of Vadinar Port

Sr. No.	Location	Day Time Average Noise Level (SPL) in dB(A)	Night Time Average Noise Level (SPL) in dB(A)
	Sampling Time	**6:00 am to 10:00 PM**	**10:00PM to 6:00 AM**
1	Marine Bhavan	70.6	67.7
2	Nirman Building 1	57.2	61.6
3	Tuna Port	65.5	55.0
4	Main Gate North	58.2	61.4
5	West Gate I	68.9	64.1
6	Canteen Area	57	60.5
7	Main Road	64.2	61.3
8	ATM Building	69.5	69.7
9	Wharf Area /Jetty Area	71.6	71.6
10	Port & Custom Office	74.3	59.3

Vadinar Port

11	Entrance Gate of Vadinar Port	48.6	48.5
12	Nr. Port Colony, Vadinar	55.1	54.3
13	Nr. Vadinar Jetty	58.0	57.4

3.3 Conclusions

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. The Day Time Average Noise Level (SPL)in all 13 locations at Deendayal Port ranged from 48.6 dB(A) to 74.3 dB(A) and it was within the permissible limits of 75 dB(A) for the industrial area for the daytime. The Night Time Average Noise Level (SPL) in all 13 locations of Deendayal Port ranged from 48.5 dB to 71.6 dB(A) and it was within the permissible limits of 70 dB(A) for the industrial area for the night time.

4. Soil Monitoring

Sampling and analysis of soil samples were undertaken at six locations within the study area (Deendayal Port and Vadinar Port) as a part of EMP. The soil sampling locations are initially decided based on the locations as provided in the tender document of the Deendayal Port.

4.1 Methodology

The soil samples were collected in the month of January 2022. The samples collected from the all locations are homogeneous representative of each location. At random locations were identified at each location and soil was dug from 30 cm below the surface. It was uniformly mixed before homogenizing the soil samples. The samples were filled in polythene bags, labeled in the field with number and site name and sent to laboratory for analysis.

4.2 Results

Table-17: Chemical Characteristics of Soil in the Study Area

Sr. No.	Parameter	Unit	Station Name					
			SL1	SL2	SL3	SL4	SL5	SL6
			Tuna Port	IFFCO Plant	Khori Creek	Nakti Creek	KPT Admin Site	KPT Colony
			Near main gate of Port	10 m away from main gate	Sand from creek at low tide		Vadinar	
1	Texture		Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	pH	-	7.46	8.23	8.92	8.71	7.97	7.58
3	Electrical Conductivity	µs/cm	12,520.0	18,150.0	14,555.0	15,330.0	209.0	341.0
4	Moisture	%	14.27	24.86	16.34	23.84	7.24	3.24
5	Total Organic Carbon	%	0.44	1.11	0.54	1.15	0.48	0.94
6	Alkalinity	mg/kg	40.04	60.06	60.06	100.10	60.06	60.06
7	Total Nitrogen	%	BQL	BQL	BQL	BQL	BQL	BQL
8	Chloride	mg/kg	1,404.0	450.0	494.0	578.0	17.0	25.5
9	Sulphate	mg/kg	1,808.0	2,294.0	7,317.0	1,106.0	20.22	19.5
10	Phosphorus	mg/kg	50.25	15.69	8.49	9.11	5.17	6.45
11	Potassium	mg/kg	154.0	139.0	149.0	107.0	5.9	22.2
12	Sodium	mg/kg	2,201.0	1,248.0	1,094.0	809.0	13.5	24.4
13	Calcium	mg/kg	153.00	139.00	149.00	106.00	941.88	180.36
14	Copper as Cu	mg/kg	20.90	45.10	21.60	64.60	78.9	51.1
15	Lead as Pb	mg/kg	8.80	23.50	9.00	23.80	BQL	7.10
16	Nickel as Ni	mg/kg	41.90	18.10	41.50	39.80	37.9	22.50
17	Zinc as Zn	mg/kg	50.30	191.60	49.8	100.00	46.50	50.00
18	Cadmium as Cd	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (TN: 0.001%, Cd: 1.0mg/kg).

4.3 Discussion

The data shows that value of pH ranges from 7.46 at IFFCO Plant to 8.92 at Khori Creek indicating that all soil samples are neutral to slight basic. Iffco Plant samples showed maximum conductivity of 18150.0 µmhos/cm, while Tuna Port location showed minimum conductivity of 12520.0 µmhos/cm. Conductivity at Vadinar Port was 209.0 and 341.0 µmhos/cm at Admin site and Vadinar Port colony respectively.

Total organic Carbon ranged from 0.44 % to 1.15 at Deendayal Port. At Vadinar Port, organic carbon content ranged from 0.48 % to 0.94 %.

The concentration of Phosphorus and Potassium in the soil samples varies from 8.49 to 50.25 mg/kg and 107 to 154 mg/kg respectively at Deendayal Port. The mean concentration of Phosphorous at Vadinar site was 5.81 mg/kg and mean concentration of Potassium at Vadinar site was 14.04 mg/kg.

These differences in NPK in soil at different locations are due to the dissimilar nature of soil at each of the locations. Samples SL3 & SL4 (Khori Creek & Nakti Creek) are of saline nature as they are coastal soil; where as other locations are inland locations and have different chemical properties.

Heavy Metals in the Soil

Traces of Copper, Lead, Nickel and Zinc were observed in the soil samples collected from all the four locations of Deendayal Port and two locations of Vadinar Port. Cadmium metal was below detection limit in the Soil.

4.4 Conclusion

The soils of Deendayal Port and Vadinar Port appears to be neutral to basic with varying levels of Chloride, Sulphate, NPK and Calcium. As the nature of soil at different locations are different with respect to its proximity to the sea, the samples showed high degree of variations in their chemical properties.

5. Sewage Treatment Plant Monitoring

This involves safe collection of waste water (spent/used water) from wash areas, bathroom, industrial units, etc., waste from toilets of various buildings and its conveyance to the treatment plant and final disposal in conformity with the requirement and guide lines of State Pollution Control Board and other statutory bodies.

5.1 Methodology for STP Monitoring

To monitor the working efficiency of Sewage Treatment Plant (STP), STP Inlet and Outlet Samples were collected once a week. Locations selected are namely Gopalpuri Township, Deendayal Port and Vadinar. Samples were collected in 1 lit. Carboys and were analyzed in laboratory for various parameters.

5.2 Results

Kandla STP

Table 18: Sewage Water Monitoring at Kandla STP (1st Week)

Date of Sampling	02.01.2022

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	7.7	7.5
2	Total Suspended Solids	mg/l	177.8	57.9
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	404.0	132.0
5	BOD @ 27 °C	mg/l	132.0	38.0
6.	Fecal Coliform	MPN Index / 100 ml	-	540.0
Aeration Tank				
7.	MLSS	mg/l	27.0	
8.	MLVSS	%	84.0	

Table 19: Sewage Water Monitoring at Kandla STP (2nd Week)

Date of Sampling	11.01.2022

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	7.68	7.46
2	Total Suspended Solids	mg/l	154.2	81.5
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	404	102.0
5	BOD @ 27 °C	mg/l	130.0	30.0
6.	Fecal Coliform	MPN Index / 100 ml	-	26.0
Aeration Tank				
7.	MLSS	mg/l	439.0	
8.	MLVSS	%	ND	

Table 20: Sewage Water Monitoring at Kandla STP (3rd Week)

Date of Sampling	19.01.2022

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	7.54	7.31
2	Total Suspended Solids	mg/l	162.4	76.5
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	353.5	212.1
5	BOD @ 27 °C	mg/l	60.0	20.0
6.	Fecal Coliform	MPN Index / 100 ml	-	63.0
Aeration Tank				
7.	MLSS	mg/l	374.0	
8.	MLVSS	%	ND	

Table 21: Sewage Water Monitoring at Kandla STP (4th Week)

Date of Sampling	24.01.2022

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	7.6	7.4
2	Total Suspended Solids	mg/l	195.4	99.6
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	232.3	101
5	BOD @ 27 °C	mg/l	77.0	28.0
6.	Fecal Coliform	MPN Index / 100 ml	-	110.0
Aeration Tank				
7.	MLSS	mg/l	238.0	
8	MLVSS	%	ND	

Gopalpuri Colony STP

Table 22: Sewage Water Monitoring at Gopalpuri STP (1st Week)

Date of Sampling	02.01.2022

Sr. No.	Parameters	Unit	Results	
			Gopalpuri STP I/L	Gopalpuri STP O/L
1	pH	pH unit	7.76	7.34
2	Total Suspended Solids	mg/l	212.4	82.8
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	434.0	152.0
5	BOD @ 27 °C	mg/l	138.0	48.0
6.	Fecal Coliform	MPN Index / 100 ml	-	79.0
Aeration Tank				
7.	MLSS	mg/l	37.0	
8	MLVSS	%	87.0	

Table 23: Sewage Water Monitoring at Gopalpuri STP (2nd Week)

Date of Sampling	11.01.2022

Sr. No.	Parameters	Unit	Results	
			Gopalpuri STP I/L	Gopalpuri STP O/L
1	pH	pH unit	7.5	7.3
2	Total Suspended Solids	mg/l	220.4	95.1
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	383.8	102
5	BOD @ 27 °C	mg/l	126.0	32.0
6.	Fecal Coliform	MPN Index / 100 ml	-	21.0
Aeration Tank				
7.	MLSS	mg/l	32.0	
8	MLVSS	%	84.0	

Table 24: Sewage Water Monitoring at Gopalpuri STP (3rd Week)

Date of Sampling	19.01.2022

Sr. No.	Parameters	Unit	Results	
			Gopalpuri STP I/L	Gopalpuri STP O/L
1	pH	pH unit	7.46	7.21
2	Total Suspended Solids	mg/l	184.8	86.1
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	373.7	110
5	BOD @ 27 °C	mg/l	120.0	28.0
6.	Fecal Coliform	MPN Index / 100 ml	-	70.0
Aeration Tank				
7.	MLSS	mg/l	9.0	
8	MLVSS	%	86.0	

Table 25: Sewage Water Monitoring at Gopalpuri STP (4th Week)

Date of Sampling	24.01.2022

Sr. No.	Parameters	Unit	Results	
			Gopalpuri STP I/L	Gopalpuri STP O/L
1	pH	pH unit	7.51	7.36
2	Total Suspended Solids	mg/l	264.2	90.1
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	202	111.1
5	BOD @ 27 °C	mg/l	58.0	30.0
6.	Fecal Coliform	MPN Index / 100 ml	-	220.0
Aeration Tank				
7.	MLSS	mg/l	22.0	
8.	MLVSS	%	ND	

Vadinar STP

Table 26: Sewage Water Monitoring at Vadinar STP (1st Week)

Date of Sampling	02.01.2022

Sr. No.	Parameters	Unit	Results	
			Vadinar STP I/L	Vadinar O/L
1	pH	pH unit	7.4	7.2
2	Total Suspended Solids	mg/l	110.5	61.1
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	353.5	101
5	BOD @ 27 °C	mg/l	110.0	28.0

Table 27: Sewage Water Monitoring at Vadinar STP (2nd Week)

Date of Sampling	11.01.2022

Sr. No.	Parameters	Unit	Results	
			Vadinar STP I/L	Vadinar O/L
1	pH	pH unit	7.46	7.32
2	Total Suspended Solids	mg/l	110	59.3
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	364.0	112.0
5	BOD @ 27 °C	mg/l	120.0	30.0

Table 28: Sewage Water Monitoring at Vadinar STP (3rd Week)

Date of Sampling	19.01.2022

Sr. No.	Parameters	Unit	Results	
			Vadinar STP I/L	Vadinar O/L
1	pH	pH unit	7.7	7.5
2	Total Suspended Solids	mg/l	105	38
3	Residual Chlorine	mg/l		<0.5
4	COD	mg/l	161.6	70.7
5	BOD @ 27 °C	mg/l	52.0	18.0

Table 29: Sewage Water Monitoring at Vadinar STP (4th Week)

Date of Sampling	24.01.2022

Sr. No.	Parameters	Unit	Results	
			Vadinar STP I/L	Vadinar O/L
1	pH	pH unit	7.71	7.43
2	Total Suspended Solids	mg/l	102.9	42.5
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	152	61
5	BOD @ 27 °C	mg/l	48.0	18.0

5.3 Conclusions:

The GPCB standards of BOD, TSS and Residual Chlorine for STP outlet are 20 mg/lit, 30 mg/lit & 0.5 mg/lit respectively. It is suggested to do treatment on regular basis to avoid flow of contaminated/polluted water into the sea.

Marine Water Monitoring

The Forty Second Amendment to the Constitution in 1976 underscored the importance of 'green thinking'. Article 48A enjoins the state to protect and improve the environment and safeguard the forests and wildlife in the country. Further, Article 51A(g) states that the "fundamental duty of every citizen is to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures".

Policy Statement for Abatement of Pollution (1992) has suggested developing relevant legislation and regulation, fiscal incentives, voluntary agreements and educational programs and information campaigns. It emphasizes the need for integration by incorporating environmental considerations into decision making at all levels by adopting frameworks namely, pollution prevention at source, application of best practicable solution, ensure polluter pays for control of pollution, focus on heavily polluted areas and river stretches and involve public in decision-making. The National Conservation Strategy and Policy Statement on Environment and Development, (1992) aimed at "integrating environmental concerns with developmental imperatives to meet the challenges by redirecting the thrust of our developmental process so that the basic needs of our people could be fulfilled by making judicious and sustainable use of natural resources." The priorities mentioned in this policy document include the sustainable use of land and water resources, prevention and control of pollution and preservation of biodiversity.

The National Water Policy, (2002) contains provisions for developing, conserving, sustainable utilizing and managing this important water resources and need to be governed by national perspectives.

Marine Environment

On national and state levels, we have several policies and regulation like Water (Prevention and Control of Pollution) Act, 1974, to regulate pollution discharges and restore water quality of our aquatic resources including the prescription of monitoring activities. One of the important provisions of the Water Act, 1974, is to maintain and restore the 'wholesomeness' of our aquatic resources. Water quality monitoring is one of the first steps required in the rational development and management of water resources. In the field of water quality management, there has been a steady evolution in procedures for designing system to obtain information on the changes of water quality. The monitoring comprises all activities to obtain 'information' with respect to the water system.

Sampling Stations

The monitoring of marine environment for the study of biological and ecological parameters was carried out on 03rd & 04th January-2022 in harbor regions of KPT and on 03rd January-2022 at Vadinar during spring tide period of New moon phase of Lunar Cycle. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 10th& 11th January 2022 in harbor regions of KPT. 10th January -2022 in Vadinar during Neap tide period first quarter of Lunar Cycle..

Plankton samples from sub surface layer was collected both during high tide period and low tide period from 3 water quality monitoring stations of KPT harbour area and two stations in Nakti creek and one station in Khori creek. The same sampling schedule was repeated during consecutive spring tide and neap tide in same month. Plankton samples from sub surface layer was collected both during high tide period and low tide period from 1 water quality monitoring stations near Vadinar jetty area during spring tide and neap tide in this month. Collected water samples were processed for estimation of Chlorophyll- a, Pheophytin- a, qualitative & quantitative evaluation of phytoplankton, qualitative & quantitative evaluation zooplanktons (density and their population).

Sampling Locations

Offshore monitoring requirement	Number of locations
Offshore Installations	3 in Kandla creek 2 in Nakti creek 1 in Khori creek 1 near Vadinar Jetty 1 near 1st SBM
Total Number of locations	**8**

5.4 Marine Water Quality

Marine water quality of marine waters of Deendayal Port Harbor waters, Khori and Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each month. The results of marine water quality and Marine sediments are as below;

Table 30: Marine Water Quality Monitoring Parameters for location near KPT colony

Sr. No.	Parameters	Unit	Kandla Creek Near KPT colony (1)			
			23°0'58"N 70°13'22."E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.23	7.36	7.41	7.36
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31.6	31.5	32.2	32.0
5	Turbidity	NTU	30	26	32	28
6	Total Dissolved Solids	mg/l	13377	15123	18967.0	20788.0
7	Total Suspended Solids	mg/l	560	709	602	670
8	Total Solids	mg/l	14110	15920	19620.0	21526.0
9	DO	mg/l	4.3	4.5	4.5	4.6
10	COD	mg/l	82.0	86.0	82.0	86.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.64	0.75	0.78	0.71
13	Phosphate	mg/l	0.24	0.20	0.22	0.22
14	Sulphate	mg/l	2652	2172	2544	2304
15	Nitrate	mg/l	2.89	3.38	2.75	2.89
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	601.20	521.04	561.12	601.2
18	Magnesium	mg/l	1652.4	1725.3	1749.6	1676.7
19	Sodium	mg/l	9468.0	8936.0	9525.0	8978.0
20	Potassium	mg/l	362.0	326.0	375.0	311.0
21	Iron	mg/l	1.09	BQL	0.66	3.41
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 31: Marine Water Quality Monitoring Parameters for location near passenger Jetty One at Kandla

Sr. No.	Parameters	Unit	Near passenger Jetty One (2)			
			23° 0'18 "N 70°13'31"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.29	7.31	7.51	7.46
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	32.0	32.5	31.6	31.1
5	Turbidity	NTU	32	28	36	27
6	Total Dissolved Solids	mg/l	28697	11321	27998.0	14910.0
7	Total Suspended Solids	mg/l	610	757	563	679
8	Total Solids	mg/l	29350	12100	28642.0	15666.0
9	DO	mg/l	4.4	4.9	4.4	4.2
10	COD	mg/l	78.0	80.0	88.0	92.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.93	1.00	0.93	0.96
13	Phosphate	mg/l	0.18	0.19	0.19	0.20
14	Sulphate	mg/l	2544	1836	2232	2340
15	Nitrate	mg/l	2.75	2.46	3.17	3.38
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	561.12	480.96	521.04	480.96
18	Magnesium	mg/l	1628.1	1652.4	1701	1676.7
19	Sodium	mg/l	9249.0	8814.0	9634.0	8912.0
20	Potassium	mg/l	368.0	318.0	384.0	314.0
21	Iron	mg/l	BQL	BQL	1.94	0.11
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Nitrite: 0.05mg/lCu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 32: Marine Water Quality Monitoring Parameters for location Near Coal Berth

Sr. No.	Parameters	Unit	Near Coal Berth			
			22°59'12"N 70°13'40"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.40	7.45	7.3	7.26
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	32.0	31.4	32.0	31.7
5	Turbidity	NTU	32	36	34	33
6	Total Dissolved Solids	mg/l	26387	32722	21814.0	31669.0
7	Total Suspended Solids	mg/l	570	744	599	790
8	Total Solids	mg/l	26980	33500	22496.0	32560.0
9	DO	mg/l	4.8	4.6	4.1	4
10	COD	mg/l	82.0	88.0	70.0	76.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.65	0.60	0.89	0.82
13	Phosphate	mg/l	0.17	0.17	0.18	0.18
14	Sulphate	mg/l	2772	2892	2148	2172
15	Nitrate	mg/l	3.59	3.94	3.94	4.29
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	641.28	681.36	641.28	681.36
18	Magnesium	mg/l	1676.7	1676.7	1555.2	1579.5
19	Sodium	mg/l	10204.0	8765.0	9168.0	8834.0
20	Potassium	mg/l	343.0	320.0	355.0	331.0
21	Iron	mg/l	4.03	0.34	0.51	1.15
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	0.41	BQL	BQL

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 33: Marine Water Quality Monitoring Parameters for location Khori creek at Kandla

Sr. No.	Parameters	Unit	KPT 4			
			Near 15/16 Berth			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.38	7.41	7.31	7.42
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31.2	31.0	31.2	31.1
5	Turbidity	NTU	40	42	39	45
6	Total Dissolved Solids	mg/l	30002	23361	29742.0	25668.0
7	Total Suspended Solids	mg/l	622	600	672	667
8	Total Solids	mg/l	30686	23978	30462.0	26410.0
9	DO	mg/l	4.3	4.5	4.6	4.5
10	COD	mg/l	85.0	89.0	78.0	80.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.75	0.82	0.65	0.56
13	Phosphate	mg/l	0.23	0.24	0.20	0.20
14	Sulphate	mg/l	1704	2292	2700	2640
15	Nitrate	mg/l	4.36	4.79	4.86	5.14
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	521.04	480.96	601.2	521.04
18	Magnesium	mg/l	1628.1	1628.1	1701	1822.5
19	Sodium	mg/l	9176.0	8836.0	9214.0	8878.0
20	Potassium	mg/l	340.0	317.0	356.0	323.0
21	Iron	mg/l	1.12	8.38	0.94	1.53
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	0.14	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	0.11	0.43	BQL

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 34: Marine Water Quality Monitoring Parameters for location Nakti Creek near Tuna Port

Sr. No.	Parameters	Unit	Nakti Creek Near Tuna Port			
			22°57'49."N 70° 7'0.67"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.50	7.60	7.4	7.5
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	32.1	32.5	32.3	32.1
5	Turbidity	NTU	35	46	36	48
6	Total Dissolved Solids	mg/l	21305	17027	19685.0	19345.0
7	Total Suspended Solids	mg/l	792	671	691	573
8	Total Solids	mg/l	22120	17780	20400.0	19210.0
9	DO	mg/l	4.4	4.6	4.8	4.7
10	COD	mg/l	96.0	92.0	98.0	96.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.87	0.91	0.96	0.89
13	Phosphate	mg/l	0.20	0.21	0.19	0.20
14	Sulphate	mg/l	2148	2772	2340	2268
15	Nitrate	mg/l	5.14	4.72	5.70	6.05
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	521.04	601.20	480.96	561.12
18	Magnesium	mg/l	1579.5	1603.8	1701	1579.5
19	Sodium	mg/l	10204.0	10310.0	10308.0	10263.0
20	Potassium	mg/l	398.0	399.0	401.0	390.0
21	Iron	mg/l	1.77	9.19	0.31	0.87
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	0.30	BQL	BQL

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 35: Marine Water Quality Monitoring Parameters for location Nakti Creek Near NH-8A at Kandla

Sr. No.	Parameters	Unit	Nakti Creek Near NH-8A			
			23° 02'01"N 70° 09'31"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.52	Sampling not possible during Low Tide	7.52	Sampling not possible during Low Tide
2	Color	-	Colorless		Colorless	
3	Odor	-	Odourless		Odourless	
4	Salinity	ppt	31.4		31.6	
5	Turbidity	NTU	38		37	
6	Total Dissolved Solids	mg/l	37757		32690.0	
7	Total Suspended Solids	mg/l	691		710	
8	Total Solids	mg/l	38496		33480.0	
9	DO	mg/l	4.8		4.5	
10	COD	mg/l	96.0		98.0	
11	BOD	mg/l	BQL		BQL	
12	Silica	mg/l	0.95		0.98	
13	Phosphate	mg/l	0.22		0.24	
14	Sulphate	mg/l	2736		2520	
15	Nitrate	mg/l	4.29		5.35	
16	Nitrite	mg/l	BQL		BQL	
17	Calcium	mg/l	641.28		641.28	
18	Magnesium	mg/l	1603.8		1506.6	
19	Sodium	mg/l	10415.0		10530.0	
20	Potassium	mg/l	404.0		409.0	
21	Iron	mg/l	0.41		0.46	
22	Chromium	mg/l	BQL		BQL	
23	Copper	mg/l	BQL		BQL	
24	Arsenic	mg/l	BQL		BQL	
25	Cadmium	mg/l	BQL		BQL	
26	Mercury	mg/l	BQL		BQL	
27	Lead	mg/l	BQL		BQL	
28	Zinc	mg/l	BQL		BQL	

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 36: Marine Water Quality Monitoring Parameters for locations Nr. Vadinar Jetty

Sr. No.	Parameters	Unit	Nr.Vadinar Jetty			
			22°26'25.26"N 69°40'20.41"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.40	7.60	7.4	7.5
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odourless	Odourless	Odourless	Odourless
4	Salinity	ppt	32.0	31.7	31.2	31.6
5	Turbidity	NTU	33	28	35	31
6	Total Dissolved Solids	mg/l	26259	23319	27011.0	22504.0
7	Total Suspended Solids	mg/l	507	485	517.1	486.5
8	Total Solids	mg/l	26800	23864	27589.0	23000.0
9	DO	mg/l	4.5	4.4	4.3	4.4
10	COD	mg/l	82.0	89.0	90.0	89.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.65	0.71	0.75	0.71
13	Phosphate	mg/l	0.19	0.18	0.22	0.23
14	Sulphate	mg/l	2520	2292	2580	2652
15	Nitrate	mg/l	5.14	4.86	4.44	4.29
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	561.12	521.04	561.12	521.04
18	Magnesium	mg/l	1676.7	1725.3	1676.7	1725.3
19	Sodium	mg/l	10518.0	10648.0	10809.0	10530.0
20	Potassium	mg/l	407.0	411.0	417.0	439.0
21	Iron	mg/l	0.52	1.27	1.52	1.16
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	0.17	BQL	0.22

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 36 (a): Marine Water Quality Monitoring Parameters for locations Nr. Vadinar SPM

Sr. No.	Parameters	Unit	Nr.Vadinar SPM			
			22°30'56.15"N 69°42'12.07"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.51	7.46	7.46	7.36
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odourless	Odourless	Odourless	Odourless
4	Salinity	ppt	32.2	31.5	31.4	32.0
5	Turbidity	NTU	30	32	28	31
6	Total Dissolved Solids	mg/l	33237	35588	34869	30549
7	Total Suspended Solids	mg/l	605	705	705	709
8	Total Solids	mg/l	33894	36882	35610	31352
9	DO	mg/l	4.7	4.6	4.6	4.1
10	COD	mg/l	96.0	90.0	96.0	90.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.93	0.96	0.96	0.76
13	Phosphate	mg/l	0.20	0.21	0.21	0.21
14	Sulphate	mg/l	2712	2556	2556	2726
15	Nitrate	mg/l	3.73	3.94	4.15	3.94
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	601.20	561.12	561.12	601.20
18	Magnesium	mg/l	1579.5	1652.4	1652.4	1725
19	Sodium	mg/l	10768.0	10804.0	10880.0	10893.0
20	Potassium	mg/l	415.0	418.0	444.0	442.0
21	Iron	mg/l	4.66	4.63	0.76	2.28
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	0.17	BQL	BQL

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

5.4.1 Marine Sediments

Sediment samples were collected with Van Veen Grab from the six locations in Kandla Port Waters and two locations in Vadinar Port. Samples were collected and preserved in silver foil in ice box to prevent the contamination/decaying of the samples.

5.5 Results

The Sediment Quality results are given in below from table no. 34 A & 34 B.

Table 34 A: Results of Analysis of Sediment of Kandla & Vadinar Port (Spring Tide)

Sr. No.	Parameters	Unit	KPT - 1	KPT - 2	KPT - 3	KPT - 4	KPT - 5	Jetty	SPM
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	2.31	3.97	2.53	1.74	1.09	1.55	1.76
3	Organic Carbon	mg/kg	1.34	2.30	1.46	1.01	0.63	0.90	1.02
4	Inorganic Phosphate	mg/kg	122.00	120.00	123.00	128.00	130.00	110.00	128.00
5	Moisture	%	6.04	20.28	5.07	4.51	1.79	27.71	27.58
6	Aluminium	mg/kg	ND	ND	ND	ND	ND	ND	ND
7	Silica	mg/kg	10.00	9.20	11.20	10.60	8.80	8.60	10.20
8	Phosphate	mg/kg	9.62	2.99	3.07	8.93	8.15	1.08	3.15
9	Sulphate	mg/kg	392.29	669.86	328.07	328.50	285.04	1060.86	1028.84
10	Nitrite	mg/kg	0.11	0.10	0.12	0.10	0.11	0.11	0.10
11	Nitrate	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
12	Calcium	mg/kg	140.28	184.37	164.33	164.33	136.27	220.44	212.42
13	Magnesium	mg/kg	51.03	94.77	43.74	36.45	34.02	133.65	165.24
14	Sodium	mg/kg	503.72	1090.45	516.67	595.13	389.07	1302.15	1504.45
15	Potassium	mg/kg	36.74	88.91	52.15	50.66	24.93	184.44	236.62
16	Chromium	mg/kg	58.10	42.60	22.60	20.90	12.20	42.90	129.20
17	Nickel	mg/kg	46.40	34.30	18.50	13.90	5.60	32.50	186.70
18	Copper	mg/kg	21.10	14.20	6.70	290.60	3.10	40.80	87.60
19	Zinc	mg/kg	60.90	58.20	24.60	32.10	7.00	80.40	145.20
20	Cadmium	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
21	Lead	mg/kg	7.50	5.40	4.30	6.90	4.00	7.80	4.10
22	Mercury	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
23	Arsenic	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL

*ND - Not Detected, BQL: Below Quantification Limit (NO3:10.0mg/kg, Cd: 1.0mg/kg, Hg: 1.0mg/kg, As: 1.0mg/kg)

Table 34 B: Results of Analysis of Sediment of Kandla & Vadinar Port (Neap Tide)

Sr. No.	Parameters	Unit	KPT - 1	KPT - 2	KPT - 3	KPT - 4	KPT - 5	Jetty	SPM
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	2.95	3.08	32.40	2.43	3.04	3.07	3.20
3	Organic Carbon	mg/kg	1.71	1.78	1.88	1.41	1.76	1.78	1.86
4	Inorganic Phosphate	mg/kg	126.00	123.00	128.00	132.00	124.00	109.00	120.00
5	Moisture	%	11.46	17.83	19.99	17.06	21.27	23.14	28.30
6	Aluminium	mg/kg	ND	ND	ND	ND	ND	ND	ND
7	Silica	mg/kg	10.00	9.20	11.20	10.60	8.80	8.60	10.20
8	Phosphate	mg/kg	3.28	BQL	BQL	BQL	1.03	BQL	1.03
9	Sulphate	mg/kg	829.31	1136.31	929.95	898.93	617.09	1032.92	1392.64
10	Nitrite	mg/kg	0.11	0.10	0.12	0.10	0.11	0.11	0.10
11	Nitrate	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
12	Calcium	mg/kg	204.41	216.43	228.46	208.42	200.40	220.44	216.43
13	Magnesium	mg/kg	82.62	114.21	111.78	75.33	97.20	143.37	153.09
14	Sodium	mg/kg	1042.67	1226.30	1316.01	1045.17	985.75	1493.79	1368.34
15	Potassium	mg/kg	84.42	106.16	123.23	95.05	107.98	159.65	172.47
16	Chromium	mg/kg	50.70	44.20	56.20	54.10	40.10	60.20	68.10
17	Nickel	mg/kg	34.70	27.60	38.50	35.50	23.70	41.10	46.60
18	Copper	mg/kg	10.10	9.90	28.10	14.40	7.40	19.00	24.50
19	Zinc	mg/kg	55.60	35.70	55.20	49.90	29.70	57.00	58.00
20	Cadmium	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
21	Lead	mg/kg	6.30	5.40	59.00	6.60	5.40	8.80	11.20
22	Mercury	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
23	Arsenic	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL

*ND - Not Detected, BQL: Below Quantification Limit (NO3:10.0mg/kg,Cd: 1.0mg/kg,Hg: 1.0mg/kg, As: 1.0mg/kg)

INTRODUCTION:

Sampling Stations:

The monitoring of marine environment for the study of biological and ecological Parameters was carried out on 04th January 2022 in harbour region of DPT at Kandla Creek, and on 05th January 2022 in creeks near by the port during spring tide. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 11th January 2022 in harbour region of DPT at Kandla Creek and on 10th January 2022 in creeks near by the port during neap tidal condition.

Plankton samples from sub surface layer was collected both during high tide period and low tide period from 3 water quality monitoring stations of KPT harbour area and one stations in Nakti creek and one station in Khori creek. Sampling at second sampling station of Nakti creek was possible only during high tide period. The same sampling schedule was repeated during consecutive Neap tide and spring tide in same month.

Plankton samples from sub surface layer were collected during high tide period and low tide period from monitoring station near Vadinar jetty at Path Finder Creek during neap tide on 04/01/2022 and spring tide period on 10/01/2022Collected water samples were processed for estimation of Chlorophyll- a, Pheophytin- a, qualitative &quantitative evaluation of phytoplankton, qualitative &quantitative evaluation zooplanktons (density and their population).

TABLE #1 SAMPLING LOCATIONS

monitoring requirement	**Number of locations**
Kandla creek Nakti creek Khori Creek Vadinar jetty SPM	3 in Kandla creek 2 in Nakti creek 1 in Khori creek 1 near Vadinar Jetty 1 near I stSPM
Total Number of locations	**8**

Sampling methodology adopted:

A marine sampling is an estimation of the body of information in the population. The theory of the sampling design is depending upon the underlying frequency distribution of the population of interest. The requirement for useful water sampling is to collect a representative sample of suitable volume from the specified depth and retain it free from contamination during retrieval.

50 litres of the water sample were collected from Sub surface by using bucket. From the collected water sample 1 litres of water sample were taken in an opaque plastic bottle for chlorophyll estimation, thereafter plankton samples were collected by using filtration assembly with nilyobolt cloth of 20µm mesh size.

Samples Processing for chlorophyll estimation:

Samples for the chlorophyll estimation were preserved in ice box on board in darkness to avoid degradation in opaque container covered with aluminium foil. Immediately after reaching the shore after sampling, 1 litre of collected water sample was filtered through GF/F filters (pore size 0.45 µm) by using vacuum filtration assembly. After vacuum filtration the glass micro fiber filter paper was grunted in tissue grinder, macerating of glass fiber filter paper along with the filtrate was done in 90% aqueous Acetone in the glass tissue grinder with glass grinding tube. Glass fiber filter paper will assist breaking the cell during grinding and chlorophyll content was extracted with 10 ml of 90% Acetone, under cold dark conditions along with saturated magnesium carbonate solution in glass screw cap tubes. After an extraction period of 24 hours, the samples were transferred to calibrated centrifuge tubes and adjusted the volume to original volume with 90% aqueous acetone solution to make up the evaporation loss. The extract was clarified by using centrifuge in closed tubes. The clarified extracts were then decanted in clean cuvette and optical density was observed at wavelength 664, 665 nm. By using corrected optical density, Chlorophyll-a value was calculated as given in (APHA, 1998).

PLANKTON:

The entire area open water in the sea is the pelagic realm. Pelagic organisms live in the open sea. In contrast to the pelagic realm, the benthic realm comprises organisms and zone of the bottom of the sea. Vertically the pelagic realm can be dividing into two zones based on light penetration; upper photic or euphotic zone and lower dark water mass, aphotic zone below the photic zone.

The term plankton is general term for organisms have such limited powers of locomotion that they are at the mercy of the prevailing water movement. Plankton is subdivided to phytoplankton and zooplankton. Phytoplankton is free floating organisms that are capable of photosynthesis and zooplankton is the various free floating animals.

Pelagic zone, represents the entire ocean water column from the surface to the deepest depths, is home to a diverse community of organisms. Differences in their locomotive ability categorize the organisms in the pelagic realm into two, ***plankton*** and ***nekton*** (Lalli and Parsons, 1997). ***Plankton*** consists of all organisms drifting in the water and is unable to swim against water currents, whereas ***Nekton*** includes organisms having strong locomotive power. Ecological studies on the plankton community, which form the base of the aquatic food chain, help in the better understanding of the dynamics and functioning of the marine ecosystem. The term 'Plankton' first coined by Victor Hensen (1887), Plankton, (Greek word: *planktos* meaning "passively drifting or wandering") is defined as drifting or free-floating organisms that inhabit the pelagic zone of water. Based on their mode of nutrition planktonic organisms are categorised into phytoplankton (organisms having an autotrophic mode of nutrition) and zooplankton (organisms having a heterotrophic mode of nutrition).

Phytoplankton in the marine environment:

Phytoplankton is free floating unicellular, filamentous and colonial eutrophic organisms that grow in aquatic environments whose movement is more or less dependent upon water currents. These micro flora acts as primary producers as well as the basis of food chain, source of protein, bio purifier and bio indicators of the aquatic ecosystems of which diverse array of the life depends .They are considered as an important component of aquatic flora, play a key role in maintaining equilibrium between abiotic and biotic components of aquatic ecosystem.

The phytoplankton includes a wide range of photosynthetic and phototrophic organisms. Marine phytoplankton is mostly microscopic and unicellular floating flora, which are the primary producers that support the pelagic food-chain. The two most prominent groups of phytoplankton are diatoms (Bacillariophyceae) and dinoflagellates (Dinophyceae).The phytoplankton those normally captured in the net from the Gulf of Kutch is normally dominated by these two major groups; diatoms and dinoflagellates. Phytoplankton also include numerous and diverse

collection of extremely small, motile algae which are termed micro flagellates (naked flagellates) as well as and Cyanophytes (blue-green algae).

Algae are an ecologically important group in most aquatic ecosystems and have been an important component of biological monitoring programs. Algae are ideally suited for water quality assessment because they have rapid reproduction rates and very short life cycles, making them valuable indicators of short-term impacts.

Aquatic populations are impacted by anthropogenic stress, resulting in a variety of alterations in the biological integrity of aquatic systems. Algae can serve as an indicator of the degree of deterioration of water quality, and many algal indicators have been used to assess environmental status.

Zooplankton in the marine environment:

Zooplankton includes a taxonomically and morphologically diverse community of heterotrophic organisms that drift in the waters of the world's oceans. Qualitative and quantitative studies on zooplankton community are a prerequisite to delineate the ecological processes active in the marine ecosystem. Zooplankton community plays a pivotal role in the pelagic food web as the primary consumers of phytoplankton and act as the food source for organisms in the higher trophic levels, particularly the economically essential groups such as fish larvae and fishes. They also function in the cycling of elements in the marine ecosystem. The dynamics of the zooplankton community, their reproduction, and growth and survival rate are all significant factors determining the recruitment and abundance of fish stocks as they form an essential food for larval, juvenile and adult fishes (Beaugrand et al., 2004). Zooplankton grazing in the marine environment controls the primary Production and helps in determining the pelagic ecosystem (Banse, 1995). Through grazing in surface waters and following the production of sinking faecal matters and also by the active transportation of dissolved and particulate matter to deeper waters via vertical migration, they help in the transport of organic carbon to deep ocean layers and thus act as key drivers of biological pump’ in the marine ecosystem. Zooplankton grazing and metabolism also, transform particulate organic matter into dissolved forms, promoting primary producer community, microbial demineralization, and particle export to the ocean’s interior.

The categorisation of zooplankton into various ecological groups is based on several factors such as duration of planktonic life, size, food preferences and habitat. As they vary significantly in size from microscopic to metazoic forms, the

classification of zooplankton based on size has paramount importance in the field of quantitative plankton research.

Based on the duration of planktonic life, zooplankton are categorised into Holoplankton (organisms which complete their entire lifecycle as plankton) and Meroplankton (organisms which are planktonic during the early part of their lives such as the larval stages of benthic and nektonic organisms). Tychoplankton are organisms which live a brief planktonic life, such as the benthic crustaceans (Cumaceans, mysids, isopods) which ascend to the water column at night for feeding and certain ectoparasitic copepods, they leave the host and spend their life as plankton during their breeding cycle.

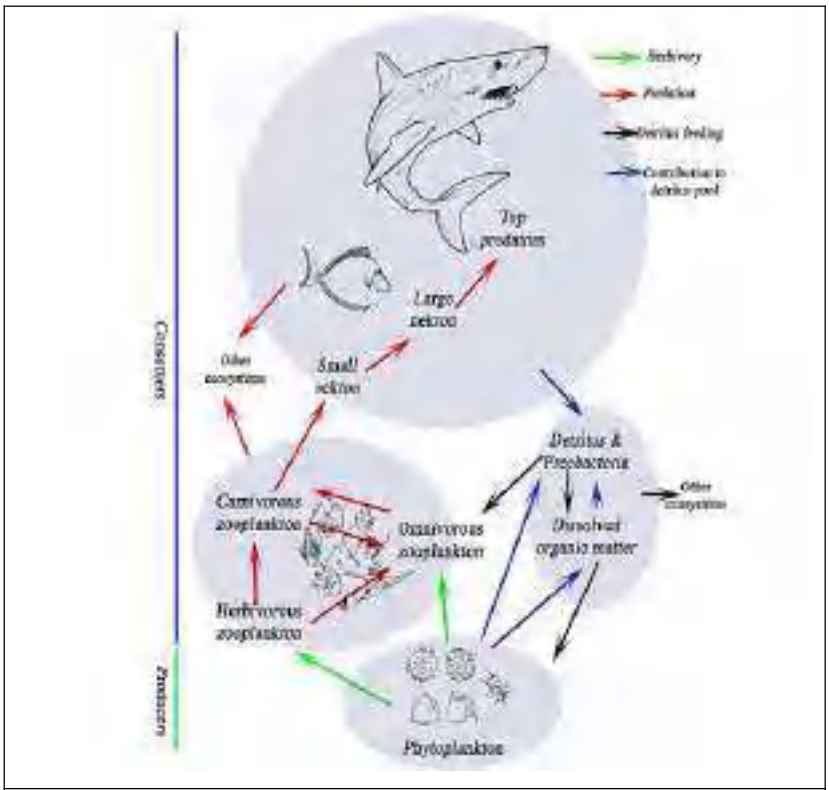
Zooplankton can be subdivided into holoplankton, i.e., permanent members of the plankton (e.g., Calanoid copepods), and meroplankton, i.e., temporary members in the plankton e.g., larvae of fish, shrimp, and crab). The meroplankton group consists of larval and young stages of animals that will adopt a different lifestyle once they mature. In contrast to phytoplankton which consist of a relatively smaller variety of organisms, Zooplankton are extremely divers, consist of a host of larval and adult forms representing many animal phylum.

Among the zooplankton one group always dominate than others; members of sub class copepods (Phylum Athropoda) and Tintinids (Phylum Protozoa) among the net planktons. These small animals are of vital importance in marine ecosystem as one of the primary herbivores animals in the sea, and it is they provide vital link between primary producer (autotrophs) and numerous small and large marine consumers.

As their community structure and function are highly susceptible to changes in the environmental conditions regular monitoring of their distribution as well as their interactions with various physicochemical parameters is inevitable for the sustainable management of the ecosystem (Kusum et al., 2014). Of all the marine zooplankton groups, copepods mainly Calanoid copepods are the dominant groups in marine subtropical and tropical waters and exhibit considerable diversity in morphology and habitats they occupy (Madhupratap, 1991;)

It has been well established that potential of pelagic fishes viz. finfishes, crustaceans, molluscs and marine mammals either directly or indirectly depend on zooplankton. The herbivorous zooplankton is efficient grazers of the phytoplankton and is referred to as living machines transforming plant material

into animal tissue. Hence they play an essential role as the intermediaries for nutrients/energy transfer between primary and tertiary trophic levels. Due to their large density, shorter lifespan, drifting nature, high group/species diversity and different tolerance to the stress, they used as the indicator organisms for the physical, chemical and biological processes in the aquatic ecosystem (Ghajbhiye, 2002).



Simplified marine food web

Spatial distribution of Plankton:

A characteristic of plankton population is that they tend to occur in patches, which are varying spatially on a scale of few meters to far as few kilometres in distance. They also vary in time scale, season as well as vertically in the water column. It is this patchiness and its constant changes in time and spot, that has made it so difficult for plankton biologist to learn about the ecology of plankton. The biological factors that causes this patchiness is due to the ability of zooplankton to migrate vertically and graze out the phytoplankton at a rapid rate that can create patchiness. Similarly the active swimming ability by certain zooplankton organisms can cause to aggregate in dense group.

At its most extreme, because the water in which plankton is suspended is constantly moving, each sample taken by the plankton biologists remain a different volume of water, so each sample is unique and replicate does not exist.

Plankton may also exhibit vertical patchiness. Physical factors contribute to this type of patchiness include light intensity, nutrients and density gradients in the water column.

Phytoplankton in particular tends to be unequally distributed vertically, which leads to the existence of different concentration of a chlorophyll value between photic zone and below the photic zone.

Methodology adopted for Plankton sampling:

Mixed plankton sample were obtained from the sub surface layer at each sampling locations by towing the net horizontally with the weight .After the tow of about 15-30minutes, plankton net was pulled up and washed down to the tail and collected the plankton adhered to plankton net in the collection bucket at the bottom by springing outer and inner surface of the net with sea water, while the net was hanging with the mouth upward. For quantitative evaluation 50 L water samples were collected from subsurface layer and filtered through 20µm mesh size net by using bucket and filtration assembly.

Preservation and storage:

Both filtered plankton and those collected from the plankton net were preserved with 5% buffered formalin and stored in 1L plastic container for further processing in the laboratory.

Sample concentration:

The collected plankton samples were concentrated by using centrifuge and made up to 50 ml with 5% formalin -Glycerine mixture.

Taxonomic evaluation:

Before processing, the sample was mixed carefully and a subsample was taken with a calibrated Stempel-pipette. 1 ml of the concentrated plankton samples were transferred on a glass slide with automatic pipette. The plankton sample on the glass slides were stained by using Lugol’s iodine and added glycerine to avoid drying while observation. The plankton samples were identified by using Labex triangular Research microscope with photographic attachment. Microphotographs of the plankton samples were taken for record as well as for confirming the identification. The bigger sized zooplankton was observed through dissecting stereomicroscope with magnification of 20-30 x. Plankton organisms in the whole slide were identified to the lowest axon possible. A thorough literature search was conducted for the identification of the different groups of zooplankton that were encountered

Cell counts by drop count method:

The common glass slide mounted with a 1ml of concentrated phytoplankton/zooplankton sample in glycerol and covered with cover slip 22x 60mm was placed under the compound microscope provided with a mechanical stage. The plankton was then counted from the microscopic field of the left top corner of the slide. Then slide is moved horizontally along the right side and plankton in each microscopic field was thus counted. When first microscopic field row was finished the next consecutive row was adjusted using the mechanical device of the stage. In this way all the plankton present in entire microscopic field are counted. From this total number in 1ml of the concentrated plankton, total number of plankton in the original volume of sample filtered was calculated as units/L.

BENTHIC ORGANISMS:

Benthos is those organisms that are associated with the sea bed or benthic habitats. Epi- benthic organisms live attached to a hard substratum or rooted to a shallow depth below the surface. In fauna organisms live below the sediment–water interface. Interstitial organisms live and move in pore water among sedimentary grains.

Because the benthic organisms are often collected and separated on sieves, a classification based on the overall size is used. Macro benthos include organisms whose shortest dimension is greater than or equal to 0.5 mm. Meio benthos are smaller than 0.5mm but larger than 42µ in size.

The terms such as macro fauna and Meio fauna generally have little relevance with taxonomic classification. The terms Meio fauna and macro fauna depend on the size. Meio fauna were considered as good bioassay of community health and rather sensitive indicators of environmental changes

SAMPLING METHODOLOGY ADOPTED FOR SUB TIDAL REGION:

Van veen sampler ($0.09m^2$) was used for sampling bottom sediments. Two sets of sediments were sampled from each location, one for macro fauna and other for Meio fauna. The macro fauna in the sediments were sieved on board to separate out the organisms. The fixation of Meio fauna is normally done by bulk fixation of the sediment sample. The bulk fixation is done by using 10% formalin (Buffered with borate). The organisms were preserved with seawater as diluting agent.

Sample sieving:

Sediments samples were sieved to extract the organisms. Sieving was performed carefully as possible to avoid any damage to the animals. The large portion of the sediment was split in to smaller portions and mixed with sea water in a bucket. The cohesive lumps were broken down by continuous stirring. The disaggregated sediments were then passed through the sieves.

Sample staining:

Sorting of the Meio fauna from the sieve is difficult task especially in the preserved material, because organisms are not easily detectable. To facilitate the animal detection the entire sample retained on the sieve after sieving operation were stained by immersing the sieve in a flat bottom tub with 1% Rose Bangal stain; a protein stain. A staining period of 10-30 minutes is sufficient for sample detection.

DIVERSITY INDICES:

On the whole, diversity indices provide more information about community composition than simply species richness (number of species present); they also, take the relative abundances of different species into account. Based on this fact, diversity indices therefore depend not only on species richness but on the evenness, or equitability, with which individuals are distributed among the different species (Magurram, A. E. (1988)

A diversity index is a measure of species diversity within a community that consists of co-occurring populations of several (two or more) different species. It includes two components: richness and evenness. Richness is the measure of the number of different species within a sample showing that more the types of species in a community, the higher is the diversity or greater is the richness. Evenness is the measure of relative abundance of the different species with in a community.

The basic idea of diversity index is to obtain a quantitative estimate of biological variability that can be used to compare biological entities composed of discrete components in space and time (Carol H.R. *etal*. 1998). Biodiversity is commonly expressed through indices based on species richness and species abundances (Whittaker 1972, Lande 1996, Purvis and Hector 2000). Biodiversity indices are a non-parametric tool used to describe the relationship between species number and abundance. The most widely used bio diversity indices are Shannon Weiner index and Simpson’s index.

A diversity Index is a single statistic that incorporates in formation on richness and evenness. The diversity measures that incorporate the two concepts may be termed heterogeneity measures (Magurran, 2004).

Any study intended to interpret causes and effect of adverse impact on Biodiversity of communities require suitable measures to evaluate specie richness and Diversity. The former is number of species in community, while latter is a function of relative frequency of different species. Species richness is the iconic measure of biological diversity (Magurran, 2004). Several indices have been created to measure the diversity of species; however, the most widely used in the last decades are the Shannon (1948) and Simpson (1949) (Buzas and Hayek 1996; Gorelick 2006), with the components of diversity: richness (*S)* and evenness (*J)*

Simpson's diversity index

Simpson's index (**D**) is a measure of diversity, which takes into account both species richness, and evenness of abundance among the species present.. The Simson index is one of the meaningful and robust biodiversity measures available.(Magurran ,2004).

The formula for calculating D is presented as:

$$D = \frac{\sum n_i(n_i - 1)}{N(N - 1)}$$

Where n_i = the total number of organisms of each individual species

N = the total number of organisms of all species

The value of D ranges from 0 to 1. With this index, 0 represents infinite diversity and, 1, no diversity. When D increases diversity decreases. Simpson's index is therefore usually expressed as 1-D or 1/D. (Magurran, 2004)

Low species diversity suggests:

- relatively few successful species in the habitat
- the environment is quite stressful with relatively few ecological niches and only a few organisms are really well adapted to that environment
- food webs which are relatively simple
- change in the environment would probably have quite serious effects

High species diversity suggests:

- a greater number of successful species and a more stable ecosystem
- more ecological niches are available and the environment is less likely to be hostile complex food webs

$$H' = -\sum_{i=1}^{s} \frac{n_i}{N} \ln\left(\frac{n_i}{N}\right)$$

environmental change is less likely to be damaging to the ecosystem as a whole

Species richness indices

The species richness ***(S)*** is simply the number of species present in an ecosystem. Species richness Indices of species richness are widely used to quantify or monitor the effects of anthropogenic disturbance. A decline in species richness may be concomitant with severe or chronic human-induced perturbation (Fair Fair weather 1990,) Species richness measures have traditionally been the mainstay in assessing the effects of environmental degradation on the biodiversity of natural assemblages of organisms (Clarke &Warwick, 2001)

Species richness is the iconic measure of biological diversity (Magurran, 2004). The species richness ***(S)*** is simply the number of species present in an ecosystem. This index makes no use of relative abundances. The term species richness was coined by McIntosh (1967) and oldest and most intuitive measure of biological diversity (Magurran, 2004).

Margalef's diversity index is a species richness index. Margalef's Species richness index (d), or indices that describe the evenness of the distribution of the numbers of individuals among species, were derived.

The value of a diversity index increases both when the number of types increases and when evenness increases. For a given number of types, the value of diversity index is maximised when all types are equally abundant (Rosenzweig, M. L. (1995).

Shannon-Wiener's index:

An index of diversity commonly used in plankton community analyses is the Shannon-Wiener's index **(H),** which emphasizes not only the number of species (richness or variety), but also the apportionment of the numbers of individuals among the species (Odum 1971 and Reish 1984). Shannon-Wiener's index **(H**) reproduces community parameters to a single number by using an equation.

Shannon and Weiner index represents entropy. It is a diversity index taking into account the number of individuals as well as the number of taxa. It varies from 0 for communities with only single taxa to high values for community with many taxa each with few individuals. This index can also determine the pollution status of a water body. Normal values range from 0 to 4. This index is a combination of species present and the evenness of the species. Examining the diversity in the

range of polluted and unpolluted ecosystems, Wilham and Dorris (1968) concluded that the values of the index greater than 3 indicate clean water, values in the range of 1 to 3 are characterized by moderate pollution and values less than 1 are characterized as heavily polluted

$$H' = -\sum_{j=1}^{s} \frac{n_i}{N} \ln\left(\frac{n_i}{N}\right)$$

RESULTS:

CHLOROPHYLL-a:

Water Samples for the chlorophyll estimation were collected from sub surface layer during high tide and low tide period of the tidal cycle for each sampling locations and analysed for Chlorophyll -a and after acidification for Pheophytin –a. Chlorophyll- a value was used as algal biomass indicator (APHA,1998) Algal biomass was estimated by converting Chlorophyll value.

In the sub surface water chlorophyll-a was varying from 0.509- 0.850 mg/m^3 with an average value 0.714 mg/m^3 of in harbour region of DPT in Kandla Creek during sampling done in spring tide period of JANUARY 2022. In the nearby creeks chlorophyll-a was varying from 0.378 -1.038 mg/m^3. with an average value 0.760 mg/m^3 Pheophytin –a level was below detectable limit- the all the sampling stations during spring tide.

In the sub surface water chlorophyll-a was varying from 0.512- 0.850 mg/m^3 with an average value 0.648 mg/m^3.in harbour region of DPT in Kandla Creek during sampling done in neap tide period of January , 2021 . In the nearby creeks chlorophyll-a was varying from 0.378–0.835 mg/m^3 with an average value 0.658 mg/m^3.·Pheophytin –a level was below detectable limit- the all the sampling stations.

In the sub surface water chlorophyll-a was varying from 0.628-1.156 mg/m^3 with an average value 0.883 mg/m^3. in harbour region of DPT OOT in path finder Creek during sampling done in spring tide period of JANUARY 2022. In the sub surface water chlorophyll-a was varying from 0.833 – 1.039 mg/m^3 with an average value 0.940 mg/m^3.in harbour region of DPT OOT in path finder Creek during sampling done in Neap Tide period of JANUARY 2022

TABLE #2 VARIATIONS IN CHLOROPHYLL –a PHEOPHYTIN- a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPT HARBOUR AREA IN KANDLA CREEK ,NEAR BY CREEKS AND DPT OOT JETTY IN PATH FINDER CREEK AND SPM NEAR VADINAR DURING SPRING TIDE IN JANUARY 2022

Sr. No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPT HARBOUR AREA KANDLA CREEK					
1	KPT1	High tide	0.613	BDL	41.07
		Low tide	0.746	BDL	49.98
2	KPT 2	High tide	0.732	BDL	49.04
		Low tide	0.834	BDL	55.88
3	KPT 3	High tide	0.850	BDL	56.95
		Low tide	0.509	BDL	34.10
CREEKS					
4	KPT-4 Khori-I	High tide	0.937	BDL	62.78
		Low tide	0.511	BDL	34.24
5	KPT-5 Nakti-I	High tide	1.038	BDL	69.54
		Low tide	0.936	BDL	62.71
6	KPT-5 Nakti-II	High tide	0.354	BDL	23.72
PATHFINDER CREEK VADINAR					
7	VADINAR-I jetty	High tide	0.917	BDL	61.44
8		Low tide	1.156	BDL	77.45
9	SPM	High tide	0.833	BDL	55.81
10	SPM	Low tide	0.628	BDL	42.08

BDL: Below Detectable Limit.

TABLE #3 VARIATIONS IN CHLOROPHYLL –a PHEOPHYTIN- a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS AND DPT OOT JETTY IN PATH FINDER CREEK AND SPM NEAR VADINAR DURING NEAP TIDE IN JANUARY 2022

Sr. No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPT HARBOUR AREA KANDLA CREEK					
1	KPT1	High tide	0.629	BDL	42.14
		Low tide	0.747	BDL	50.04
2	KPT 2	High tide	0.512	BDL	34.30
		Low tide	0.526	BDL	35.24
3	KPT 3	High tide	0.850	BDL	56.95
		Low tide	0.627	BDL	42.01
CREEKS					
4	KPT-4 Khori-I	High tide	0.716	BDL	47.97
		Low tide	0.630	BDL	42.21
5	KPT-5 Nakti-I	High tide	0.732	BDL	49.04
		Low tide	0.834	BDL	55.88
6	KPT-5 Nakti-II	High tide	0.378	BDL	25.32
PATHFINDER CREEK VADINAR					
7	VADINAR-I jetty	High tide	0.936	BDL	62.71
8		Low tide	0.953	BDL	63.85
9	SPM	High tide	0.833	BDL	55.81
10	SPM	Low tide	1.039	BDL	69.61

BDL: Below Detectable Limit.

PHYTOPLANKTON POPULATION:

For the evaluation of the Phytoplankton population in DPT harbour area and within the immediate surroundings of the port, sampling was conducted from 5 sampling locations (3 in harbour area and two in Nakti creek) during high tide period and low tide period of spring tide and neap tide.

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by, Diatoms blue green algae and dinoflagellates during spring tide period. Diatoms were represented by 24 genera. Blue green were represented by 2 genera and dinoflagellates were represented by 3 genera during the sampling conducted in spring tide in JANUARY 2022. Phytoplankton of

the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 41-205 units/ L during high tide period and 110-178 units/ L during low tide of Spring Tide.

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by Diatoms. Blue green algae and Dinoflagellates during Neap tide period. Diatoms were represented by 21 genera Blue green algae were represented 4 genera and dinoflagellates with 4 genera during the sampling conducted in Neap tide in January 2022. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 118-271 units/ L during high tide period and 228-304 units/ L during low tide of Neap Tide.

For the evaluation of the Phytoplankton population in DPT OOT jetty area in Path Finder creek sampling was conducted from two sampling locations ; jetty area during high tide period and low tide of spring tide and Neap tide period.

The phytoplankton community of the sub surface water in the path finder creeks was represented by Diatoms, Blue green anlage and Dinoflagellates during spring tide period. Diatoms were represented by 13 genera , Blue Green algae and Dinoflagellates 3 genera each during the sampling conducted in spring tide in January 2022. Phytoplankton of the sampling stations at sub surface layer in the harbour area was varying from 193 units/ L during high tide period and 172 units/ L during low tide of Spring Tide. Phytoplankton of the sampling stations at sub surface layer in the SPM area was varying from 107 units/ L during high tide period and 124 units/ L during low tide of Spring Tide.

The phytoplankton community of the sub surface water in the path finder creeks was represented by Diatoms, Blue green and Dinoflagellates during Neap tide period. Diatoms were represented by 14 genera and Blue green algae and dinoflagellates by two genera each during the sampling conducted in Neap tide in January 2022. Phytoplankton of the sampling stations at sub surface path finder creek near OOT Jetty was varying from 117 units/ L during high tide period and 174 units/ L during low tide of Neap Tide. Phytoplankton of the sampling stations at sub surface path finder creek near SPM area was varying from 162 units/ L during high tide period and 202 units/ L during low tide of Neap Tide.

Species Richness Indices and Diversity Indices:

Margalef's diversity index (Species Richness)S

At the organismal level, the most widely used biodiversity measures are those based on the number of species present, perhaps adjusted for the number of

individuals sampled, Here Margalef's Species richness index (d), or indices that describe the evenness of the distribution of the numbers of individuals among species, are derived.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek and nearby creeks sampling stations was varying from 2.962-4.532 with an average of 3.837 during the sampling conducted in High tide period of spring tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek region and nearby creeks was varying from 3.482 - 3.86 with an average of 3.657 during the consecutive low tide period.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations in Kandla creek and nearby creeks was varying from 3.149 - 5.12 with an average of 4.292 during the sampling conducted in High tide period of Neap tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek region and nearby creeks was varying from 3.996 - 4.973 with an average of 4.456 during consecutive low tide.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations was 3.407 at OOT jetty area and 3.282at SPM area during the sampling conducted in High tide period of spring tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the path finder creek near OOT jetty was 3.381 and 3.493 at SPM during the consecutive low tide period.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations was 3.772 at OOT jetty area and 3.823 at SPM area during the sampling conducted in High tide period of Neap tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the path finder creek near OOT jetty was 2.779 and SPM area was 3.64 during the consecutive low tide period.

Shannon-Wiener's index:

Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.844 - 1.02 (H'(log10)) between selected sampling stations with an average value of 0.941 during high tide period of spring tide at Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.799 - 1.002 (H'(log10)) between selected sampling stations with an average value of

0.922 during consecutive low tide at Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.9163- 1.209- (H'(log10)) between selected sampling stations with an average value of 1.088 during high tide period of neap tide at Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 1.087 - 1.237 (H'(log10)) between selected sampling stations with an average value of 1.149 during consecutive low tide at Kandla creek and nearby creeks.

Shannon-Wiener's Index (H) of phytoplankton communities in the stations was 0.8483 at OOT jetty area and 0.992 at SPM area during the sampling conducted in High tide period of spring tide. While Shannon-Wiener's Index (H) of phytoplankton communities in the path finder creek near OOT jetty was 0.9335 and 1.06 at SPM during the consecutive low tide period.

Shannon-Wiener's Index (H) of phytoplankton communities in the stations was 0.9458 at OOT jetty area and 1.029 at SPM area during the sampling conducted in High tide period of Neap tide. While Shannon-Wiener's Index (H) of phytoplankton communities in the path finder creek near OOT jetty was 0.9644 and at SPM area was 0.9767during the consecutive low tide period.

Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon-Wiener's index increases as both the richness and the evenness of the community increase. This result indicates that diversity of phytoplankton of Kandla Harbour region and nearby creeks is less but with abundant population of few, with relatively few ecological niches and only very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson's diversity index:

Simpson's index (D) is a measure of diversity, which takes into account both species richness, and an evenness of abundance among the species present. The Simson index is one of the meaningful and robust biodiversity measures available. (Magurran,2004).

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks, which was varying from 0.7702- 0.8524 between selected sampling stations with an average of 0.823 during high tide period of spring tide. Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks, which was varying from 0.744- 0.853

between selected sampling stations with an average of 0.810 during consecutive low tide .

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations except few in Kandla Harbour region and nearby creeks, during high tide period and low tide period during neap tide also, which was varying from 0.804- 0.905 with an average value of 0.866 between selected sampling stations during high tide period and 0.869 -0.908 varying from with an average value of 0.887 between selected sampling stations during consecutive low tide period Low species diversity suggests a relatively few successful species in this habitat.

Simpson diversity index (1-D) of phytoplankton communities in the stations was 0.7143 at OOT jetty area and 0.8243 at SPM area during the sampling conducted in High tide period of spring tide at Path finder creek . While Simpson diversity index (1-D) of phytoplankton communities in the path finder creek near OOT jetty was 0.7944 and 0.8825 at SPM during the consecutive low tide period in the path finder creek.

Simpson diversity index (1-D) of phytoplankton communities in the stations was 0.8103 at OOT jetty area and 0.8349 at SPM area during the sampling conducted in High tide period of Neap tide at Path finder Creek. While Simpson diversity index (1-D) of phytoplankton communities in the path finder creek near OOT jetty was 0.834 and at SPM area was 0.8239 during the consecutive low tide period.

Low species diversity suggests a relatively few successful species in this habitat. The environment is quite stressful with relatively few ecological niches and only a few organisms are really well adapted to that environment. Any change in the environment would probably have quite serious effects.

Table # 4 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND ,NEAR BY CREEKS DURING SPRING TIDE IN JANUARY 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	221	31/31	100	5.557	1.2	0.8849
	2	202	26/31	83.87	4.71	1.111	0.8589
	3	219	30/31	96.77	5.381	1.149	0.8646
	4	230	29/31	93.55	5.149	1.123	0.8458
	5	234	29/31	93.55	5.133	1.01	0.8031
	6	64	16/31	51.61	3.607	1.081	0.9038
LOW TIDE	1	201	24/31	77.42	4.337	1.092	0.86
	2	232	30/31	96.77	5.324	1.257	0.9132
	3	219	29/31	93.55	5.196	1.215	0.9083
	4	201	29/31	93.55	5.28	1.239	0.9122
	5	265	28/31	90.32	4.839	1.161	0.8949

Table # 5 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND ,NEAR BY CREEKS DURING NEAP TIDE IN JANUARY 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	231	27/29	93.10	4.777	1.159	0.8801
	2	195	28/29	96.55	5.12	1.209	0.9051
	3	271	28/29	96.55	4.82	1.05	0.8426
	4	248	26/29	89.65	4.534	1.116	0.8704
	5	221	18/29	62.07	3.149	0.9163	0.8042
	6	118	17/29	58.52	3.354	1.078	0.8948
LOW TIDE	1	246	23/29	79.31	3.996	1.087	0.8709
	2	228	28/29	96.55	4.973	1.237	0.9085
	3	304	28/29	96.55	4.723	1.178	0.9005
	4	259	25/29	86.20	4.319	1.154	0.8859
	5	276	25/29	86.20	4.27	1.093	0.8697

Table # 6 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND , NEAR BY CREEKS DURING SPRING TIDE IN JANUARY 2022

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	DIATOMS	57-209	22/31	70.97
			BLUE GREEN	7-20	5/31	16.13
			DINOFLAGELLATES	0-14	4/31	12.90
			TOTAL PHYTO PLANKTON	64-234	31	-
LOW TIDE	Sub surface	5	DIATOMS	181-201	22/31	70.97
			BLUE GREEN	19-18	5/31	16.13
			DINOFLAGELLATES	1-13	4/31	12.90
			TOTAL PHYTO PLANKTON	201-232	31	-

Table # 7 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND , NEAR BY CREEKS DURING NEAP TIDE IN JANUARY 2022

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	DIATOMS	99-243	21/29	72.42
			BLUE GREEN	1-14	4/29	13.79
			DINOFLAGELLATES	7-23	4/29	13.79
			TOTAL PHYTO PLANKTON	118-271	29	
LOW TIDE	Sub surface	5	DIATOMS	185-269	21/29	72.42
			BLUE GREEN	10-19	4/29	13.79
			DINOFLAGELLATES	14-24	4/29	13.79
			TOTAL PHYTO PLANKTON	**228-304**	29	

Table # 8 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING SPRING TIDE IN JANUARY 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	jetty	264	20/20	100	3.407	0.8483	0.7143
	SPM	276	20/20	100	3.381	0.9335	0.7944
LOW TIDE	jetty	241	19/20	95	3.282	0.992	0.8243
	SPM	173	19/20	95	3.493	1.06	0.8825

Table # 9 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING NEAP TIDE IN JANUARY 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	154	20/20	100	3.772	0.9458	0.8103
	SPM	154	15/20	75	2.779	0.9644	0.834
LOW TIDE	Jetty	144	20/20	100	3.823	1.029	0.8349
	SPM	185	20/20	100	3.64	0.9767	0.8239

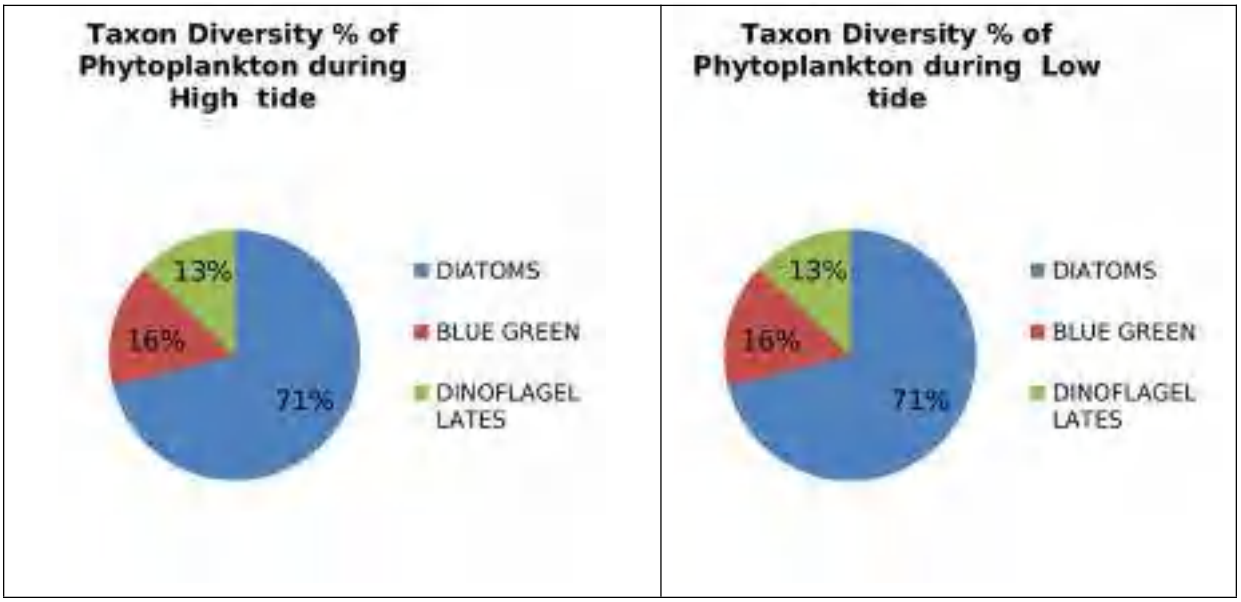
Table # 10 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT DPT OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING SPRING TIDE IN JANUARY 2022

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	1	BLUE GREEN	4-9	3/19	15.78
			DIATOMS	102-177	13/19	68.44
			DINOFLAGELLATES	1-7	3/19	15.78
			TOTAL PHYTO PLANKTON	**107-193**	**19**	
LOW TIDE	Sub surface	1	BLUE GREEN	4-14	3/19	15.78
			DIATOMS	17-154	13/19	68.44
			DINOFLAGELLATES	4-3	3/19	15.78
			TOTAL PHYTO PLANKTON	**124-172**	**19**	

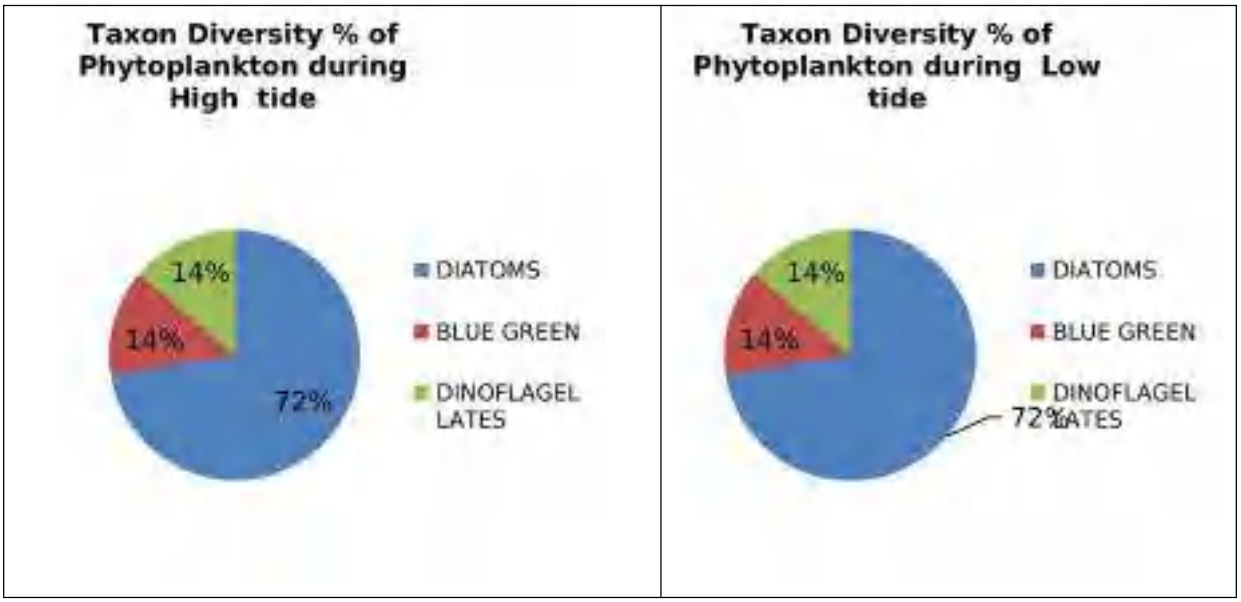
Table # 11 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT DPT OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING NEAP TIDE IN JANUARY 2022

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	BLUE GREEN	4-5	2/18	11.11
			DIATOMS	109-154	14/18	77.78
			DINOFLAGELLATES	3-4	2/18	11.11
			TOTAL PHYTO PLANKTON	**117-162**	**18**	-
LOW TIDE	Sub surface	2	BLUE GREEN	5-8	2/18	11.11
			DIATOMS	158-194	14/18	77.78
			DINOFLAGELLATES	3-8	2/18	11.11
			TOTAL PHYTO PLANKTON	**174-202**	**18**	-

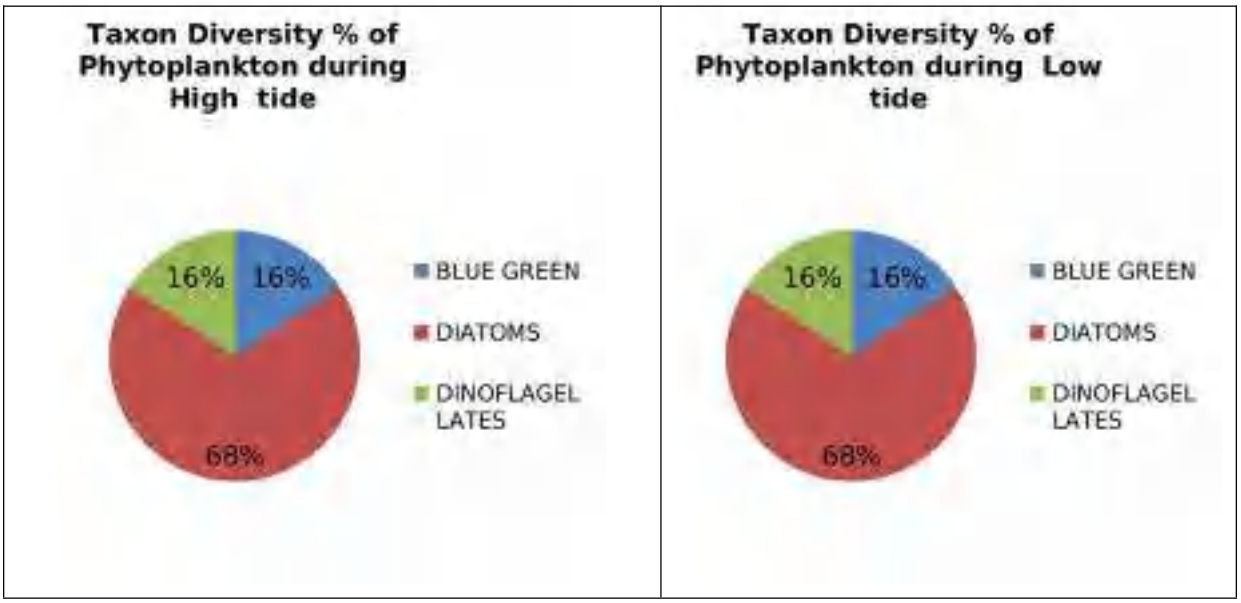
Taxon Diversity % of Phytoplankton during High tide and Low tide period during spring tide in Kandala creek and nearby creeks



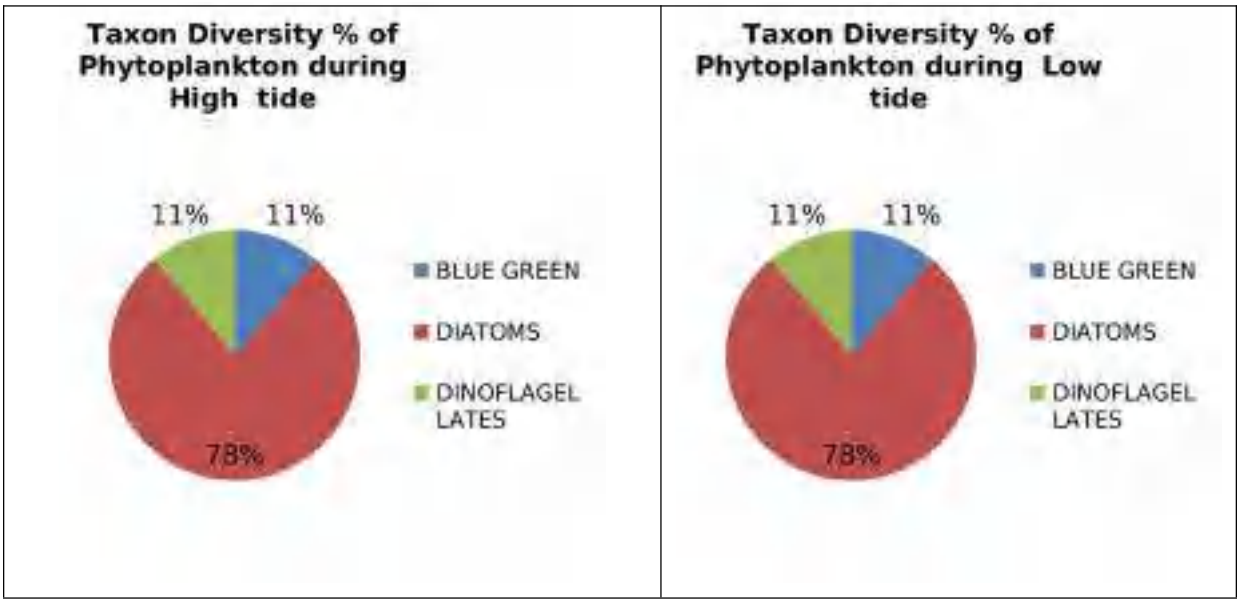
Taxon Diversity % of Phytoplankton during High tide and Low tide period during Neap tide in Kandala creek and nearby creeks



Taxon Diversity % of Phytoplankton during High tide and Low tide period during spring tide in Path Finder Creek, Vadinar



Taxon Diversity % of Phytoplankton during High tide and Low tide period during Neap tide in Path Finder Creek, Vadinar



ZOOPLANKTON POPULATION:

For the evaluation of the Zooplankton population in DPT harbour area and within the immediate surroundings of the port sampling was conducted from 6 sampling locations (3 in harbour area and two in Nakti creek and one in Khori creek) during high tide period and low tide period of spring tide and Neap tide in January 2022. The Zooplankton community of the sub surface water in the harbour and nearby creeks during spring tide was represented by mainly 7

groups, and 9 larval forms; Tintinids, Copepods, Arrow worms, Mysids, Urochordata, Medusa, Foraminiferans , and 9 larval forms; Nauplius larvae of Copepods, Actinula larvae , Brachyuran Zoea larvae, Cyphonautes larvae, Cirripede larvae, Ophipluutes larvae/ chinoplutes larvae,Opisthobranchia larvae ,Trochophore larvae and Veliger larvae of Bivalves

. The Zooplankton community of the sub surface water in the harbour and nearby creeks during neap tide was represented by mainly 7 groups, Tintinids, Copepods, Arrow worms, Mysids, Urochordata, Ciliates and unidentified Cnidarian member, Foraminiferans and 9 larval forms ; Nauplius larvae of Copepods, Actinula larvae, Brachyuran Zoea larvae, Cirripede larvae, Cyphonautes larvae, Opisthobranchia larvae, Ophipluutes larvae/ Echinoplutes larvae,Trochophore larvae, and Veliger larvae of Bivalves.

Zooplankton of the sampling stations at sub surface layer in the DPT harbour area and nearby creek was varying from 72-236 x103 N/ m^3 during high tide and 210-241 x103 N/ m^3 during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPT harbour area and nearby creek was varying from 89-218 $x10^3$ N/ m^3 during high tide and 89-208 $x10^3$ N/ m^3 during low tide of Neap Tide period.

For the evaluation of the Zoo plankton population in DPT OOT jetty area in Path Finder creek and SPM in Vadinar selected 2 sampling locations (1 in jetty area and one near SPM) During spring tide sampling plankton sample were collected at Jetty area and near SPM during consecutive high tide period and low tide period. During Neap tide sampling Plankton samples were collected from jetty area and SPM during consecutive high tide period and low tide period.
The Zooplankton community of the sub surface water in the path finder creek creeks during spring tide was represented by mainly Titinids , Copepods, Arrow worms and larval forms; Nauplius larvae of Copepods, Brachyuran Zoea larvae, Cirripede larvae, Opisthobranchia larvae, Trochophore larvae and Veliger larvae of Bivalves

.The Zooplankton community of the sub surface water in the path Finder creeks at Jetty region and SPM during neap tide was represented by mainly two groups, Tintinids, Copepods , and , 7 Larval forms ,. Nauplius larvae of Copepods, Cirripede larvae, Cyphonautes larvae, Ophipluutes larvae/ Echinoplutes larvae, Opisthobranchia larvae, Trochophore larvae and Veliger larvae of Bivalves

Zooplankton of the sampling stations at sub surface layer in the DPT OOTJetty area of path finder creek was 145 x10^3 N/ m^3 during high tide and 144 x10^3 N/ m^3 during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPT SPM area of path finder creek was 155 x10^3 N/ m^3 during high tide and 124 x10^3 N/ m^3 during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPT OOT jetty area in path finder creek was recorded 104x10^3 N/ m^3 during high tide and 103 x10^3 N/ m^3 during consecutive low tide period of Neap. Zooplankton of the sampling stations at sub surface layer in the DPT SPM area in path finder creek was recorded 131 x10^3 N/ m^3 during high tide and 134 x10^3 N/ m^3 during consecutive low tide period of Neap Tide .

Species Richness Indices and Diversity Indices:

Margalef's diversity index (Species Richness)S

At the organismal level, the most widely used biodiversity measures are those based on the number of species present, perhaps adjusted for the number of individuals sampled, Here Margalef's Species richness index (d), or indices that describe the evenness of the distribution of the numbers of individuals among species, are derived.

Margalef's diversity index (Species Richness) S of Zooplankton communities in the stations Kandla creek region and nearby creeks was varying from 3.274 - 5.353 with an average of 4.516 during the sampling conducted in High tide period. Margalef's diversity index (Species Richness) S of Zooplankton communities varying from 3.862 - 4.488 with an average of 4.323 during the sampling conducted in low tide period during Spring tide.

Margalef's diversity index (Species Richness) S of Zooplankton communities in the Kandla creek region and nearby creeks sampling stations was varying from 4.01-5.31 with an average of 4.479 during the sampling conducted in high tide and varying from 3.708-4.684 with an average of 4.218 during the sampling conducted in low tide during Neap tide period.

Margalef's diversity index (Species Richness) S of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 3.416 and 3.421 respectively. Margalef's diversity index (Species Richness) S of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High

tide period and low tide of spring tide was recorded as 3.172 and 3.319 respectively.

Margalef's diversity index (Species Richness) S of Zooplankton communities near Jetty at Path finder creek was varying from 3.66-2.805 during the sampling conducted in consecutive High tide period and Low tide period of Neap tide. While Margalef's diversity index (Species Richness) S of Zooplankton communities near SPM at Path finder creek was varying from 3.692-3.063 during the consecutive High tide and low tide period.

Shannon-Wiener's index:

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 1.051 - 1.316 (H'(log10)) between selected sampling stations with an average value of 1.203 (H'(log10)) during high tide period of spring tide. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 1.172- 1.274 (H'(log10)) between selected sampling stations with an average value of 1.231 (H'(log10)) during consecutive low tide period .

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 1.037-1.254 (H'(log10)) between selected sampling stations with an average value of 1.163 (H'(log10)) during high tide period of Neap tide. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range 1.037-1.268 of (H'(log10)) between selected sampling stations with an average value of 1.197 (H'(log10)) during consecutive low tide period.

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 1.101and 1.114 respectively. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 1.070 and 1.059 respectively

Shannon-Wiener's Index (H)of Zooplankton communities near jetty at Path finder creek was varying from 1.081-0.897 during the sampling conducted consecutive High tide period and Low tide period of Neap tide. While Shannon-Wiener's Index (H)of Zooplankton communities near SPM at Path finder creek

was varying from 0.967 - 0.942 during the consecutive High tide and low tide period.

Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon-Wiener's index increases as both the richness and the evenness of the community increase. This result indicates that diversity of Zooplankton of Kandla Harbour region and nearby creeks stations is slightly high with very minimum diverse population but very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson's diversity index:

Simpson's index (D) is a measure of diversity, which takes into account both species richness, and an evenness of abundance among the species present. The Simson index is one of the meaningful and robust biodiversity measures available. (Magurran, 2004).

Simpson diversity index (1-D) of Zooplankton communities was above 0.9 most of sampling stations in the Kandla Harbour region and nearby creeks during high tide and low tide of spring tide period except few , which was varying from 0.897-0.942 between selected sampling stations with an average of 0.921 during high tide period and was varying from 0.918- 0.940 with an average value of 0.928 between selected sampling stations during low tide

Simpson diversity index (1-D) of Zooplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks during high tide and low tide period of neap tide except few, which was varying from 0.844 - 0.929 between selected sampling stations with an average of 0.897 during high tide period and was varying from 0.844 -0.940 with an average value of 0.916 between selected sampling stations during consecutive low tide .This species diversity suggests a relatively more successful species in this habitat during January 2022 sampling.

Simpson diversity index (1-D) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.902 and 0.906 respectively. Simpson diversity index (1-D) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.892 and 0.894respectively.

Simpson diversity index (1-D) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of Neap tide was recorded as 0.896 - 0.810 respectively. Simpson diversity index (1-D) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.805 and 0.814 respectively.

Table # 12 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND NEAR BY CREEKS DURING SPRING TIDE IN JANUARY 2022

Tide	Sampling Station	Abundance In N x10³/m³	No of Species /groups observed /total species/ group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	197	29/33	87.88	5.3	1.301	0.9413
	2	187	29/33	87.88	5.353	1.316	0.9421
	3	224	25/33	75.75	4.435	1.208	0.9251
	4	236	28/33	84.85	4.942	1.218	0.9177
	5	195	21/33	63.64	3.793	1.124	0.8971
	6	72	15/33	45.45	3.274	1.051	0.9053
LOW TIDE	1	210	25/33	75.75	4.488	1.274	0.9402
	2	217	25/33	75.75	4.461	1.219	0.9268
	3	241	25/33	75.75	4.376	1.219	0.9186
	4	225	25/33	75.75	4.431	1.273	0.9394
	5	230	22/33	75.75	3.862	1.172	0.9185

Table # 13 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND NEAR BY CREEKS DURING NEAP TIDE IN JANUARY 2022

Tide	Sampling Station	Abundance In No x10³/ m³	No of Species /groups observed /total species/ group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	195	29/31	93.55	5.31	1.254	0.9265
	2	159	22/31	70.97	4.143	1.173	0.9184
	3	205	25/31	80.64	4.509	1.227	0.9192
	4	218	27/31	87.09	4.829	1.109	0.8611
	5	135	21/31	67.74	4.077	1.181	0.9152
	6	89	19/31	61.29	4.01	1.037	0.844
LOW TIDE	1	199	25/31	80.64	4.534	1.268	0.9407
	2	192	24/31	77.42	4.375	1.216	0.9249
	3	208	26/31	83.87	4.684	1.257	0.9348
	4	191	22/31	70.96	3.998	1.221	0.9306
	5	168	20/31	64.52	3.708	1.183	0.9261

Table # 14 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND , NEAR BY CREEKS DURING SPRING TIDE IN JANUARY 2022

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton x10³ Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinids	4-46	7/33	21.22
			Copepods	62-47	11/33	33.33
			Arrow worms	0-4	1/33	3.03
			Mysids	0-4	1/33	3.03
			Urochordata	0-4	1/33	3.03
			Medusa	0-4	1/33	3.03
			Foraminferans	8-14	2/33	6.06
			Larval forms	29-109	9/33	27.27
			TOTAL ZOOPLANKTON N/ M³	197-187	33	-
LOW TIDE	Sub surface	5	Tintinids	39-42	7/33	21.22
			Copepods	51-59	11/33	33.33
			Arrow worms	1-4	1/33	3.03
			Mysids	0-4	1/33	3.03
			Urochordata	0-4	1/33	3.03
			Medusa	0-4	1/33	3.03
			Foraminferans	12-19	2/33	6.06
			Larval forms	92-117	9/33	27.27
			TOTAL ZOOPLANKTON N/M³	210-217	33	-

Table # 15 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA IN KANDLA CREEK AND , NEAR BY CREEKS DURING NEAP TIDE IN JANUARY 2022

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^3$ Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinids	16-32	4/31	12.90
			Copepods	28-79	11/31	35.48
			Arrow worms	0-6	1/31	3.23
			Urochordata	0-6	2/31	6.45
			Ciliates	0-2	1/31	3.23
			Medusa	0-4	1/31	3.23
			Larval forms	38-115	9/31	29.03
			Foraminiferans	0-10	2/31	6.45
			TOTAL ZOOPLANKTON N/M^3	89-218	31	-
LOW TIDE	Sub surface	5	Tintinids	27-37	4/31	12.90
			Copepods	39-59	11/31	35.48
			Arrow worms	0-4	1/31	3.23
			Urochordata	0-4	2/31	6.45
			Ciliates	0-2	1/31	3.23
			Medusa	0-4	1/31	3.23
			Larval forms	93-102	9/31	29.03
			Foraminiferans	5-10	2/31	6.45
			TOTAL ZOOPLANKTON N/M^3	168-208	31	

Table # 16 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING SPRING TIDE IN JANUARY 2022

Tide	Sampling Station	Abundance In x10^{3}N / m^3	No of Species /groups observed /total species/ group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	145	18/18	100	3.416	1.101	0.9023
	SPM	144	18/18	100	3.421	1.114	0.9068
LOW TIDE	Jetty	155	17/18	94.44	3.172	1.07	0.8925
	SPM	124	17/18	94.44	3.319	1.059	0.894

Table # 17 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING NEAP TIDE IN JANUARY 2022

Tide	Sampling Station	Abundance In N x10^3/ m^3	No of Species /groups observed /total species/ group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	104	18/19	94.74	3.66	1.081	0.8969
	SPM	103	14/19	73.68	2.805	0.8971	0.8104
LOW TIDE	Jetty	131	19/19	100	3.692	0.9673	0.8055
	SPM	134	16/19	100	3.063	0.9421	0.8147

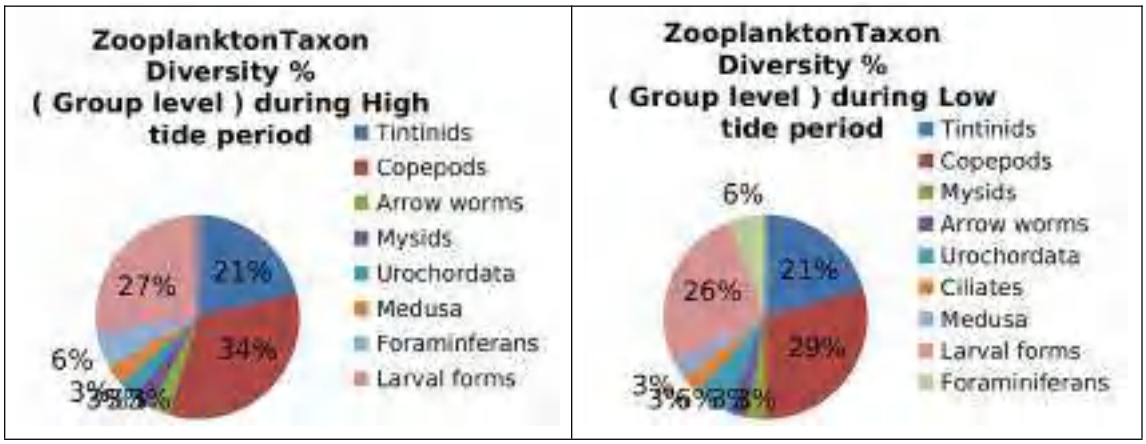
Table # 18 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING SPRING TIDE IN JANUARY 2022

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton x10^3 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	Tintinids	25-27	4/18	22.22
			Copepods	49-57	6/18	33.33
			Arrow worms	4	1/18	5.56
			Foraminferans	2-4	1/18	5.56
			Larval forms	55-62	6/18	33.33
			TOTAL ZOOPLANKTON NO/L	**144-145**	**18**	
LOW TIDE	Sub surface	2	Tintinids	22-25	4/18	22.22
			Copepods	44-62	6/18	33.33
			Arrow worms	1-2	1/18	5.56
			Foraminferans	1-2	1/18	5.56
			Larval forms	55-63	6/18	33.33
			TOTAL ZOOPLANKTON NO/M3	**124-155**	**18**	

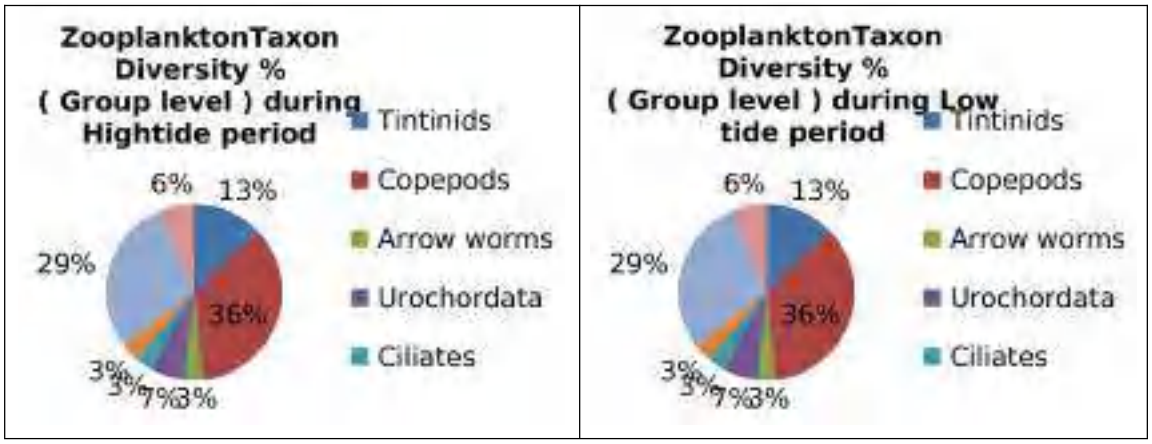
Table # 19 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING NEAP TIDE IN JANUARY 2022

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton x10^3 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	Tintinids	10-17	4/19	21.05
			Copepods	36-42	6/19	31.58
			Foraminferans	0-2	2/19	10.53
			Larval forms	43-57	7/19	36.84
			TOTAL ZOOPLANKTON	**103-104**	**19**	**-**
LOW TIDE	Sub surface	2	Tintinids	14-21	4/19	21.05
			Copepods	31-39	6/19	31.58
			Foraminferans	4-10	2/19	10.53
			Larval forms	71-75	7/19	36.84
			TOTAL ZOOPLANKTON NO/M3	**131-134**	**19**	**-**

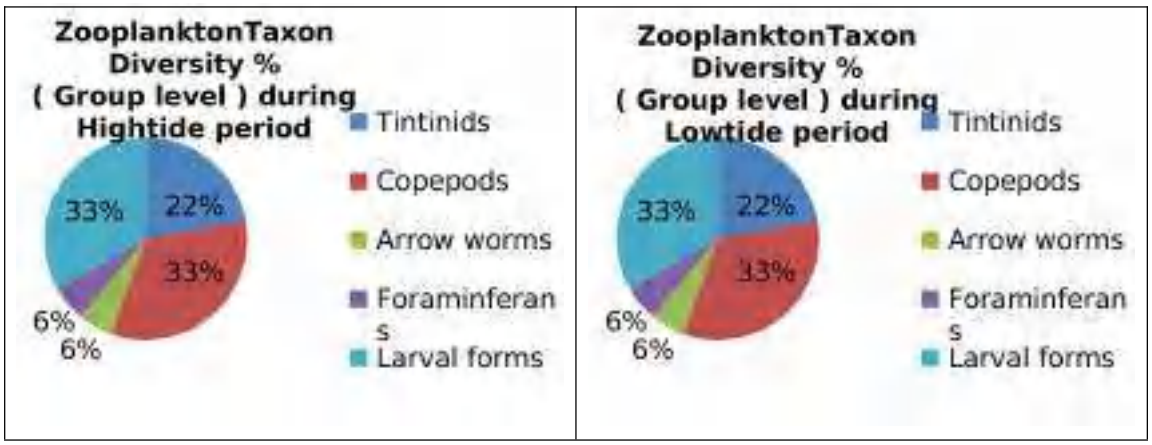
Taxon Diversity % of Zooplankton during High tide and Low tide period of Spring tide In Kandla Creek and nearby Creeks



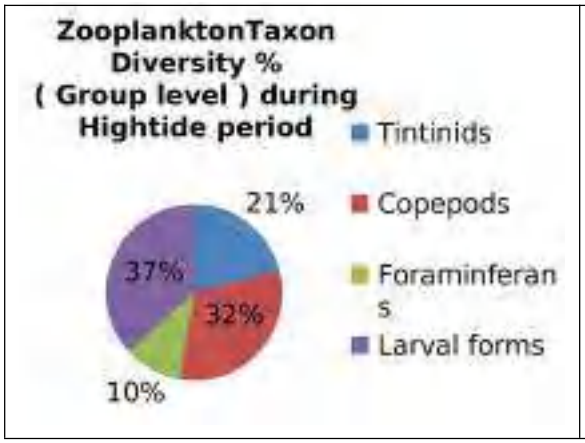
Taxon Diversity % of Zooplankton during High tide and Low tide period of Neap tide In Kandla Creek and nearby Creeks



Taxon Diversity % of Zooplankton during High tide and Low tide period of Spring tide In Path Finder Creek and near Jetty



Taxon Diversity % of Zooplankton during High tide and Low tide period of Neap tide In Path Finder Creek near jetty and nearby SPM



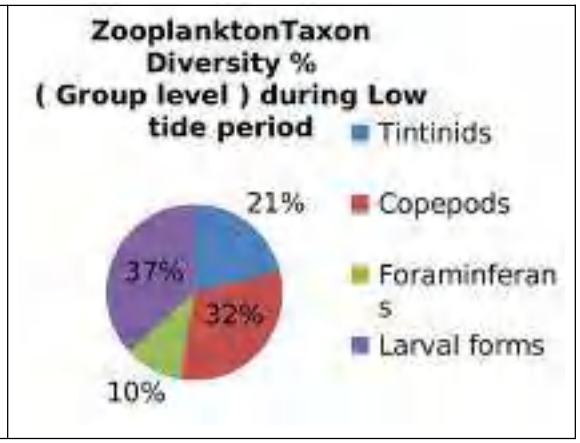


TABLE # 20 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS OF DPT HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING SPRING TIDE OF JANUARY 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAE	Cyanophyta	Cyanophyceae	Nostocales	Oscillatoriaceae	*Arthrospira sp.*	B1	Very sparse
					Oscillatoria sp.	B2	Very sparse
					Lyngbya sp.	B3	Very sparse
			Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B4	Sparse
			Stigonematales	Stigonemataceae	*Stigonema sp.*	B5	Very sparse
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Thalassiosirales	Thalassiosiraceae	*Planktoniella* sp	D1	Very sparse
			Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D2	Dominant
			Triceratiales	Triceratiaceae	*Odontella sp*	D3	Very sparse
					Triceratium sp.	D4	Very sparse
			Biddulphiales	Biddulphiaceae	*Biddulphia* sp	D5	Scattered
			Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D6	Very sparse
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D7	Scattered
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp	D8	Abundant
			Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D9	Sparse
			Melosirales	Melosiraceae	*Melosira sp*	D10	Very sparse
		Bacillariophyceae	Naviculales	Pleurosigmataceae	*Pleurosigma* sp	D11	Very sparse
			Naviculales Suborder:Sellaphorineae	Pinnulariaceae	*Pinnularia sp.*	D12	Very sparse
			Bacillariales	Bacillariaceae	*Bacillaria* sp.	D13	Sparse
					Nitzschia sp	D14	Very sparse
					Pseudo-nitzschia sp	D15	Very sparse
			Surirellales	Surirellaceae	*Surirella* sp	D16	Very sparse
				Entomoneidaceae	*Entomoneis sp.*	D17	Very sparse
		Fragilariophyceae	Thalassionematales	Thalassionemataceae	*Thalassiothrix sp.*	D18	Sparse
					Thalassionema sp.	D19	Very sparse
			Fragilariales	Fragilariaceae	*Fragilaria* sp	D20	Sparse
					Synedra sp	D21	Sparse
			Tabellariales	Tabellariaceae	*Tabellaria* sp	D22	Very sparse
DINO FLAGELLATES	Dinoflagellata / Dinozoa	Noctilucea / Noctiluciphyceae (Dinokaryota)	Noctilucales	Noctilucaceae	*Noctiluca* sp.	DF1	Very sparse
		Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF2	Very sparse
			Gonyaulacales	Ceratiaceae	*Ceratium furca*	DF3	Sparse
					Ceratium tripos	DF4	Very sparse

TABLE # 21 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPT HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING AND NEAP TIDE OF JANUARY 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAE	Cyanophyta	Cyanophyceae	Nostocales	Oscillatoriaceae	*Oscillatoria sp.*	B1	Very Sparse
					Lyngbya sp.	B2	Very Sparse
			Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B3	Very Sparse
			Stigonematales	Stigonemataceae	*Stigonema sp.*	B4	Very Sparse
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Thalassiosirales	Thalassiosiraceae	*Planktoniella* sp	D1	Very Sparse
					Thalassiosira sp	D2	Very Sparse
				Lauderiaceae	*Lauderia sp*	D3	Very Sparse
			Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D4	Dominant
			Triceratiales	Triceratiaceae	*Odontella sp*	D5	Very Sparse
					Triceratium sp.	D6	Very Sparse
			Biddulphiales	Biddulphiaceae	*Biddulphia* sp	D7	Sparse
			Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D8	Very Sparse
				Hemiaulaceae	*Cerataulina sp.*	D9	Very Sparse
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D10	Sparse
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp.	D11	Abundant
			Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D12	Scattered
		Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria* sp.	D13	Sparse
					Nitzschia sp	D14	Sparse
					Pseudo-nitzschia sp.	D15	Very Sparse
			Naviculales	Pleurosigmataceae	*Pleurosigma* sp.	D16	Sparse
		Fragilariophyceae	Thalassionematales	Thalassionemataceae	*Thalassiothrix sp.*	D17	Sparse
					Thalassionema sp.	D18	Very Sparse
			Fragilariales	Fragilariaceae	*Fragilaria* sp	D19	Sparse
					Synedra sp	D20	Sparse
			Tabellariales	Tabellariaceae	*Tabellaria* sp	D21	Very Sparse
DINO FLAGELLATES	Dinoflagellata / Dinozoa	Noctilucea / Noctiluciphyceae (Dinokaryota)	Noctilucales	Noctilucaceae	*Noctiluca* sp.	DF1	Very Sparse
		Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF2	Very Sparse
			Gonyaulacales	Ceratiaceae	*Ceratium furca*	DF3	Sparse
					Ceratium tripos	DF4	Very Sparse

TABLE # 22 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPT OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING SPRING TIDE OF JANUARY 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAE	Cyanophyta	Cyanophyceae	Nostocales	Oscillatoriaceae	*Lyngbya sp.*	B1	Very sparse
					Oscillatoria sp.	B2	Very sparse
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D1	Dominant
			Triceratiales	Triceratiaceae	*Odontella* sp	D2	Very sparse
			Biddulphiales	Biddulphiaceae	*Biddulphia* sp	D3	Sparse
			Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D4	Very sparse
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D5	Scattered
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp	D6	Abundant
			Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D7	Sparse
		Bacillariophyceae	Naviculales	Pleurosigmataceae	*Pleurosigma* sp	D8	Very sparse
			Bacillariales	Bacillariaceae	*Bacillaria* sp.	D9	Sparse
					Nitzschia sp	D10	Sparse
		Fragilariophyceae	Fragilariales	Fragilariaceae	*Fragilaria* sp	D11	Very sparse
					Synedra sp.	D12	Sparse
			Climacospheniales	Climacospheniaceae	*Climacosphenia sp.*	D13	Very sparse
			Licmophorales	Licmophoraceae	*Licmophora sp.*	D14	Very sparse
			Thalassionematales	Thalassionemataceae	*Thalassiothrix sp.*	D15	Very sparse
DINOFLAGELLATES	Dinoflagellata / Dinozoa	Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Very sparse
			Gonyaulacales	Ceratiaceae	*Ceratium furca*	DF2	Sparse
					Ceratium tripos	DF3	Very sparse

TABLE # 23 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPT OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING AND NEAP TIDE OF JANUARY 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAE	Cyanophyta	Cyanophyceae	Nostocales	Oscillatoriaceae	*Arthrospira sp.*	B1	Very Sparse
					Lyngbya sp.	B2	Very Sparse
					Oscillatoria sp.	B3	Sparse
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D1	Dominant
			Triceratiales	Triceratiaceae	*Odontella sp.*	D2	Very Sparse
					Triceratium sp	D3	Very Sparse
			Biddulphiales	Biddulphiaceae	*Biddulphia* sp	D4	Scattered
			Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D5	Very Sparse
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D6	Very Sparse
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp	D7	Sparse
			Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D8	Scattered
		Bacillariophyceae	Naviculales	Naviculaceae	*Navicula* sp	D9	Very Sparse
				Pleurosigmataceae	*Pleurosigma* sp	D10	Very Sparse
			Bacillariales	Bacillariaceae	*Bacillaria* sp.	D11	Scattered
					Nitzschia sp	D12	Sparse
		Fragilariophyceae	Fragilariales	Fragilariaceae	*Synedra sp.*	D13	Sparse
			Thalassionematales	Thalassionemataceae	*Thalassiothrix sp.*	D14	Sparse
			Climacospheniales	Climacospheniaceae	*Climacosphenia sp.*	D15	Very Sparse
			Licmophorales	Licmophoraceae	*Licmophora sp.*	D16	Very Sparse
DINO FLAGELLATES	Dinoflagellata / Dinozoa	Dinophyceae	Gonyaulacales	Ceratiaceae	*Ceratium furca*	DF1	Very Sparse

TABLE # 24 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPT HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING SPRING TIDE OF JANUARY 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnus sp.*	T1	Scattered
				Codonellidae	*Tintinnopsis dadayi*	T2	Very sparse
					Tintinnopsis failakkaensis	T3	Sparse
					Tintinnopsis gracilis	T4	Sparse
					Tintinnopsis mortensenii	T5	Very sparse
					Tintinnopsis radix	T6	Sparse
				Xystonellidae	*Favella* sp.	T7	Very sparse
COPEPODS	ATHROPODA	Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Scattered
					Parvocalanus sp.	C2	Very sparse
				Eucalanidae	*Pareucalanus sp.*	C3	Very sparse
				Clausocalanidae	*Clausocalanus sp.*	C4	Very sparse
				Euchaetidae	*Euchaeta sp.*	C5	Very sparse
				Centropagidae	*Centropages sp.*	C6	Very sparse
			Cyclopoida	Oithonidae	*Oithona sp.*	C7	Abundant
			Harpacticoida	Ectinosomatidae	*Microsetella* sp.	C8	Abundant
				Clytemnestridae	*Clytemnestra sp.*	C9	Very sparse
				Euterpinidae	*Euterpina sp.*	C10	Very sparse
			Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C11	Very sparse
ARROW WORMS	CHAETOGNATHA	Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse
MYSIDS	ATHROPODA CRUSTACEA	Malacostraca	Mysida, Decapoda	Penaeidae	*Metapenaeus sp.*	M1	Very sparse
UROCHORDATA	CHORDATA SUB PHYLUM UROCHORDATA	Appendicularia		Oikopleuridae	*Oikopleura sp.*	U1	Very sparse
MEDUSA	PHYLUM CNIDARIA	Hydrozoa			Unidentified medusa	ME1	Very sparse
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of Copepods	L1	Dominant
HYDROZOA LARVAE	CNIDARIA	Hydrozoa			Actinula larvae	L2	Very sparse
BRACHYURA LARVAE	ARTHROPODA (CRUSTACEA)	Malacostraca Decapoda			Brachyuran Zoea larvae	L3	Abundant
CYPHONAUTES LARVAE	BRYOZOA				Cyphonautes larvae	L4	Very sparse

BARNACLE LARVAE	ATHROPODA CRUSTACEA	Maxillopoda Thecostraca			Cirripede larvae	L5	Very sparse
ECHINODERMATA LARVAE	ECHINODERMATA				Ophipluutes larvae/ Echinoplutes larvae	L6	Very sparse
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L7	Sparse
POLYCHAETE LARVAE	ANNELIDA	Polychaeta			Trochophore larvae	L8	Sparse
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of Bivalves	L9	Sparse
FORAMINIFERA	FORAMINIFERA	Globothalamea	Rotaliida	Globigerinidae	*Globigerina* sp.	F1	Sparse
				Rotalliidae	*Rotalia* sp.	F2	Sparse

TABLE # 25 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING OF DPT HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING NEAP TIDE OF JANUARY 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnus sp.*	T1	Sparse
				Codonellidae	*Tintinnopsis gracilis*	T2	Very Sparse
					Tintinnopsis radix	T3	Sparse
					Tintinnopsis failakkaensis	T4	Sparse
COPEPODS	ATHROPODA	Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Scattered
					Parvocalanus sp.	C2	Very Sparse
				Eucalanidae	*Pareucalanus sp.*	C3	Very Sparse
				Clausocalanidae	*Clausocalanus sp.*	C4	Very Sparse
				Centropagidae	*Centropages sp.*	C5	Very Sparse
				Temoridae	*Temora sp.*	C6	Very Sparse
			Cyclopoida	Oithonidae	*Oithona sp.*	C7	Abundant
			Harpacticoida	Ectinosomatidae	*Microsetella* sp.	C8	Abundant
				Euterpinidae	*Euterpina sp.*	C9	Very Sparse
			Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C10	Very Sparse
				Corycaeidae	*Corycaeus sp.*	C11	Very Sparse
ARROW WORMS	CHAETOGNATHA	Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very Sparse

UROCHORDATA	CHORDATA SUB PHYLUM UROCHORDATA	Appendicularia		Oikopleuridae	*Oikopleura sp.*	U1	Very Sparse
				Fritillariidae	*Fritillaria sp.*	U2	Very Sparse
CILIATES	CILIOPHORA	Oligohymenophorea	Sessilida	Zoothamniidae	*Zoothamnium sp.*	CI1	Very Sparse
MEDUSA	PHYLUM CNIDARIA	Hydrozoa			Unidentified medusa	ME 1	Very Sparse
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of Copepods	L1	Dominant
HYDROZOA LARVAE	CNIDARIA	Hydrozoa			Actinula larvae	L2	Very Sparse
BRACHYURA LARVAE	ARTHROPODA (CRUSTACEA)	Malacostraca Decapoda			Brachyuran Zoea larvae	L3	Scattered
BARNACLE LARVAE	ATHROPODA CRUSTACEA	Maxillopoda Thecostraca			Cirripede larvae	L4	Sparse
CYPHONAUTES LARVAE	BRYOZOA				Cyphonautes larvae	L5	Sparse
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L6	Sparse
ECHINODERMATA LARVAE	ECHINODERMATA				Ophipluutes larvae/ Echinoplutes larvae	L7	Sparse
POLYCHAETE LARVAE	ANNELIDA	Polychaeta			Trochophore larvae	L8	Sparse
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of Bivalves	L9	Very Sparse
FORAMINIFERA	FORAMINIFERA	Globothalamea	Rotaliida	Globigerinidae	*Globigerina* sp.	F1	Sparse
				Rotalliidae	*Rotalia* sp.	F2	Very Sparse

TABLE # 26 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPT OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING SPRING TIDE OF JANUARY 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnus sp.*	T1	Sparse
				Codonellidae	*Tintinnopsis failakkaensis*	T2	Very sparse
					Tintinnopsis gracilis	T3	Sparse
				Xystonellidae	*Favella* sp.	T4	Very sparse
COPEPODS	ATHROPODA	Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Sparse
				Eucalanidae	*Pareucalanus sp.*	C2	Very sparse
			Cyclopoida	Oithonidae	*Oithona sp.*	C3	Abundant
			Harpacticoida	Ectinosomatidae	*Microsetella* sp.	C4	Scattered
				Euterpinidae	*Euterpina sp.*	C5	Sparse
			Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C6	Very sparse
ARROW WORMS	CHAETOGNATHA	Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of Copepods	L1	Dominant
BRACHYURA LARVAE	ARTHROPODA (CRUSTACEA)	Malacostraca Decapoda			Brachyuran Zoea larvae	L2	Sparse
BARNACLE LARVAE	ATHROPODA CRUSTACEA	Maxillopoda Thecostraca			Cirripede larvae	L3	Very sparse
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L4	Very sparse
POLYCHAETE LARVAE	ANNELIDA	Polychaeta			Trochophore larvae	L5	Sparse
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of Bivalves	L6	Very sparse
FORAMINIFERA	FORAMINIFERA	Globothalamea	Rotaliida	Globigerinidae	*Globigerina* sp.	F1	Very sparse

TABLE # 27 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPT OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING NEAP TIDE OF JANUARY 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnus sp.*	T1	Sparse
				Codonellidae	*Tintinnopsis failakkaensis*	T2	Sparse
					Tintinnopsis gracilis	T3	Very Sparse
				Xystonellidae	*Favella* sp.	T4	Very Sparse
COPEPODS	ATHROPODA	Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Scattered
					Parvocalanus sp.	C2	Very Sparse
			Cyclopoida	Oithonidae	*Oithona sp.*	C3	Abundant
			Harpacticoida	Euterpinidae	*Euterpina sp.*	C4	Sparse
				Ectinosomatidae	*Microsetella* sp.	C5	Very Sparse
			Poicilostomatatoid a	Oncaeidae	*Oncaea sp.*	C6	Very Sparse
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of Copepods	L1	Dominant
BARNACLE LARVAE	ATHROPODA CRUSTACEA	Maxillopoda Thecostraca			Cirripede larvae	L2	Sparse
CYPHONAUTES LARVAE	BRYOZOA				Cyphonautes larvae	L3	Sparse
ECHINODERMATA LARVAE	ECHINODERMAT A				Ophipluutes larvae/ Echinoplutes larvae	L4	Sparse
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L5	Very Sparse
POLYCHAETE LARVAE	ANNELIDA	Polychaeta			Trochophore larvae	L6	Very Sparse
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of Bivalves	L7	Very Sparse
FORAMINIFERA	FORAMINIFERA	Globothalamea	Rotaliida	Globigerinidae	*Globigerina* sp.	F1	Very Sparse
				Rotalliidae	*Rotalia* sp.	F2	Very Sparse

BENTHIC ORGANISMS:

Few Benthic organisms were observed in the collected sediments by using the Van-veen grabs during the sampling conducted during spring tide period and Neap tide period from DPT harbour region and nearby creek. The meiobenthic organisms during spring tide were represented by Polychaetes *Dasybranchus* sp., *Notomastus* sp and *Syllis* sp., and Nematodes. , During Neap tide Polychates *Phyllodoce* sp. , Dasybranchus sp *Notomastus* sp and Nematode worms were detected.

Table # 28 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPT HARBOUR AREA CREEKS DURING SPRING TIDE IN JANUARY 2022

Benthic fauna	ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS REPRESENTATION BY GROUP						
	DPT HARBOUR			CREEKS			
POLYCHAETES	KPT-1	KPT-2	KPT-3	KPT-4	KPT-5	KPT-6	
Family : Capit*ellidae* *Dasybranchus* sp.	0	60	0	20	10	0	
Family : Capit*ellidae* *Notomastus* sp	0	40	20	40	20	0	
Family : Syllidae *Syllis* sp.	0	0	40	0	0	0	
Total Polychates N/M^2	0	60	40	20	10	0	
Un identified Nematode worms	20	40	20	40	40		
TOTAL Benthic Fauna NUMBER/ M^2	20	200	120	120	80	0	

NS : No sample

Table # 29 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPT HARBOUR AREA CREEKS DURING NEAP TIDE IN JANUARY 2022

Benthic fauna	ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS REPRESENTATION BY GROUP						
	DPT HARBOUR			CREEKS			
POLYCHAETES	KPT-1	KPT-2	KPT-3	KPT-4	KPT-5	KPT-6	
Family Phyllodocidae *Phyllodoce* sp.	0	40	20	60	50	0	
Family : Capit*ellidae* Dasybranchus sp	0	20	40	20	20	0	
Family : Capit*ellidae* *Notomastus* sp	0	0	20	40	40	0	
Total Plychates	0	60	80	120	110	0	
Un identified Nematode worms	20	40	40	20	10	0	
TOTAL Benthic Fauna NUMBER/ M^2	20	100	120	140	120	0	

Table # 30 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPT OOT AT PATH FINDER CREEK DURING Spring TIDE IN JANUARY 2022

Benthic fauna	ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS REPRESENTATION BY GROUP	
	OOT jetty	SPM
POLYCHAETES		
Family: Nereidae Perineris sp.	10	20
Family Glyceridae	10	40
Total Polychates N/M^2		
Un identified Amphipods	20	40
Un identified Nematodes	30	40
Brittle star	0	10
TOTAL Benthic Fauna NUMBER/ M^2	70	150

6. Meteorological Data

Automatic Weather station have been installed in Seva Sadan -3 at the Deendayal Port which records the data on Temperature (°C), Humidity (%),Wind (mph), Dew Point (°C), Wind Direction (°), Pressure, Solar radiation, heat Index and UVI.

Temperature

The mean day time temperature for Deendayal Port was 19.8 °C. The day-time maximum temperature was 30.8°C. The mean night time temperature was 12.6 °C. The minimum mean night time temperature recorded was 25.2 °C.

Air Pressure

The mean absolute air pressure for the month of January was 1015.9 hpa, whereas the mean relative pressure was 1016.04 hpa. The maximum absolute air pressure recorded for the month of January was 1021.9 hpa.

Heat Index

The mean day-time heat index for the month of January was 27.18 ^{o}C. The maximum heat index recorded was 32°C.

Solar Radiation

The mean Solar Radiation in January was 115.27 w/m^2. The maximum solar radiation recorded in the month of October was 530.7 w/m^2.

Humidity

The mean day-time humidity was 61.69 % for the month of January and mean night time humidity was 47.22%. Maximum humidity recorded during day-time was 96.0 % and maximum humidity recorded during night-time was 69.0%.

Wind Velocity and Wind Direction

The mean wind velocity for the entire month of January was 4.4 km/hour. Maximum wind velocity recorded was 20.9 Km/hr . The wind direction was mostly N to NW.

Conclusive Summary and Remedial measures Suggested

The AAQ monitoring at six locations of Deendayal Port indicates that the mean PM_{10} values at four locations viz. Coal storage area, Marine Bhavan, Gopalpuri, Tuna Port , Kandla Colony and Oil Jetty area were found above the permissible standards (100 µg/m^3) and $PM_{2.5}$ was above permissible limits at Coal storage location(Limit 60 µg/m^3).

Drinking water at all the twenty locations was found potable and was within permissible limits of BIS standards (IS 10500).

Noise quality was also within the set permissible standards of an Industrial Area. The noise level observed during day time was >75 dB (A) and at night time was >70 dB (A) during the entire monitoring period.

The sewage treated water of Deendayal Port Colony (Gopalpuri) was in line with the standards set by the Gujarat Pollution Control Board.

Reasons for higher Values of PM_{10}

Large amount of coal is handled at Berth No. 6, 7, 8 and 9. The unloading of coal directly in the truck, using grabs cause coal to spread in air as well as coal dust to fall on ground. This settled coal dust again mixes with the air while trucks travel through it.

Also, the coal laden trucks are not always covered with tarpaulin sheets and these results in spillage of coal from trucks/dumpers during its transit from vessel to yard or storage site. This also increased PM values around marine Bhavan & Coal storage area.

Remedial Measures

The values of PM_{10} & PM2.5 during the month of January, 2022 were observed beyond the permissible limit at four locations mentioned above. Given below are the remedial measures suggest to minimize the Air pollution at Deendayal Port.

Guidelines for Coal Handling by GPCB should be strictly followed. (http://gpcb.gov.in/pdf/coal-handling-guidelines.pdf)

Except for the higher values of PM_{10} & PM2.5 at Coal storage site, Oil Jetty, Tuna Port and Marine Bhavan locations, the monitoring results for the present month suggest that the overall Environment Quality of Deendayal Port is satisfactory.

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Introduction

Monitoring of various environmental aspects of the Deendayal port by M/s Detox Corporation Pvt. Ltd. has been carried out through collection of samples, analysis of the same, comparing results with respect to the national standards and any other relevant standards by GPCB/CPCB/MoEF to identify non conformity in the Environment of the Deendayal Port. The results shall address the identified impacts and suggest measures to minimize the environmental impact due to various operations at Deendayal Port.

The environmental monitoring is carried out as per the Environment Management and Monitoring Plan submitted by Detox Corporation Pvt. Ltd.

1. Ambient Air Quality Monitoring

As per the Environmental Monitoring Plan of Deendayal Port Trust, Air monitoring was carried out at six identified locations at Deendayal Port and two locations at Vadinar Port.

1.1 Air Quality Monitoring Methodology

Air quality is measured in all the stations, for 24 hour for Total Suspended Particulate Matter (TSPM), PM_{10}, $PM_{2.5}$, SO_2, NO_X, NH_3 & Benzene, and Grab-sampling for CO & CO_2 measurements. The Air samplers are operated for a period of 24 hours and after a continuous operation of 8 hours of the sampler, the reagents were replaced to obtain 3 samples per day for each parameter namely, SO_2, NO_X. The EPM 2000 filter paper and PTFE Membrane bound filter paper are used for a period of 24 hours to obtain one sample each of TSPM, PM_{10} & $PM_{2.5}$. The AAQ samples are collected twice a week from all the eight locations as per the EMP.

1.2 Results

The ambient air quality monitoring data for six stations, viz. Marine Bhavan, Oil Jetty, Port Colony, Gopalpuri Hospital, Tuna Port and Nr. Coal Storage Area for the month of February 2022 are given in Tables 1A to 6B. The ambient air quality monitoring data for two stations at Vadinar (Nr. Admin Building & Nr. Signal Building) are given in Tables 7A to 8B.

Location 1: Marine Bhavan (AL1)

Table 1 : Results of Air Pollutant Concentration at Marine Bhavan

Parameter	Date	TSPM [µg/m³]	PM10 [µg/m³]	PM2.5 [µg/m³]	SO_2 [µg/m³]		NOx [µg/m³]		NH_3 [µg/m³]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit		NS	100 [µg/m3]	60 [µg/m3]		80 [µg/m3]		80 [µg/m3]		400 [µg/m³]
AL1 – 1	01.02.2022	330	188	76	3.08	4.69	18.42	15.46	10.47	11.57
					5.28		13.34		11.49	
					5.71		14.61		12.76	
AL1 – 2	04.02.2022	330	183	65	3.08	4.4	12.07	15.24	12.76	11.15
					4.84		12.7		10.21	
					5.28		20.96		10.47	
AL1 – 3	08.02.2022	341	195	84	3.52	4.1	15.24	19.48	10.21	9.87
					3.08		22.23		10.47	
					5.71		20.96		8.93	
AL1 – 4	11.02.2022	427	231	102	3.52	3.66	17.15	16.3	12.76	11.83
					2.64		19.69		12.25	
					4.84		12.07		10.47	
AL1 – 5	15.02.2022	477	304	108	3.08	4.4	15.24	16.09	7.4	9.36
					5.28		12.07		10.21	
					4.84		20.96		10.47	
AL1 - 6	18.02.2022	522	319	106	3.08	3.81	13.34	15.46	9.19	8.76
					4.4		20.96		9.7	
					3.96		12.07		7.4	
AL1 - 7	22.02.2022	423	231	93	3.52	3.37	13.34	16.94	9.7	8.68
					3.96		19.69		8.93	
					2.64		17.78		7.4	
AL1 – 8	25.02.2022	447	247	98	3.52	3.52	19.05	16.94	10.21	10.55
					2.64		12.07		10.98	
					4.4		19.69		10.47	
Monthly		412	237	92		3.99		16.49		10.22

Average									
Standard Deviation	72	52	15		0.47		1.37		1.24

NS -Not Specified

Table 1 : Results of Air Pollutant Concentration at Marine Bhavan					
Parameter	**Date**	**C_6H_6 [µg/m³]**	**HC* [ppm]**	**CO [mg/m³]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m³**	**NS**	**4.0 mg/m³**	**NS**
AL1 – 1	01.02.2022	1.2	BDL	1.06	516
AL1 – 2	04.02.2022	1.16	BDL	1.92	430
AL1 – 3	08.02.2022	1.32	BDL	1.49	513
AL1 – 4	11.02.2022	1.2	BDL	2.09	923
AL1 – 5	15.02.2022	1.23	BDL	1.97	1038
AL1 - 6	18.02.2022	1.165	BDL	1.95	437
AL1 - 7	22.02.2022	1.181	BDL	1.94	1127
AL1 - 8	25.02.2022	1.033	BDL	2.24	435
Monthly Average		**1.19**	**-**	**1.83**	**677**
Standard Deviation		**0.08**	**-**	**0.38**	**298**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm) NS -Not Specified

At Marine Bhavan, the overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_X and NH_3 is attributed mainly by motor vehicle emission produced from various types of automobiles (both diesel and petrol driven). Moreover, the loading and unloading of Food Grains and Timber at Jetty no. 1 and 2 also contributes to the high levels of TSPM and PM_{10}. The mean TSPM value at Marine Bhavan was 412µg/m³, The mean PM_{10} values were 237.0 µg/m³, which is above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean 92.0 µg/m³). The average values of SO_2, NO_x and NH_3 were within the permissible limit. The average values of SO_2, NO_x and NH3 were 3.99 µg/ m³, 16.49 µg/ m³ & 10.22 µg/ m³ respectively. These were within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Marine Bhavan. The mean Benzene concentration was 1.19 µg/m³, well below the permissible limit of 5.0 µg/m³. HC's were below the detectable limit

and Carbon Monoxide concentration was 1.83 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 2: Oil Jetty (AL2)

Table 1 : Results of Air Pollutant Concentration atOil Jetty										
Parameter	**Date**	**TSPM [µg/m³]**	**PM10 [µg/m³]**	**PM2.5 [µg/m³]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit		**NS**	**100 [µg/m3]**	**60 [µg/m3]**		**80 [µg/m3]**		**80 [µg/m3]**		**400 [µg/m³]**
AL2 – 1	01.02.2022	260	108	72	3.08	3.52	15.24	18	12.51	11.66
					3.52		19.69		13.27	
					3.96		19.05		9.19	
AL2 – 2	04.02.2022	337	179	80	2.2	2.93	20.33	17.15	7.91	7.4
					2.64		17.78		10.47	
					3.96		13.34		3.83	
AL2 – 3	08.02.2022	377	180	88	5.71	4.98	11.43	16.73	10.98	11.23
					4.84		19.05		9.96	
					4.4		19.69		12.76	
AL2 – 4	11.02.2022	467	272	96	3.52	3.08	19.05	18.21	7.66	9.02
					2.64		19.69		10.47	
					3.08		15.88		8.93	
AL2 – 5	15.02.2022	431	252	92	3.52	3.96	19.05	17.36	8.93	8.42
					3.96		19.69		7.4	
					4.4		13.34		8.93	
AL2 – 6	18.02.2022	500	298	100	5.28	4.84	17.15	13.97	7.4	8.68
					5.71		12.07		7.91	
					3.52		12.7		10.72	
AL2 – 7	22.02.2022	354	190	98	4.4	4.98	19.69	19.9	8.93	10.38
					4.84		19.05		11.49	
					5.71		20.96		10.72	
AL2 – 8	25.02.2022	418	228	94	5.71	4.69	15.24	16.51	7.15	7.74
					4.4		19.69		7.91	
					3.96		14.61		8.17	
Monthly Average		393	213	90		4.12		17.23		9.32
Standard Deviation		77	61	10		0.86		1.69		1.59

NS: Not Specified

Table 2B : Results of Air Pollutant Concentration at Oil Jetty					
Parameter	**Date**	**C_6H_6 [µg/m³]**	**HC* ppm**	**CO [mg/m³]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m³**	**NS**	**4.0 mg/m³**	**NS**
AL2 -1	01.02.2022	1.11	BQL	2.06	546
AL2 -2	04.02.2022	1.17	BQL	1.75	398
AL2 -3	08.02.2022	1.06	BQL	1.86	489
AL2 -4	11.02.2022	1.05	BQL	2.15	1042
AL2 – 5	15.02.2022	1.18	BQL	2.02	29.1
AL2 – 6	18.02.2022	1.13	BQL	1.84	511
AL2 -7	22.02.2022	1.02	BQL	2.03	1131
AL2 – 8	25.02.2022	1.12	BQL	1.95	509
Monthly Average		**1.09**	**-**	**1.96**	**644**
Standard Deviation		**0.05**	**-**	**0.13**	**461**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm) NS- Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Oil Jetty area was mainly by motor vehicle emission produced from various types of vehicles Oil Jetty Area. The mean TSPM values at Oil Jetty were 393 µg/m³. The mean PM_{10} values were 213 µg/m³, which is above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean = 90 µg/m³). The average values of SO_2, NO_x and NH_3 were within the permissible limit, The mean concentration of SO_2, NO_x and NH3 were 4.12 µg/m³,17.23 µg/m³ and 9.32 µg/m³ respectively.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Oil Jetty. The mean Benzene concentration was **1.09** µg/m³. Well below the permissible limit of 5.0 µg/m³. , HC's were below the detectable limit and Carbon Monoxide concentration was 1.96 mg/m³, well below the permissible limit of 4.0 mg/m³.

Location 3: Kandla Colony – Estate Office (AL-3)

Table 1 : Results of Air Pollutant Concentration at Estate Office

Parameter	Date	TSPM [µg/m³]	PM10 [µg/m³]	PM2.5 [µg/m³]	SO2 [µg/m³]		NOx [µg/m³]		NH₃ [µg/m³]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit		NS	100 [µg/m3]	60 [µg/m3]		80 [µg/m3]		80 [µg/m3]		400 [µg/m³]
AL3 – 1	01.02.2022	219	115	80	3.52	3.66	10.8	13.55	10.47	11.83
					3.08		16.51		10.72	
					4.4		13.34		14.3	
AL3 – 2	04.02.2022	379	192	96	4.84	4.54	18.42	19.05	10.21	9.28
					5.28		19.05		10.47	
					3.52		19.69		7.15	
AL3 – 3	08.02.2022	392	248	89	3.08	3.22	14.61	13.13	8.93	9.87
					3.96		12.07		10.21	
					2.64		12.7		10.47	
AL3 – 4	11.02.2022	445	280	100	5.71	4.25	19.05	16.73	8.17	8.17
					3.96		17.78		8.93	
					3.08		13.34		7.4	
AL3 – 5	15.02.2022	425	247	177	5.28	3.37	20.96	18.21	9.96	9.36
					2.2		16.51		10.21	
					2.64		17.15		7.91	
AL3 – 6	18.02.2022	476	282	88	5.71	4.25	17.78	17.15	10.47	10.47
					3.08		13.97		10.21	
					3.96		19.69		10.72	
AL3 – 7	22.02.2022	303	162	96	3.08	3.22	12.07	13.13	10.21	8.51
					3.96		12.7		7.4	
					2.64		14.61		7.91	
AL3 – 8	25.02.2022	328	196	90	3.08	3.96	12.7	17.15	10.21	8.42
					3.52		19.05		7.66	
					5.28		19.69		7.4	
Monthly Average		371	215	102		3.81		16.01		9.49
Standard Deviatio		84	59	31		0.51		2.39		1.22

n										

NS: Not Specified

Table 3B : Results of Air Pollutant Concentration at Estate Office					
Parameter	**Date**	**C6H6 [µg/m3]**	**HC* ppm**	**CO [mg/m3]**	**CO2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**	**NS**	**4.0 mg/m3**	**NS**
AL3 -1	01.02.2022	1.12	BQL	2.14	535
AL3 -2	04.02.2022	1.18	BQL	1.92	444
AL3 -3	08.02.2022	1.04	BQL	7.03	378
AL3 -4	11.02.2022	1.19	BQL	1.97	1087
AL3 – 5	15.02.2022	1.18	BQL	2.05	1122
AL3 – 6	18.02.2022	1.19	BQL	1.73	421
AL3 – 7	22.02.2022	1.16	BQL	1.95	966
AL3 – 8	25.02.2022	1.111	BDL	2.23	419
Monthly Average		**1.15**	**-**	**2.63**	**672**
Standard Deviation		**0.05**	**-**	**1.79**	**326**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm) NS- Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Kandla Port Colony was attributed by vehicle emission produced from trucks and heavy duty vehicles that pass through the road outside Kandla Port Colony. The mean TSPM values at Oil Jetty were 371µg/m^3, The mean PM_{10} values were 215 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean =102 µg/m^3). The average values of SO_2, NO_x and NH_3 were 3.81 µg/m^3,
16.01 µg/m^3 and 9.49 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Kandla Port Colony. The mean Benzene concentration was **1.15** µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC's were below the

detectable limit and Carbon Monoxide concentration was **2.63** mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 4: Gopalpuri Hospital (AL-4)

Table 1 : Results of Air Pollutant Concentration at Gopalpuri Hospital										
Parameter	**Date**	**TSPM [µg/m³]**	**PM10 [µg/m³]**	**PM2.5 [µg/m³]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit		**NS**	**100 [µg/m3]**	**60 [µg/m3]**		**80 [µg/m3]**		**80 [µg/m3]**		**400 [µg/m³]**
AL4 -1	01.02.2022	160	102	54	3.52	3.96	9.53	11.43	7.4	8.08
					3.96		13.34		7.91	
					4.4		11.43		8.93	
AL4 -2	04.02.2022	218	124	91	3.96	2.93	13.34	13.34	5.87	7.57
					2.64		12.07		7.91	
					2.2		14.61		8.93	
AL4 -3	08.02.2022	277	147	80	3.08	3.22	13.34	14.61	7.15	7.06
					2.64		14.61		7.66	
					3.96		15.88		6.38	
AL4 -4	11.02.2022	204	113	88	2.2	2.93	11.43	13.13	7.91	8.17
					3.08		13.34		7.66	
					3.52		14.61		8.93	
AL4 – 5	15.02.2022	355	211	92	3.08	3.52	13.97	13.97	7.66	7.66
					3.52		12.07		7.91	
					3.96		15.88		7.4	
AL4 – 6	18.02.2022	257	155	90	3.08	3.08	15.88	13.97	7.4	8.34
					2.64		11.43		9.19	
					3.52		14.61		8.42	
AL4 – 7	22.02.2022	216	113	72	3.08	3.52	15.24	13.76	7.15	7.57
					3.96		13.34		7.66	
					3.52		12.7		7.91	
AL4 – 8	25.02.2022	261	144	90	3.52	3.66	12.07	13.55	8.42	9.19
					3.08		13.97		8.93	
					4.4		14.61		10.21	
Monthly Average		243	139	82		3.35		13.47		7.96
Standard		58	35	13		0.37		0.94		0.64

Deviation										

NS: Not Specified

Table 4 : Results of Air Pollutant Concentration at Gopalpuri Hospital					
Parameter	**Date**	**C6H6 [µg/m3]**	**HC* ppm**	**CO [mg/m3]**	**CO2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**	**NS**	**4.0 mg/m3**	**NS**
AL4 -1	01.02.2022	1.1	BDL	2.17	532
AL4 -2	04.02.2022	1.26	BDL	1.55	394
AL4 -3	08.02.2022	1.09	BDL	1.68	579
AL4 -4	11.02.2022	1.06	BDL	1.87	994
AL4 – 5	15.02.2022	1.14	BDL	2.1	1123
AL4 – 6	18.02.2022	1.13	BDL	1.78	784
AL4 – 7	22.02.2022	1.14	BDL	2.05	473
AL4 – 8	25.02.2022	1.1	BDL	2.18	780
Monthly Average		**1.13**	**-**	**1.92**	**707**
Standard Deviation		**0.06**	**-**	**0.24**	**258**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm) NS-Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Gopalpuri Hospital was attributed by vehicle emission produced from light motor vehicles of the colony residents. The mean TSPM values at Oil Jetty were 243 µg/m^3, The mean PM_{10} values were 139 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean= 82 µg/m^3). The average values of SO_2, NO_x and NH_3 were 3.35 µg/m^3, 13.47 µg/m^3 and 7.96 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Gopalpuri Hospital. The mean Benzene concentration was **1.13** µg/m^3, well below the permissible limit of

5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was **1.92**

mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 5: Coal Storage Area (AL-5)

Table 1 : Results of Air Pollutant Concentration at Coal Storage Area										
Parameter	**Date**	**TSPM [µg/m³]**	**PM10 [µg/m³]**	**PM2.5 [µg/m³]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit		**NS**	**100 [µg/m3]**	**60 [µg/m3]**		**80 [µg/m3]**		**80 [µg/m3]**		**400 [µg/m³]**
AL5 – 1	01.02.2022	390	208	108	3.52	4.1	20.33	17.57	11.74	9.19
					3.96		20.33		7.4	
					4.84		12.07		8.42	
AL5 – 2	04.02.2022	413	248	104	2.64	3.81	15.88	16.51	8.93	9.45
					4.84		16.51		9.19	
					3.96		17.15		10.21	
AL5 – 3	08.02.2022	566	314	112	4.4	4.54	17.78	15.24	9.96	8.17
					3.96		15.24		7.4	
					5.28		12.7		7.15	
AL5 – 4	11.02.2022	539	301	116	4.4	3.66	13.34	13.97	10.98	9.45
					3.52		14.61		9.19	
					3.08		13.97		8.17	
AL5 – 5	15.02.2022	623	389	130	3.52	3.96	19.69	19.05	10.72	11.66
					3.96		17.78		11.49	
					4.4		19.69		12.76	
AL5 – 6	18.02.2022	640	391	118	3.08	3.81	13.34	17.36	10.21	10.47
					3.52		19.05		10.47	
					4.84		19.69		10.72	
AL5 – 7	22.02.2022	474	253	100	3.08	3.81	12.07	14.4	7.66	7.91
					4.84		12.7		7.91	
					3.52		18.42		8.17	
AL5 – 8	25.02.2022	537	300	109	3.52	4.54	17.78	15.24	9.96	9.02
					4.84		13.34		8.93	
					5.28		14.61		8.17	
Monthly Average		523	300	112		4.03		16.17		9.41
Standard Deviation		91	65	9		0.34		1.75		1.2

on										

NS: Not Specified

Table 6 : Results of Air Pollutant Concentration at Coal Storage Area					
Parameter	**Date**	**C6H6 [µg/m3]**	**HC* ppm**	**CO [mg/m3]**	**CO2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**	**NS**	**4.0 mg/m3**	**NS**
AL5 – 1	01.02.2022	1.114	BDL	2.12	524
AL5 – 2	04.02.2022	1.127	BDL	1.4	432
AL5 – 3	08.02.2022	1.201	BDL	1.93	539
AL5 – 4	11.02.2022	1.097	BDL	1.97	1164
AL5 – 5	15.02.2022	1.231	BDL	2	1447
AL5 – 6	18.02.2022	1.103	BDL	1.87	562
AL5 – 7	22.02.2022	1.165	BDL	2.09	1408
AL5 – 8	25.02.2022	1.2	BDL	2.17	561
Monthly Average		**1.15**	**-**	**1.94**	**830**
Standard Deviation		**0.05**	**-**	**0.24**	**432**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm) NS-Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Coal Storage Area was comparatively highest among all the locations of Air Quality monitoring in Kandla Port. High values of TSPM, $PM_{10,}$ $PM_{2.5}$, SO_2, NO_X at this location was due to lifting of coal with grab and other coal handling processes near Berth no. 6 & 7. Moreover, the traffic was also heavy around this place for transport of coal thus emissions produced from heavy vehicles. The mean TSPM values at Coal storage were 523 µg/m^3. The mean PM_{10} values were 300 µg/m^3, which is well above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean = 112 µg/m^3). The average values of SO_2, NO_x and NH_3 were 4.03 µg/m^3, 16.17 µg/m^3 and 9.41 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Coal Storage Area. The mean Benzene concentration was **1.15** µg/m^3,

well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was **1.94** mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 6: Tuna Port (AL-6)

Table 1 : Results of Air Pollutant Concentration atTuna Port										
Parameter	**Date**	**TSPM [µg/m³]**	**PM10 [µg/m³]**	**PM2.5 [µg/m³]**	**SO_2 [µg/m³]**		**NOx [µg/m³]**		**NH_3 [µg/m³]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit		**NS**	**100 [µg/m3]**	**60 [µg/m3]**		**80 [µg/m3]**		**80 [µg/m3]**		**400 [µg/m³]**
AL6 -1	01.02.2022	211	96	88	4.84	4.69	15.88	13.97	9.96	9.1
					5.28		14.61		10.21	
					3.96		11.43		7.15	
AL6 – 2	04.02.2022	241	159	77	3.08	3.66	17.78	15.03	7.15	8
					4.4		15.24		7.91	
					3.52		12.07		8.93	
AL6 – 3	08.02.2022	370	203	167	4.4	4.84	19.05	20.75	7.91	7.74
					5.28		20.96		7.4	
					4.84		22.23		7.91	
AL6 – 4	11.02.2022	304	183	114	3.96	4.4	12.07	13.55	10.21	9.36
					4.4		12.7		10.47	
					4.84		15.88		7.4	
AL6 – 5	15.02.2022	287	172	113	4.4	4.98	19.05	18.84	10.72	11.66
					4.84		17.78		11.49	
					5.71		19.69		12.76	
AL6 – 6	18.02.2022	306	171	128	3.96	4.4	19.05	19.9	7.66	12
					4.4		19.69		15.57	
					4.84		20.96		12.76	
AL6 – 7	22.02.2022	242	137	97	4.4	4.25	17.78	18.84	8.93	9.87
					4.84		19.05		10.21	
					3.52		19.69		10.47	
AL6 – 8	25.02.2022	313	169	127	4.84	4.69	19.69	17.78	10.47	9.79
					5.28		16.51		9.7	
					3.96		17.15		9.19	
Monthly Average		284	161	114		4.49		17.33		9.69
Standard Deviat		51	32	28		0.41		2.78		1.53

on										

NS: Not Specified

Table 6B : Results of Air Pollutant Concentration at Tuna Port					
Parameter	**Date**	**C_6H_6 [µg/m³]**	**HC* ppm**	**CO [mg/m³]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m³**	**NS**	**4.0 mg/m³**	**NS**
AL6 -1	01.02.2022	1.115	BDL	1.64	552
AL6 -2	04.02.2022	1.088	BDL	1.5	425
AL6 -3	08.02.2022	1.271	BDL	1.9	466
AL6 -4	11.02.2022	1.197	BDL	2.12	1122
AL6 -5	15.02.2022	1.088	BDL	2.18	1006
AL6 -6	18.02.2022	1.044	BDL	1.96	430
AL6 -7	22.02.2022	1.096	BDL	2.07	436
AL6 -8	25.02.2022	1.145	BDL	2.22	430
Monthly Average		**1.13**	**-**	**1.95**	**608**
Standard Deviation		**0.07**	**-**	**0.26**	**286**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm) NS- Not Specified

The mean TSPM values at Tuna Port were 284 µg/m³, The mean PM_{10} values were 161 µg/m³, which is above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean = 114 µg/m³). The average values of SO_2, NO_x and NH_3 were 4.49µg/m³, 17.33 µg/m³ and 9.69 µg/m³ respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Tuna Port. The mean Benzene concentration was **1.13** µg/m³, well below the permissible limit of 5.0 µg/m³. HC's were below the detectable limit and Carbon Monoxide concentration was 1.95 mg/m³, well below the permissible limit of 4.0 mg/m³.

Location 7: Signal Building (Vadinar) (AL-7)

Table 1 : Results of Air Pollutant Concentration at Signal Building

Parameter	Date	TSPM [µg/m³]	PM10 [µg/m³]	PM2.5 [µg/m³]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit		NS	100 [µg/m3]	60 [µg/m3]		80 [µg/m3]		80 [µg/m3]		400 [µg/m³]
AL7 -1	01.02.22	170	101	68	3.96	3.81	13.34	13.34	8.42	8.34
					3.08		12.07		8.93	
					4.4		14.61		7.66	
AL7 -2	04.02.22	190	114	73	4.84	4.1	22.23	18.42	7.66	7.32
					3.96		19.69		7.91	
					3.52		13.34		6.38	
AL7 -3	08.02.22	152	86	64	4.84	5.28	12.7	14.61	8.68	9.79
					5.28		14.61		10.21	
					5.71		16.51		10.47	
AL7 -4	11.02.22	211	119	90	4.4	4.84	19.69	16.94	7.66	8.34
					4.84		17.78		8.42	
					5.28		13.34		8.93	
AL7 -5	15.02.22	154	86	65	5.71	4.69	20.33	19.9	9.7	8
					4.84		22.87		7.4	
					3.52		16.51		6.89	
AL7 -6	18.02.22	173	94	70	3.08	3.66	12.07	13.97	7.66	9.45
					3.52		13.34		10.21	
					4.4		16.51		10.47	
AL7 -7	22.02.22	154	93	58	3.52	3.52	14.61	16.51	10.72	9.36
					3.96		19.69		8.93	
					3.08		15.24		8.42	
AL7 -8	25.02.22	165	89	68	5.28	4.25	12.07	15.46	10.21	9.87
					3.96		15.24		10.98	
					3.52		19.05		8.42	
Monthly Average		171	98	69		4		16		9
Standard Deviation		21	13	9		1		2		1

NS: Not Specified

Table 7B : Results of Air Pollutant Concentration at Signal Building					
Parameter	**Date**	**C_6H_6 [µg/m³]**	**HC* ppm**	**CO [mg/m³]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m³**	**NS**	**4.0 mg/m³**	**NS**
AL7 -1	01.02.2022	1.17	BQL	1.73	485
AL7 – 2	04.02.2022	1.2	BQL	1.95	323
AL7 – 3	08.02.2022	1.02	BQL	2.04	227
AL7 – 4	11.02.2022	1.13	BQL	1.99	232
AL7 – 5	15.02.2022	1.04	BQL	2.11	400
AL7 – 6	18.02.2022	1.15	BQL	1.93	165
AL7 – 7	22.02.2022	1.2	BQL	1.75	312
AL7 – 8	25.02.2022	1.23	BQL	1.87	275
Monthly Average		**1.14**	**-**	**1.92**	**302**
Standard Deviation		**0.08**	**-**	**0.13**	**103**

*NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm) NS Not Specified

The mean TSPM values at Vadinar Port were 171 µg/m³. The mean PM_{10} values were 98 µg/m³, which is below the permissible limit. $PM_{2.5}$ values were also within the permissible limit (mean = 69 µg/m³). The average values of SO_2, NO_x and NH_3 were 4.0 µg/m³, 16.0 µg/m³ and 9.0 µg/m³ respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Vadinar Port. The mean Benzene concentration was 1.14 µg/m³, well below the permissible limit of 5.0 µg/m³. HC's were below the detectable limit and Carbon Monoxide concentration was 1.92mg/m³, well below the permissible limit of 4.0 mg/m³.

Location 8: Admin Building (Vadinar) (AL-8)

Table 1 : Results of Air Pollutant Concentration at Admin Building

Parameter	Date	TSPM [µg/m³]	PM10 [µg/m³]	PM2.5 [µg/m³]	SO_2 [µg/m³]		NOx [µg/m³]		NH_3 [µg/m³]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit		NS	100 [µg/m3]	60 [µg/m3]		80 [µg/m3]		80 [µg/m3]		400 [µg/m³]
AL8 -1	01.02.22	120	74	43	5.28	4.54	17.78	17.78	7.15	8.08
					2.64		19.69		6.89	
					5.71		15.88		10.21	
AL8 -2	04.02.22	188	111	75	3.08	3.37	16.51	18.21	8.42	7.83
					2.64		20.33		7.4	
					4.4		17.78		7.66	
AL8 -3	08.02.22	189	108	79	3.96	3.22	17.15	18.21	7.66	7.15
					3.08		22.23		7.4	
					2.64		15.24		6.38	
AL8 -4	11.02.22	168	96	69	3.52	3.96	12.07	16.94	7.4	9.36
					3.96		19.69		10.21	
					4.4		19.05		10.47	
AL8 -5	15.02.22	213	113	90	3.08	3.37	13.34	14.61	7.91	8.08
					2.64		14.61		8.93	
					4.4		15.88		7.4	
AL8 -6	18.02.22	210	107	88	4.84	5.28	19.05	18.63	9.7	8.51
					5.71		20.96		8.42	
					5.28		15.88		7.4	
AL8 -5	22.02.22	195	109	85	2.64	3.96	17.78	19.69	8.68	7.91
					4.4		19.69		7.4	
					4.84		21.6		7.66	
AL8-6	25.02.22	206	114	80	4.84	5.42	19.69	19.69	9.45	8
					5.28		20.96		7.4	
					6.15		18.42		7.15	
Monthly Average		186	104	76		4		18		8
Standard Deviation		31	13	15		1		2		1

NS: Not Specified

Table 8B : Results of Air Pollutant Concentration at Admin Building					
Parameter	**Date**	**C_6H_6 [µg/m³]**	**HC* ppm**	**CO [mg/m³]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m³**	**NS**	**4.0 mg/m³**	**NS**
AL8 -1	01.02.2022	1.14	BQL	1.63	545
AL8-2	04.02.2022	1.15	BQL	2	346
AL8 -3	08.02.2022	1.16	BQL	2.09	160
AL8-4	11.02.2022	1.13	BQL	2.17	216
AL8 -5	15.02.2022	1.01	BQL	2.16	352
AL8-6	18.02.2022	1.26	BQL	1.95	292
AL8-7	22.02.2022	1.04	BQL	2.14	148
AL8-8	25.02.2022	1.13	BQL	1.87	275
Monthly Average		**1.13**	**-**	**2**	**292**
Standard Deviation		**0.08**	**-**	**0.18**	**128**

* NMHC- Non- Methane Hydrocarbon
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm) NS-Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Admin Building Vadinar was comparatively low among all the locations of Air Quality monitoring in Kandla Port and Vadinar Port. The mean TSPM values at Vadinar Port were 186 µg/m³. The mean PM_{10} values were 104 µg/m³, which is above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean = 76.0 µg/m³). The average values of SO_2, NO_x and NH_3 were 4.0µg/m³, 18.0µg/m³ and 8.0µg/m³ respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Admin Building, Vadinar Port. The mean Benzene concentration was 1.13 µg/m³, well below the permissible limit of 5.0 µg/m³. HC's were below the detectable limit and Carbon Monoxide concentration was

2.00 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

1.4 Observations and Conclusion

During the monitoring period, the overall Ambient Air Quality of the port area was found to be well within the desired levels for various gaseous pollutants. However, Particulate matter as PM_{10} and $PM_{2.5}$ was found to exceed the limits at locations like Near Coal storage area, Marine Bhavan, Estate Office, Tuna Port and Oil Jetty area.

2. Drinking Water Quality Monitoring

Drinking Water Quality Monitoring was carried out at twenty stations at Kandla, Vadinar & Township Area of Deendayal Port.

2.1 Drinking Water Monitoring Methodology

Drinking water samples were collected from 20 locations as prescribed in the tender document. Samples for physico-chemical analysis were collected in 1 liter carboys and samples for microbiological parameters were collected in sterilized bottles. These samples were then analyzed in laboratory for various drinking water parameters at Kandla Lab/Surat.

The Sampling and Analysis was done as per standard methods - IS 10500:2012. The water samples were analyzed for various parameters, viz. Color , Odor, Turbidity , Conductivity , pH , Chlorides , TDS, Total Hardness, Iron , Sulphate , Salinity , DO, BOD, Na, K, Ca, Mg, F, NO_3, NO_2, Mn, Cr-6, Cu, Cd, As, Hg, Pb, Zn, Bacterial Count (cfu) .

2.2 Results

The Drinking Water Quality monitoring data for 20 stations are given in below from table No. 9 to Table No. 15

Table 9: Drinking Water Quality Monitoring Parameters for Nirman Building 1, P & C building & Main Gate (North) at Kandla

Sr. No.	Parameter	Unit	Nirman Building 1	P & C building	Main Gate North	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.2	7.1	7.3	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	950	1120	1020	500	2000
3	Turbidity	NTU	0	0	1	1	5
4	Odor	-	Odourless	Odourless	Odourless	Agreeable	Agreeable
5	Color	Hazen Units	Colourless	Colourless	Colourless	5	15
6	Conductivity	µs/cm	1720	2130	1820	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	561.2	606.35	546.21	250	1000
9	Ca as Ca	mg/l	60.12	64.13	68.14	75	200
10	Mg as Mg	mg/l	68.04	68.04	70.47	30	100
11	Total Hardness	mg/l	430	440	460	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.74	0.69	0.81	1	1.5
14	Sulphate as SO_4	mg/l	254.4	222	206.4	200	400
15	Nitrite as NO_2	mg/l	ND	ND	ND	NS*	NS*
16	Nitrate as NO_3	mg/l	7.18	6.9	7.88	45	No Relaxation
17	Salinity	%	1.01	1.09	0.98	NS*	NS*
18	Sodium as Na	mg/l	322.8	278.8	319.4	NS*	NS*
19	Potassium as K	mg/l	3.89	3.18	4.11	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	0.003
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05

25	Mercury	mg/l	BQL	BQL	BQL	0.001	0.001
26	Lead	mg/l	BQL	BQL	BQL	0.01	0.01
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100 ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe- 0.009 mg/l, Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu- 0.004 mg/l, Cd- 0.003mg/l, As- 0.003mg/l, Hg- 0.001 mg/l, Pb- 0.006mg/l, Zinc- 0.021 mg/l).

Table 10: Drinking Water Quality Monitoring Parameters for Canteen, West Gate – I & Wharf Area at Kandla

Sr. No.	Parameter	Unit	Canteen	West Gate – I	Wharf Area	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.4	7.5	7.3	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1160	970	1060	500	2000
3	Turbidity	NTU	1	1	0	1	5
4	Odor	-	Odourless	Odourless	Odourless	Agreeable	Agreeable
5	Color	Hazen Units	Colourless	Colourless	Colourless	5	15
6	Conductivity	µs/cm	2160	1790	1950	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	626.39	586.3	616.37	250	1000
9	Ca as Ca	mg/l	56.11	52.1	60.12	75	200
10	Mg as Mg	mg/l	75.33	70.47	63.18	30	100
11	Total Hardness	mg/l	450	420	410	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.82	0.4	0.52	1	1.5
14	Sulphate as SO_4	mg/l	246	217.2	214.8	200	400
15	Nitrite as NO_2	mg/l	ND	ND	ND	NS*	NS*
16	Nitrate as NO_3	mg/l	8.65	9.5	9.92	45	No Relaxation
17	Salinity	%	1.13	1.06	1.11	NS*	NS*
18	Sodium as Na	mg/l	301.8	284.8	310.8	NS*	NS*
19	Potassium as K	mg/l	3.74	3.94	4.74	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	0.003
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	0.001
26	Lead	mg/l	BQL	BQL	BQL	0.01	0.01
27	Zinc	mg/l	BQL	BQL	BQL	5	15

28	Bacterial Count	CFU/100 ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l,As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

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Table 11: Drinking Water Quality Monitoring Parameters for Sewa sadan – 3, Workshop I & Custom Building at Kandla

Sr. No.	Parameter	Unit	Sewa Sadan – 3	Workshop	Custom Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.2	7.6	7.2	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	980	1120	1210	500	2000
3	Turbidity	NTU	0	0	1	1	5
4	Odor	-	Odourless	Odourless	Odourless	Agreeable	Agreeable
5	Color	Hazen Units	Colourless	Colourless	Colourless	5	15
6	Conductivity	µs/cm	1730	2090	2230	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride	mg/l	546.21	581.29	611.35	250	1000
9	Ca as Ca	mg/l	72.14	56.11	48.1	75	200
10	Mg as Mg	mg/l	63.18	75.33	72.9	30	100
11	Total Hardness	mg/l	440	450	420	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides	mg/l	0.55	0.85	0.92	1	1.5
14	Sulphate	mg/l	231.6	252	265.2	200	400
15	Nitrite	mg/l	ND	ND	ND	NS*	NS*
16	Nitrate	mg/l	12.32	10.77	11.33	45	No Relaxation
17	Salinity	%	0.98	1.05	1.1	NS*	NS*
18	Sodium as Na	mg/l	286.3	334.8	326.4	NS*	NS*
19	Potassium as K	mg/l	3.69	5.08	4.57	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	0.003
2	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05

4							
25	Mercury	mg/l	BQL	BQL	BQL	0.001	0.001
26	Lead	mg/l	BQL	BQL	BQL	0.01	0.01
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100 ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l,As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 12: Drinking Water Quality Monitoring Parameters for Port Colony Kandla, Hospital Kandla & A.O. Building at Gandhidham

Sr. No.	Parameter	Unit	Port Colony Kandla	Hospital Kandla	A.O. Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.3	7.5	7.2	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1130	1210	960	500	2000
3	Turbidity	NTU	1	1	0	1	5
4	Odor	-	Odourless	Odourless	Odourless	Agreeable	Agreeable
5	Color	Hazen Units	Colourless	Colourless	Colourless	5	15
6	Conductivity	µs/cm	2040	2360	1750	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride	mg/l	656.45	646.43	576.28	250	1000
9	Ca as Ca	mg/l	52.1	60.12	64.13	75	200
10	Mg as Mg	mg/l	1.18	1.16	1.04	30	100
11	Total Hardness	mg/l	410	440	450	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides	mg/l	0.81	0.73	0.86	1	1.5
14	Sulphate	mg/l	184.8	195.6	202.8	200	400
15	Nitrite	mg/l	ND	ND	ND	NS*	NS*
16	Nitrate	mg/l	8.87	12.32	12.74	45	No Relaxation
17	Salinity	%	1.18	1.16	1.04	NS*	NS*
18	Sodium as Na	mg/l	301.8	332.4	296.3	NS*	NS*
19	Potassium as K	mg/l	4.86	5.11	3.73	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	0.003
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	0.001
26	Lead	mg/l	BQL	BQL	BQL	0.01	0.01
27	Zinc	mg/l	BQL	BQL	BQL	5	15

28	Bacterial Count	CFU/100 ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l,As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

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Table 13: Drinking Water Quality Monitoring Parameters for School Gopalpuri, Guest House & E - Type Quarter at Gopalpuri, Gandhidham

Sr. No.	Parameter	Unit	School Gopalpuri	Guest House	E - Type Quarter	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.3	7.6	7.5	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1060	1220	1130	500	2000
3	Turbidity	NTU	0	1	1	1	5
4	Odor	-	Odourless	Odourless	Odourless	Agreeable	Agreeable
5	Color	Hazen Units	Colourless	Colourless	Colourless	5	15
6	Conductivity	µs/cm	1850	2360	2100	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride	mg/l	616.37	531.181	516.147	250	1000
9	Ca as Ca	mg/l	68.14	60.12	64.13	75	200
10	Mg as Mg	mg/l	72.9	75.33	70.47	30	100
11	Total Hardness	mg/l	470	460	450	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides	mg/l	0.636	0.69	0.74	1	1.5
14	Sulphate	mg/l	206.4	198	174	200	400
15	Nitrite	mg/l	ND	ND	ND	NS*	NS*
16	Nitrate	mg/l	10	10.98	9.5	45	No Relaxation
17	Salinity	%	1.11	0.95	0.93	NS*	NS*
18	Sodium as Na	mg/l	312.7	304.8	88.26	NS*	NS*
19	Potassium as K	mg/l	4.39	4.27	7.43	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	0.003

24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	0.001
26	Lead	mg/l	BQL	BQL	BQL	0.01	0.01
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l,As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

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Table 14: Drinking Water Quality Monitoring Parameters for F - Type Quarter, Hospital Gopalpuri & Tuna Port

Sr. No.	Parameter	Unit	F - Type Quarter	Hospital Gopalpuri	Tuna Port	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.4	7.3	7.2	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1080	1100	980	500	2000
3	Turbidity	NTU	1	0	0	1	5
4	Odor	-	Odourless	Odourless	Odourless	Agreeable	Agreeable
5	Color	Hazen Unit	Colourless	Colourless	Colourless	5	15
6	Conductivity	µs/cm	1830	2140	1920	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride	mg/l	566.25	616.37	542.14	250	1000
9	Ca as Ca	mg/l	68.14	72.14	76.15	75	200
10	Mg as Mg	mg/l	58.32	60.75	55.89	30	100
11	Total Hardness	mg/l	410	430	420	200	600
12	Iron as Fe+3	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides	mg/l	0.95	0.86	0.66	1	1.5
14	Sulphate	mg/l	181.2	213.6	218.4	200	400
15	Nitrite	mg/l	ND	ND	ND	NS*	NS*
16	Nitrate	mg/l	10.77	8.51	7.6	45	No Relaxation
17	Salinity	%	1.02	1.11	0.93	NS*	NS*
18	Sodium as Na	mg/l	325.9	286.8	330.9	NS*	NS*
19	Potassium as K	mg/l	4.12	3.36	5.28	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	0.003
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	0.001
26	Lead	mg/l	BQL	BQL	BQL	0.01	0.01
27	Zinc	mg/l	BQL	BQL	BQL	5	15

28	Bacterial Count	CFU/100 ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l,As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

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Table 15: Drinking Water Quality Monitoring Parameters for Vadinar Jetty & Port Colony at Vadinar

Sr. No.	Parameter	Unit	Vadinar Jetty	Port Colony Vadinar	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.5	7.3	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1070	1030	500	2000
3	Turbidity	NTU	0	1	1	5
4	Odor	-	Odourless	Odourless	Agreeable	Agreeable
5	Color	Hazen Units	Colourless	Colourless	5	15
6	Conductivity	µs/cm	2010	1030	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	NS*	NS*
8	Chloride	mg/l	496.1	511.13	250	1000
9	Ca as Ca	mg/l	64.13	56.11	75	200
10	Mg as Mg	mg/l	72.9	75.33	30	100
11	Total Hardness	mg/l	460	450	200	600
12	Iron as Fe+3	mg/l	BQL	BQL	0.3	No Relaxation
13	Fluorides	mg/l	0.86	0.8	1	1.5
14	Sulphate	mg/l	19.44	19.08	200	400
15	Nitrite	mg/l	ND	ND	NS*	NS*
16	Nitrate	mg/l	7.95	8.51	45	No Relaxation
17	Salinity	%	0.89	0.92	NS*	NS*
18	Sodium as Na	mg/l	467.8	478	NS*	NS*
19	Potassium as K	mg/l	4.36	4.72	NS*	NS*
20	Manganese	mg/l	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	0.003	0.003
24	Arsenic	mg/l	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	0.001	0.001
26	Lead	mg/l	BQL	BQL	0.01	0.01
27	Zinc	mg/l	BQL	BQL	5	15
28	Bacterial Count	CFU/100	Absent	Absent	Absent	Absent

		ml				

*NS: Not Specified,
BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

2.3 Results & Discussion

The colour of all drinking water samples was <5 Hazen unit and odour of the samples was also agreeable. All parameters are found to be within the specified limit of the Drinking water Standard.

pH

The limit of pH value for drinking water is specified as 6.5 to 8.5. pH value in the studied area varied from 7.1 to 7.6 pH unit. All the sampling points showed pH values within the prescribed limit by Indian Standards.

Total Dissolved Solids (TDS)

TDS values in the studied area varied between 950 - 1220 mg/l. None of the sampling points showed higher TDS values than the prescribed limit by Indian standards.

Conductivity

Electrical Conductivity is the ability of a solution to transfer (conduct) electric current. Conductivity is used to measure the concentration of dissolved solids which have been ionized in a polar solution such as water. The conductivity in the samples collected during the month of February ranged from 1030-2360 µs/cm. Electrical conductivity standards do not appear in BIS standards for drinking water.

BOD

BOD value in the studied area was found Below Quantification Limit (2.0 mg/l). Indian standards does not show any standard values for BOD in drinking water.

Chlorides

Excessive chloride concentration increase rates of corrosion of metals in the distribution system. This can lead to increased concentration of metals in the supply. Chloride value in the studied area varied between 496.1- 656.4 mg/l and is found to be within the Permissible limit of the Drinking Water Standard.

Calcium

Calcium value in the studied area varied between 48.09 - 76.15 mg/l and is found to be within the Permissible limit of the Drinking Water Standard. If calcium is present beyond the maximum acceptable limit, it causes incrustation of pipes.

Magnesium

Magnesium value in the studied area varied between 55.89 - 75.33 mg/l. All the locations had Magnesium within the prescribed limits of 30-100 mg/L.

Total Hardness

Hardness value in the studied area varied between 410 - 470 mg/l and is found to be within the Permissible limit of the Drinking Water Standard. The prescribed limit by Indian Standards is 200-600 mg/L.

Iron

Iron value in the studied area was found Below Quantification Limit (0.009 mg/l) and hence well below the permissible limit as per Indian Standards is 0.3 mg/L. The excess amount of iron causes slight toxicity; gives stringent taste to water.

Fluoride

Fluoride value in the studied area varied between 0.4 – 0.9 mg/l and hence well below the permissible limit as per Indian Standards is 1.0-1.5 mg/L. Moderate amounts lead to dental effects, but long-term ingestion of large amounts can lead to potentially severe skeletal problems.

Sulphates

Sulphate value in the studied area varied between 19.08 – 265.2mg/l. All the sampling points showed sulphate values within the prescribed limits by Indian Standards (200-400 mg/L). Sulphate content in drinking water exceeding the 400 mg/L imparts bitter taste.

Nitrites (NO_2) and Nitrates (NO_3)

Nitrite values in all the water samples were found Below Quantification Limit (0.1 mg/l). There are no specified standard values for Nitrites in Drinking water. The minimum Nitrate value in drinking water of KPT was 0.0055 mg/l which is well within the permissible limit of the Drinking water Standard.

Salinity

Salinity in drinking water in the present samples collected ranged from 0.8 to 1.1%. There are no prescribed Indian standards for salinity in Drinking water.

Sodium and Potassium Salts

Sodium values in the samples collected ranged from 88 - 478 mg/l and Potassium salts ranged from 3.18 to 7.43 mg/l. There are no prescribed limits of Sodium and Potassium in Indian standards for Drinking water.

Heavy Metals in Drinking Water

In the present study period drinking water samples were analyzed for Mn, Cr, Cu, Cd, As, Hg, Pb and Zn. All these heavy metals were well Below the Quantification limits prescribed by the Indian Standards.

Bacteriological Study

Analysis of the bacteriological parameter at all location shows that Bacteria is not present and hence Bacterial count is in line with the permissible limit of drinking water. This shows that all the drinking water samples were safe from any bacteriological contamination.

2.4 Conclusions

These results are compared with acceptable limits as prescribed in IS 10500:2012 – Drinking Water Specification. It is seen from the analysis data that during the study period the water was safe for human consumption at all drinking water monitoring stations.

3. Noise Level Monitoring

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. Noise Monitoring was done at 13 stations at Kandla, Vadinar and Township area.

3.1 Method of Monitoring

Sampling was done at all stations for 24 hour period. Data was recorded using automated sound level meter. The intensity of sound was measured in sound pressure level (SPL) and common unit of measurement is decibel (dB).

3.2 Results

Table 16: Noise Monitoring data for ten locations of Deendayal Port and three locations of Vadinar Port

Sr. No.	Location	Day Time Average Noise Level (SPL) in dB(A)	Night Time Average Noise Level (SPL) in dB(A)
	Sampling Time	**6:00 am to 10:00 PM**	**10:00PM to 6:00 AM**
1	Marine Bhavan	55.2	55.5
2	Nirman Building 1	47	53.9
3	Tuna Port	45.2	44.6
4	Main Gate North	60.8	53.1
5	West Gate I	61.8	60.3
6	Canteen Area	54.5	53.4
7	Main Road	58.4	57.1
8	ATM Building	60.7	51.5
9	Wharf Area /Jetty Area	64	58.8
10	Port & Custom Office	48.4	47.2
Vadinar Port			
11	Entrance Gate of Vadinar Port	59.8	58
12	Nr. Port Colony, Vadinar	57	53.4
13	Nr. Vadinar Jetty	58.3	54.7

3.3 Conclusions

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. The Day Time Noise Level (SPL)in all 13 locations at Deendayal Port ranged from 45.24 dB(A) to 63.98 dB(A) and it was within the permissible limits of 75 dB(A) for the industrial area for the daytime. The Night Time Average Noise Level (SPL) in all 13 locations of Deendayal Port ranged from 44.58 dB to 60.26 dB(A) and it was within the permissible limits of 70 dB(A) for the industrial area for the night time.

4. Soil Monitoring

Sampling and analysis of soil samples were undertaken at six locations within the study area (Deendayal Port and Vadinar Port) as a part of EMP. The soil sampling locations are initially decided based on the locations as provided in the tender document of the Deendayal Port.

4.1 Methodology

The soil samples were collected in the month of February 2022. The samples collected from the all locations are homogeneous representative of each location. At random locations were identified at each location and soil was dug from 30 cm below the surface. It was uniformly mixed before homogenizing the soil samples. The samples were filled in polythene bags, labeled in the field with number and site name and sent to laboratory for analysis.

4.2 Results

Table-17: Chemical Characteristics of Soil in the Study Area

Sr. No.	Parameter	Unit	Station Name					
			SL1	SL2	SL3	SL4	SL5	SL6
			Tuna Port	IFFCO Plant	Khori Creek	Nakti Creek	KPT Admin Site	KPT Colony
			Near main gate of Port	10 m away from main gate	Sand from creek at low tide			Vadinar
1	Texture		Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	pH	-	8.59	8.6	8.68	8.47	7.64	7.11
3	Electrical Conductivity	µs/cm	2,839.00	1,442.00	1,950.00	2,848.00	1,417.00	299.6
4	Moisture	%	22	28.37	21	24.88	8.49	3.96
5	Total Organic Carbon	%	0.96	0.71	0.98	0.84	0.32	0.67
6	Alkalinity	mg/kg	40.04	40.04	40.04	40.04	60.06	40.04
7	Total Nitrogen	%	BQL	BQL	BQL	BQL	BQL	BQL
8	Chloride	mg/kg	3,545.00	2,481.50	2,836.00	3,190.50	141.8	70.9
9	Sulphate	mg/kg	3,891.18	1,650.89	1,292.27	4,950.89	250.38	BQL
10	Phosphorus	mg/kg	50.87	5.33	8.87	8.5	1..88	BQL
11	Potassium	mg/kg	192.3	155.01	160.36	178.48	30.01	28.87
12	Sodium	mg/kg	2,466.12	1,500.32	1,839.79	2,450.29	153.5	20.32
13	Calcium	mg/kg	284.57	432.86	232.46	492.9	837.67	472.94

14	Copper as Cu	mg/kg	26.2	35.6	31.8	25	18.3	62.3
15	Lead as Pb	mg/kg	7.5	10.8	5.4	7.6	BQL	BQL
16	Nickel as Ni	mg/kg	39.1	42.9	42	31.9	60.2	33.3
17	Zinc as Zn	mg/kg	58.2	102.7	76.7	48.1	84.6	44
18	Cadmium as Cd	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (TN: 0.001%, Cd: 1.0mg/kg).

4.3 Discussion

The data shows that value of pH ranges from 7.11 at KPT Colony (Vadinar) to 8 . 68 at Khori Creek indicating that all soil samples are neutral to slight basic. Nakti creek samples showed maximum conductivity of 2848.0 µmhos/cm, while KPT Colony (Vadinar) location showed minimum conductivity of 299.6 µmhos/cm. Conductivity at Vadinar Port was 299.6 and 1417.0 µmhos/cm at Admin site and Vadinar Port colony respectively.

Total organic Carbon ranged from 0.32 % to 0.98 at Deendayal Port. At Vadinar Port, organic

The concentration of Phosphorus and Potassium in the soil samples varies from 5.33 to 50.87 mg/kg and 28.87 to 192.3 mg/kg respectively at Deendayal Port. The mean concentration of Phosphorous at Vadinar site was 1.88 mg/kg and mean concentration of Potassium at Vadinar site was 29.44 mg/kg.

These differences in NPK in soil at different locations are due to the dissimilar nature of soil at each of the locations. Samples SL3 & SL4 (Khori Creek & Nakti Creek) are of saline nature as they are coastal soil; where as other locations are inland locations and have different chemical properties.

Heavy Metals in the Soil

Traces of Copper, Lead, Nickel and Zinc were observed in the soil samples collected from all the four locations of Deendayal Port and two locations of Vadinar Port. Cadmium metal was below detection limit in the Soil.

4.4 Conclusion

The soils of Deendayal Port and Vadinar Port appears to be neutral to basic with varying levels of Chloride, Sulphate, NPK and Calcium. As the nature of soil at different locations are different with respect to its proximity to the sea, the samples showed high degree of variations in their chemical properties.

5. Sewage Treatment Plant Monitoring

This involves safe collection of waste water (spent/used water) from wash areas, bathroom, industrial units, etc., waste from toilets of various buildings and its conveyance to the treatment plant and final disposal in conformity with the requirement and guide lines of State Pollution Control Board and other statutory bodies.

5.1 Methodology for STP Monitoring

To monitor the working efficiency of Sewage Treatment Plant (STP), STP Inlet and Outlet Samples were collected once a week. Locations selected are namely Gopalpuri Township, Deendayal Port and Vadinar. Samples were collected in 1 lit. Carboys and were analyzed in laboratory for various parameters.

5.2 Results

Kandla STP

Table 18: Sewage Water Monitoring at Kandla STP (1st Week)

Date of Sampling	03.02.22

Sr. No.	**Parameters**	**Unit**	**Results**	
			KPT STP I/L	**KPT STP O/L**
1	pH	pH unit	7.75	7.54
2	Total Suspended Solids	mg/l	144	93.1
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	434.3	102
5	BOD @ 27 °C	mg/l	140	28
6	Fecal Coliform	MPN Index / 100 ml	-	110
Aeration Tank				
7	MLSS	mg/l	88	
8	MLVSS	%	56	

Table 19: Sewage Water Monitoring at Kandla STP (2nd Week)

Date of Sampling	07.02.

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	7.72	7.41
2	Total Suspended Solids	mg/l	193.4	101.5
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	373	104
5	BOD @ 27 °C	mg/l	108	24
6	Fecal Coliform	MPN Index / 100 ml	-	920
Aeration Tank				
7	MLSS	mg/l	80	
8	MLVSS	%	52	

Table 20: Sewage Water Monitoring at Kandla STP (3rd Week)

Date of Sampling	14.02.22

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	7.73	7.5
2	Total Suspended Solids	mg/l	211.2	101.3
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	242.4	105
5	BOD @ 27 °C	mg/l	108	24
6	Fecal Coliform	MPN Index / 100 ml	-	>1600.0
Aeration Tank				
7	MLSS	mg/l	85	

8	MLVSS	%	63

Table 21: Sewage Water Monitoring at Kandla STP (4th Week)

Date of Sampling	21.02.22

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	7.51	7.35
2	Total Suspended Solids	mg/l	191.4	105.2
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	232.3	101.1
5	BOD @ 27 °C	mg/l	64	21
6	Fecal Coliform	MPN Index / 100 ml	-	320
Aeration Tank				
7	MLSS	mg/l	87	
8	MLVSS	%	51	

Gopalpuri Colony STP

Table 22: Sewage Water Monitoring at Gopalpuri STP (1st Week)

Date of Sampling	03.02.22

Sr. No.	Parameters	Unit	Results	
			Gopalpuri STP I/L	Gopalpuri STP O/L
1	pH	pH unit	7.8	7.61
2	Total Suspended Solids	mg/l	198.2	97
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	393.9	102.1
5	BOD @ 27 °C	mg/l	130	26
6	Fecal Coliform	MPN Index / 100 ml	-	350
Aeration Tank				
7	MLSS	mg/l	28	
8	MLVSS	%	92	

Table 23: Sewage Water Monitoring at Gopalpuri STP (2nd Week)

Date of Sampling	07.02.22

Sr. No.	Parameters	Unit	Results	
			Gopalpuri STP I/L	Gopalpuri STP O/L
1	pH	pH unit	7.51	7.25
2	Total Suspended Solids	mg/l	405.6	107.2
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	384	112
5	BOD @ 27 °C	mg/l	122	28
6	Fecal Coliform	MPN Index / 100 ml	-	170
Aeration Tank				
7	MLSS	mg/l	32	
8	MLVSS	%	90	

Table 24: Sewage Water Monitoring at Gopalpuri STP (3rd Week)

Date of Sampling	14.02.22

Sr. No.	Parameters	Unit	Results	
			Gopalpuri STP I/L	Gopalpuri STP O/L
1	pH	pH unit	7.6	7.4
2	Total Suspended Solids	mg/l	308.4	119.7
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	474	101
5	BOD @ 27 °C	mg/l	160	28
6	Fecal Coliform	MPN Index / 100 ml	-	>1600.0
Aeration Tank				
7	MLSS	mg/l	27	
8	MLVSS	%	98	

Table 25: Sewage Water Monitoring at Gopalpuri STP (4th Week)

Date of Sampling	21.02.22

Sr. No.	Parameters	Unit	Results	
			Gopalpuri STP I/L	Gopalpuri STP O/L
1	pH	pH unit	7.75	7.45
2	Total Suspended Solids	mg/l	244.2	102.5
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	212.1	101
5	BOD @ 27 °C	mg/l	72	20
6	Fecal Coliform	MPN Index / 100 ml	-	
Aeration Tank				
7	MLSS	mg/l	37	
8	MLVSS	%	90	

Vadinar STP

Table 26: Sewage Water Monitoring at Vadinar STP (1st Week)

Date of Sampling	03.02.22

Sr. No.	Parameters	Unit	Results	
			Vadinar STP I/L	Vadinar O/L
1	pH	pH unit	7.65	7.36
2	Total Suspended Solids	mg/l	103.8	63.5
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	243	98
5	BOD @ 27 °C	mg/l	86	24
6	Fecal Coliform	MPN Index /100 ml	-	540

Table 27: Sewage Water Monitoring at Vadinar STP (2nd Week)

Date of Sampling	07.02.22

Sr. No.	Parameters	Unit	Results	
			Vadinar STP I/L	Vadinar O/L
1	pH	pH unit	7.5	7.3
2	Total Suspended Solids	mg/l	108.8	31
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	373.0	102.0
5	BOD @ 27 °C	mg/l	102.0	28.0
6.	Fecal Coliform	MPN Index /100 ml	-	540.0

Table 28: Sewage Water Monitoring at Vadinar STP (3rd Week)

Date of Sampling	14.02.22

Sr. No.	Parameters	Unit	Results	
			Vadinar STP I/L	Vadinar O/L
1	pH	pH unit	7.39	7.2
2	Total Suspended Solids	mg/l	107	56.5
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	171.0	61.0
5	BOD @ 27 °C	mg/l	56.0	21.0

6.	Fecal Coliform	MPN Index /100 ml	-	350.0

Table 29: Sewage Water Monitoring at Vadinar STP (4th Week)

Date of Sampling	21.02.22

Sr. No.	Parameters	Unit	Results	
			Vadinar STP I/L	Vadinar O/L
1	pH	pH unit	7.42	7.26
2	Total Suspended Solids	mg/l	105	58.8
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	202	80.8
5	BOD @ 27 °C	mg/l	88.0	23.0
6.	Fecal Coliform	MPN Index /100 ml	-	220.0

5.3 Conclusions:

The GPCB standards of BOD, TSS and Residual Chlorine for STP outlet are 20 mg/lit, 30 mg/lit &

0.5 mg/lit respectively. It is suggested to do treatment on regular basis to avoid flow of contaminated/polluted water into the sea.

Marine Water Monitoring

The Forty Second Amendment to the Constitution in 1976 underscored the importance of 'green thinking'. Article 48A enjoins the state to protect and improve the environment and safeguard the forests and wildlife in the country. Further, Article 51A(g) states that the "fundamental duty of every citizen is to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures".

Policy Statement for Abatement of Pollution (1992) has suggested developing relevant legislation and regulation, fiscal incentives, voluntary agreements and educational programs and information campaigns. It emphasizes the need for integration by incorporating environmental considerations into decision making at all levels by adopting frameworks namely, pollution prevention at source, application of best practicable solution, ensure polluter pays for control of pollution, focus on heavily polluted areas and river stretches and involve public in decision- making. The National Conservation Strategy and Policy Statement on Environment and Development, (1992) aimed at "integrating environmental concerns with developmental imperatives to meet the challenges by redirecting the thrust of our developmental process so that the basic needs of our people could be fulfilled by making judicious and sustainable use of natural resources." The priorities mentioned in this policy document include the sustainable use of land and water resources, prevention and control of pollution and preservation of biodiversity.

The National Water Policy, (2002) contains provisions for developing, conserving, sustainable utilizing and managing this important water resources and need to be governed by national perspectives.

Marine Environment

On national and state levels, we have several policies and regulation like Water (Prevention and Control of Pollution) Act, 1974, to regulate pollution discharges and restore water quality of our aquatic resources including the prescription of monitoring activities. One of the important provisions of the Water Act, 1974, is to maintain and restore the 'wholesomeness' of our aquatic resources. Water quality monitoring is one of the first steps required in the rational development and management of water resources. In the field of water quality management, there has been a steady evolution in procedures for designing system to obtain information on the changes of water quality. The monitoring comprises

all activities to obtain ‘information’ with respect to the water system.

Sampling Stations

The monitoring of marine environment for the study of biological and ecological parameters was carried out on 03rd & 04th February-2022 in harbor regions of KPT and on 03rd February-2022 at Vadinar during spring tide period of New moon phase of Lunar Cycle. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 10th& 11th February 2022 in harbor regions of KPT. 10th February -2022 in Vadinar during Neap tide period first quarter of Lunar Cycle..

Plankton samples from sub surface layer was collected both during high tide period and low tide period from 3 water quality monitoring stations of KPT harbour area and two stations in Nakti creek and one station in Khori creek. The same sampling schedule was repeated during consecutive spring tide and neap tide in same month. Plankton samples from sub surface layer was collected both during high tide period and low tide period from 1 water quality monitoring stations near Vadinar jetty area during spring tide and neap tide in this month. Collected water samples were processed for estimation of Chlorophyll- a, Pheophytin- a, qualitative & quantitative evaluation of phytoplankton, qualitative & quantitative evaluation zooplanktons (density and their population).

Sampling Locations

Offshore monitoring requirement	**Number of locations**
Offshore Installations	3 in Kandla creek2 in Nakti creek 1 in Khori creek 1 near Vadinar Jetty1 near 1st SBM
Total Number of locations	**8**

5.4 Marine Water Quality

Marine water quality of marine waters of Deendayal Port Harbor waters, Khori and Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each month. The results of marine water quality and Marine sediments are as below;

Table 30: Marine Water Quality Monitoring Parameters for location near KPT colony

Sr. No.	Parameters	Unit	Kandla Creek Near KPT colony (1)			
			23°0'58"N 70°13'22."E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.3	7.32	7.4	7.35
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31.2	31	32.3	32
5	Turbidity	NTU	34	31	36	32
6	Total Dissolved Solids	mg/l	41406	42523	40796	42487
7	Total Suspended Solids	mg/l	532	643	663.9	659.2
8	Total Solids	mg/l	41976	43186	41520	43162
9	DO	mg/l	4.1	4.2	4.3	4.2
10	COD	mg/l	78	80	82	86
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.75	0.69	0.82	0.71
13	Phosphate	mg/l	0.25	0.23	0.23	0.22
14	Sulphate	mg/l	2676	2304	2256	2340
15	Nitrate	mg/l	2.68	2.53	3.03	2.75
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	681.36	721.44	641.28	601.2
18	Magnesium	mg/l	1652.4	1603.8	1628.1	1628.1
19	Sodium	mg/l	9167	9088	9038	9181
20	Potassium	mg/l	346	335	338	342
21	Iron	mg/l	1.71	1.98	0.62	0.25
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL

28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 31: Marine Water Quality Monitoring Parameters for location near passenger Jetty One at Kandla

Sr. No.	Parameters	Unit	Near passenger Jetty One (2)			
			23° 0'18 "N 70°13'31"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.4	7.26	7.45	7..38
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31.8	32.1	31.8	31.9
5	Turbidity	NTU	30	28	29	35
6	Total Dissolved Solids	mg/l	41960	40901	42303	41608
7	Total Suspended Solids	mg/l	656	706	657.3	558.1
8	Total Solids	mg/l	42620	41610	42961	42170
9	DO	mg/l	4.3	4.4	4.6	4.7
10	COD	mg/l	80	78	86	88
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.65	0.6	0.75	0.65
13	Phosphate	mg/l	0.24	0.21	0.22	0.21
14	Sulphate	mg/l	2544	2520	2412	2544
15	Nitrate	mg/l	2.89	3.17	3.17	3.59
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	641.28	601.2	521.04	681.36
18	Magnesium	mg/l	1628.1	1628.1	1725.3	1676.7
19	Sodium	mg/l	9748	9232	9530	9408
20	Potassium	mg/l	385	353	379	371
21	Iron	mg/l	0.55	0.1	BQL	0.2
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL

28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Nitrite: 0.05mg/lCu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 32: Marine Water Quality Monitoring Parameters for location Near Coal Berth

Sr. No.	Parameters	Unit	Near Coal Berth			
			22°59'12"N 70°13'40"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.36	7.4	7.28	7.31
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31.7	31.8	32	31.9
5	Turbidity	NTU	29	32	34	31
6	Total Dissolved Solids	mg/l	40799	38680	41634	42504
7	Total Suspended Solids	mg/l	599	709	599.5	614
8	Total Solids	mg/l	41401	39390	42233	43120
9	DO	mg/l	4.5	4.7	4.8	4.4
10	COD	mg/l	82	86	88	90
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.78	0.82	0.84	0.93
13	Phosphate	mg/l	0.19	0.2	0.21	0.2
14	Sulphate	mg/l	2220	2268	2100	2184
15	Nitrate	mg/l	3.94	3.59	3.87	4.01
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	561.12	641.28	721.44	641.28
18	Magnesium	mg/l	1749.6	1676.7	1676.7	1676.7
19	Sodium	mg/l	9446	9008	9030	9278
20	Potassium	mg/l	372	319	337	349
21	Iron	mg/l	0.62	1.55	0.21	1.36
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL

28	Zinc	mg/l	BQL	BQL	BQL	4.28

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

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Table 33: Marine Water Quality Monitoring Parameters for location Khori creek at Kandla

Sr. No.	Parameters	Unit	KPT 4			
			Near 15/16 Berth			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.41	7.36	7.41	7.46
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	32	31.5	31.8	32.1
5	Turbidity	NTU	38	36	30	28
6	Total Dissolved Solids	mg/l	40160	42448	39993	39941
7	Total Suspended Solids	mg/l	661	720	715.9	723.9
8	Total Solids	mg/l	40830	43187	40710	40670
9	DO	mg/l	4.6	4.3	4.5	4.6
10	COD	mg/l	88	80	78	72
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.93	0.89	0.89	0.71
13	Phosphate	mg/l	0.21	0.2	0.23	0.23
14	Sulphate	mg/l	1872	1944	2652	2700
15	Nitrate	mg/l	4.36	4.58	4.44	4.29
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	681.36	601.2	601.2	561.12
18	Magnesium	mg/l	1676.7	1749.6	1676.7	1652.4
19	Sodium	mg/l	9423	9064	9390	9725
20	Potassium	mg/l	332	299	357	387
21	Iron	mg/l	0.74	0.32	1.13	0.52
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL

27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 34: Marine Water Quality Monitoring Parameters for location Nakti Creek near Tuna Port

Sr. No.	Parameters	Unit	Nakti Creek Near Tuna Port			
			22°57'49."N 70° 7'0.67"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.4	7.48	7.33	7.39
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31.8	31.8	32	31.8
5	Turbidity	NTU	35	37	37	38
6	Total Dissolved Solids	mg/l	38698	41456	38575	33050
7	Total Suspended Solids	mg/l	674	789	704.4	733.2
8	Total Solids	mg/l	39380	42245	39280	33790
9	DO	mg/l	4.4	4.5	4.3	4.4
10	COD	mg/l	96	90	92	90
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.65	0.67	0.67	0.73
13	Phosphate	mg/l	0.22	0.21	0.19	0.2
14	Sulphate	mg/l	2100	2172	2628	2580
15	Nitrate	mg/l	5	4.86	5.07	4.93
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	721.44	761.52	521.04	480.96
18	Magnesium	mg/l	1579.5	1530.9	1701	1773.9
19	Sodium	mg/l	10518	10127	9831	9748
20	Potassium	mg/l	415	403	388	376
21	Iron	mg/l	BQL	0.65	1.12	0.46
22	Chromium	mg/l	BQL	BQL	BQL	BQL

23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 35: Marine Water Quality Monitoring Parameters for location Nakti Creek Near NH-8A at Kandla

Sr. No.	Parameters	Unit	Nakti Creek Near NH-8A			
			23° 02'01"N 70° 09'31"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.5	Sampling not possible during Low Tide	7.5	Sampling not possible during Low Tide
2	Color	-	Colorless		Colorless	
3	Odor	-	Odorless		Odorless	
4	Salinity	ppt	20.8		18.1	
5	Turbidity	NTU	41		40	
6	Total Dissolved Solids	mg/l	35179		41035	
7	Total Suspended Solids	mg/l	614		678.5	
8	Total Solids	mg/l	35793		41714	
9	DO	mg/l	4.3		4.5	
10	COD	mg/l	96		90	
11	BOD	mg/l	BQL		BQL	
12	Silica	mg/l	0.82		0.85	
13	Phosphate	mg/l	0.21		0.21	
14	Sulphate	mg/l	2340		2376	
15	Nitrate	mg/l	5.07		4.65	
16	Nitrite	mg/l	BQL		BQL	
17	Calcium	mg/l	641.28		641.28	
18	Magnesium	mg/l	1676.7		1725.3	
19	Sodium	mg/l	10489		9631	
20	Potassium	mg/l	429		376	
21	Iron	mg/l	2.08		1.07	
22	Chromium	mg/l	BQL		BQL	
23	Copper	mg/l	BQL		BQL	
24	Arsenic	mg/l	BQL		BQL	
25	Cadmium	mg/l	BQL		BQL	
26	Mercury	mg/l	BQL		BQL	
27	Lead	mg/l	BQL		BQL	
28	Zinc	mg/l	BQL		BQL	

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 36: Marine Water Quality Monitoring Parameters for locations Nr. Vadinar Jetty

Sr. No.	Parameters	Unit	Nr.Vadinar Jetty			
			22°26'25.26"N 69°40'20.41"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.42	7.38	7.45	7.39
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	20.4	19.9	20.4	19.9
5	Turbidity	NTU	42	43	42	43
6	Total Dissolved Solids	mg/l	42652	41202	42652	41202
7	Total Suspended Solids	mg/l	690.6	741.7	690.6	741.7
8	Total Solids	mg/l	43343	41944	43343	41943
9	DO	mg/l	4.6	4.7	4.6	4.7
10	COD	mg/l	70	68	72	76
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.93	0.89	0.93	0.89
13	Phosphate	mg/l	0.22	0.2	0.22	0.2
14	Sulphate	mg/l	2508	2388	2508	2388
15	Nitrate	mg/l	3.17	2.89	3.17	2.89
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	561.12	601.2	561.12	601.2
18	Magnesium	mg/l	1798.2	1725.3	1798.2	1725.3
19	Sodium	mg/l	9768	9808	9106	9020
20	Potassium	mg/l	240	272	250	262
21	Iron	mg/l	BQL	BQL	BQL	BQL
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL

27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 36 (a): Marine Water Quality Monitoring Parameters for locations Nr. Vadinar SPM

Sr. No.	Parameters	Unit	Nr.Vadinar SPM			
			22°30'56.15"N 69°42'12.07"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.4	7.6	7.45	7.26
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odor	Odor	Odor	Odor
4	Salinity	ppt	22.2	22.1	22	21.8
5	Turbidity	NTU	33	34	36	33
6	Total Dissolved Solids	mg/l	21700	21987	20620	20825
7	Total Suspended Solids	mg/l	635	480	513	548
8	Total Solids	mg/l	23340	23324	21384	22000
9	DO	mg/l	4.3	4.1	4.5	4.3
10	COD	mg/l	89	92	78	70
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.92	0.96	0.6	0.78
13	Phosphate	mg/l	0.24	0.25	0.2	0.16
14	Sulphate	mg/l	2628	2364	2316	2556
15	Nitrate	mg/l	3.1	3.38	3.34	3.68
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	481	561.12	521	561.12
18	Magnesium	mg/l	1652.4	2065.5	1676.7	1701
19	Sodium	mg/l	9318	9829	9428	9686
20	Potassium	mg/l	254	255	277	254
21	Iron	mg/l	1.11	1.62	1.27	1.9
22	Chromium	mg/l	BQL	BQL	BQL	BQL

23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

5.4.1 Marine Sediments

Sediment samples were collected with Van Veen Grab from the six locations in Kandla Port Waters and two locations in Vadinar Port. Samples were collected and preserved in silver foil in ice box to prevent the contamination/decaying of the samples.

5.5 Results

The Sediment Quality results are given in below from table no. 34 A & 34 B.

Table 34 A: Results of Analysis of Sediment of Kandla & Vadinar Port (Spring Tide)

Sr. No.	Parameters	Unit	KPT - 1	KPT - 2	KPT - 3	KPT - 4	KPT - 5	Jetty	SPM
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	3.29	2.98	1.62	1.31	3.72	3.84	3.38
3	Organic Carbon	mg/kg	1.91	1.73	0.94	0.76	2.16	2.22	1.96
4	Inorganic Phosphate	mg/kg	110	121	122	135	125	118	119
5	Moisture	%	6.86	29.03	0.33	5.05	14.71	31.25	34.64
6	Aluminium	mg/kg	ND	ND	ND	ND	ND	ND	ND
7	Silica	mg/kg	12.5	11.6	10	11.3	12.5	12.7	11.1
8	Phosphate	mg/kg	17.75	14.14	6.72	3.15	2.11	14.34	ND
9	Sulphate	mg/kg	395.09	747.14	258.86	280.97	639.06	1178.56	977.43
10	Nitrite	mg/kg	0.12	0.11	0.12	0.11	0.13	232.46	228.46
11	Nitrate	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
12	Calcium	mg/kg	160.32	168.34	156.31	168.34	200.4	232.46	228.46
13	Magnesium	mg/kg	38.88	80.19	46.17	55.89	121.5	119.07	94.77
14	Sodium	mg/kg	347.42	986.9	290.88	488.44	840.13	1381.03	1134.96
15	Potassium	mg/kg	22.5	97.95	36.87	52.4	89.96	180.87	158.17
16	Chromium	mg/kg	24.4	21.8	17.3	11	20.3	82.5	106
17	Nickel	mg/kg	2.5	14.8	13.9	3.2	9	41.5	34.6

18	Copper	mg/kg	3.3	8.3	4.1	3.1	4	29	25.6
19	Zinc	mg/kg	11.1	20	16.8	9.8	14.9	40.3	107.5
20	Cadmium	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
21	Lead	mg/kg	3.6	4.2	3.4	3.8	3.5	6.6	8.2
22	Mercury	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
23	Arsenic	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL

*ND - Not Detected, BQL: Below Quantification Limit (NO3:10.0mg/kg, Cd: 1.0mg/kg, Hg: 1.0mg/kg, As: 1.0mg/kg).

Table 34 B: Results of Analysis of Sediment of Kandla & Vadinar Port (Neap Tide)

Sr. No.	Parameters	Unit	KPT - 1	KPT - 2	KPT - 3	KPT - 4	KPT - 5	Jetty	SPM
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	1.53	1.5	1.62	1.31	3.72	3.05	3.14
3	Organic Carbon	mg/kg	0.89	0.87	0.94	0.76	2.16	1.83	1.82
4	Inorganic Phosphate	mg/kg	116	120	123	111	128	112	129
5	Moisture	%	0.81	0.27	0.33	5.05	14.71	24.04	26.83
6	Aluminium	mg/kg	ND	ND	ND	ND	ND	ND	ND
7	Silica	mg/kg	12.3	11.8	12.2	11.3	13.2	11.7	10
8	Phosphate	mg/kg	18.07	15.08	6.72	3.15	2.11	0.63	ND
9	Sulphate	mg/kg	456.82	295.8	258.86	280.97	639.06	577.88	756.91
10	Nitrite	mg/kg	0.12	0.11	0.11	0.12	0.11	0.11	0.12
11	Nitrate	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
12	Calcium	mg/kg	152.3	160.32	156.31	168.34	200.4	196.39	208.42
13	Magnesium	mg/kg	41.31	51.03	46.17	55.89	121.5	143.37	179.82
14	Sodium	mg/kg	435.4	357.09	290.88	488.44	840.13	1019.68	1354.17
15	Potassium	mg/kg	22.6	39.84	36.87	52.4	89.96	191.04	187.09
16	Chromium	mg/kg	10.8	38.6	16.2	6.9	30.9	40	40.3
17	Nickel	mg/kg	3.6	5.4	15.5	5.5	21.5	26.2	25.9
18	Copper	mg/kg	2.8	4.3	127.1	0.9	7.6	14.5	13.2
19	Zinc	mg/kg	7	11.5	66.5	3.4	26	37.8	32
20	Cadmium	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
21	Lead	mg/kg	3.1	2.7	3.6	3.4	2.2	4.6	3.7
22	Mercury	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
23	Arsenic	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL

*ND - Not Detected, BQL: Below Quantification Limit (NO3:10.0mg/kg,Cd: 1.0mg/kg,Hg: 1.0mg/kg, As: 1.0mg/kg)

REPORT ON ECOLOGICAL MONITORING OF MARINE ENVIRONMENT IN DPT HARBOUR AREA, NEAR BY CREEKS AND VADINAR JETTY AND SPM FOR

DEENDAYAL PORT TRUST

February, 2022

INTRODUCTION:

Sampling Stations:

The monitoring of marine environment for the study of biological and ecological Parameters was carried out on 02nd February 2022 in harbour region of DPT at Kandla Creek, and on 03rd February 2022 in creeks near by the port during spring tide. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 8th February, 2022 in harbour region of DPT at Kandla Creek and on 9th February, 2022 in creeks near by the port during neap tidal condition.

Plankton samples from sub surface layer was collected both during high tide period and low tide period from 3 water quality monitoring stations of KPT harbour area and one stations in Nakti creek and one station in Khori creek. Sampling at second sampling station of Nakti creek was possible only during high tide period. The same sampling schedule was repeated during consecutive Neap tide and spring tide in same month.

Plankton samples from sub surface layer were collected during high tide period and low tide period from monitoring station near Vadinar jetty at Path Finder Creek during neap tide on 02/02/2022 and spring tide period on 08/02/2022 .Collected water samples were processed for estimation of Chlorophyll- a, Pheophytin- a, qualitative &quantitative evaluation of phytoplankton, qualitative &quantitative evaluation zooplanktons (density and their population).

TABLE #1 SAMPLING LOCATIONS

monitoring requirement	**Number of locations**
Kandla creek Nakti creek Khori Creek Vadinar jetty SPM	3 in Kandla creek 2 in Nakti creek 1 in Khori creek 1 near Vadinar Jetty 1 near I stSPM
Total Number of locations	**8**

Sampling methodology adopted:

A marine sampling is an estimation of the body of information in the population. The theory of the sampling design is depending upon the underlying frequency

distribution of the population of interest. The requirement for useful water sampling is to collect a representative sample of suitable volume from the specified depth and retain it free from contamination during retrieval.

50 litres of the water sample were collected from Sub surface by using bucket. From the collected water sample 1 litres of water sample were taken in an opaque plastic bottle for

chlorophyll estimation, thereafter plankton samples were collected by using filtration assembly with nilyobolt cloth of 20µm mesh size.

Samples Processing for chlorophyll estimation:

Samples for the chlorophyll estimation were preserved in ice box on board in darkness to avoid degradation in opaque container covered with aluminium foil. Immediately after reaching the shore after sampling, 1 litre of collected water sample was filtered through GF/F filters (pore size 0.45 µm) by using vacuum filtration assembly. After vacuum filtration the glass micro fiber filter paper was grunted in tissue grinder, macerating of glass fiber filter paper along with the filtrate was done in 90% aqueous Acetone in the glass tissue grinder with glass grinding tube. Glass fiber filter paper will assist breaking the cell during grinding and chlorophyll content was extracted with 10 ml of 90% Acetone, under cold dark conditions along with saturated magnesium carbonate solution in glass screw cap tubes. After an extraction period of 24 hours, the samples were transferred to calibrated centrifuge tubes and adjusted the volume to original volume with 90% aqueous acetone solution to make up the evaporation loss. The extract was clarified by using centrifuge in closed tubes. The clarified extracts were then decanted in clean cuvette and optical density was observed at wavelength 664, 665 nm. By using corrected optical density, Chlorophyll-a value was calculated as given in (APHA, 1998).

PLANKTON:

The entire area open water in the sea is the pelagic realm. Pelagic organisms live in the open sea. In contrast to the pelagic realm, the benthic realm comprises organisms and zone of the bottom of the sea. Vertically the pelagic realm can be dividing into two zones based on light penetration; upper photic or euphotic zone and lower dark water mass, aphotic zone below the photic zone.

The term plankton is general term for organisms have such limited powers of locomotion that they are at the mercy of the prevailing water movement. Plankton is subdivided to phytoplankton and zooplankton. Phytoplankton is free floating organisms that are capable of photosynthesis and zooplankton is the various free floating animals.

Pelagic zone, represents the entire ocean water column from the surface to the deepest depths, is home to a diverse community of organisms. Differences in their locomotive ability categorize the organisms in the pelagic realm into two, ***plankton*** and ***nekton*** (Lalli and Parsons, 1997). ***Plankton*** consists of all organisms drifting in the water and is unable to swim against water currents, whereas ***Nekton*** includes organisms having strong locomotive power. Ecological

studies on the plankton community, which form the base of the aquatic food chain, help in the better understanding of the dynamics and functioning of the marine ecosystem. The term ‘Plankton’ first coined by Victor Hensen (1887), Plankton, (Greek word: *planktos* meaning “passively drifting or wandering”) is defined as drifting or free-floating

organisms that inhabit the pelagic zone of water. Based on their mode of nutrition planktonic organisms are categorised into phytoplankton (organisms having an autotrophic mode of nutrition) and zooplankton (organisms having a heterotrophic mode of nutrition).

Phytoplankton in the marine environment:

Phytoplankton is free floating unicellular, filamentous and colonial eutrophic organisms that grow in aquatic environments whose movement is more or less dependent upon water currents. These micro flora acts as primary producers as well as the basis of food chain, source of protein, bio purifier and bio indicators of the aquatic ecosystems of which diverse array of the life depends. They are considered as an important component of aquatic flora, play a key role in maintaining equilibrium between abiotic and biotic components of aquatic ecosystem.

The phytoplankton includes a wide range of photosynthetic and phototrophic organisms. Marine phytoplankton is mostly microscopic and unicellular floating flora, which are the primary producers that support the pelagic food-chain. The two most prominent groups of phytoplankton are diatoms (Bacillariophyceae) and dinoflagellates (Dinophyceae). The phytoplankton those normally captured in the net from the Gulf of Kutch is normally dominated by these two major groups; diatoms and dinoflagellates. Phytoplankton also include numerous and diverse collection of extremely small, motile algae which are termed micro flagellates (naked flagellates) as well as and Cyanophytes (blue-green algae).

Algae are an ecologically important group in most aquatic ecosystems and have been an important component of biological monitoring programs. Algae are ideally suited for water quality assessment because they have rapid reproduction rates and very short life cycles, making them valuable indicators of short-term impacts.

Aquatic populations are impacted by anthropogenic stress, resulting in a variety of alterations in the biological integrity of aquatic systems. Algae can serve as an indicator of the degree of deterioration of water quality, and many algal indicators have been used to assess environmental status.

Zooplankton in the marine environment:

Zooplankton includes a taxonomically and morphologically diverse community of heterotrophic organisms that drift in the waters of the world's oceans. Qualitative and quantitative studies on zooplankton community are a prerequisite to delineate the ecological processes active in the marine ecosystem. Zooplankton community plays a pivotal role in the pelagic food web as the primary consumers

of phytoplankton and act as the food source for organisms in the higher trophic levels, particularly the economically essential groups such as fish larvae and fishes. They also function in the cycling of elements in the marine ecosystem. The dynamics of the zooplankton community, their reproduction, and growth and survival

rate are all significant factors determining the recruitment and abundance of fish stocks as they form an essential food for larval, juvenile and adult fishes (Beaugrand et al., 2004). Zooplankton grazing in the marine environment controls the primary Production and helps in determining the pelagic ecosystem (Banse, 1995). Through grazing in surface waters and following the production of sinking faecal matters and also by the active transportation of dissolved and particulate matter to deeper waters via vertical migration, they help in the transport of organic carbon to deep ocean layers and thus act as key drivers of biological pump' in the marine ecosystem. Zooplankton grazing and metabolism also, transform particulate organic matter into dissolved forms, promoting primary producer community, microbial demineralization, and particle export to the ocean's interior.

The categorisation of zooplankton into various ecological groups is based on several factors such as duration of planktonic life, size, food preferences and habitat. As they vary significantly in size from microscopic to metazoic forms, the classification of zooplankton based on size has paramount importance in the field of quantitative plankton research.

Based on the duration of planktonic life, zooplankton are categorised into Holoplankton (organisms which complete their entire lifecycle as plankton) and Meroplankton (organisms which are planktonic during the early part of their lives such as the larval stages of benthic and nektonic organisms). Tychoplankton are organisms which live a brief planktonic life, such as the benthic crustaceans (Cumaceans, mysids, isopods) which ascend to the water column at night for feeding and certain ectoparasitic copepods, they leave the host and spend their life as plankton during their breeding cycle.

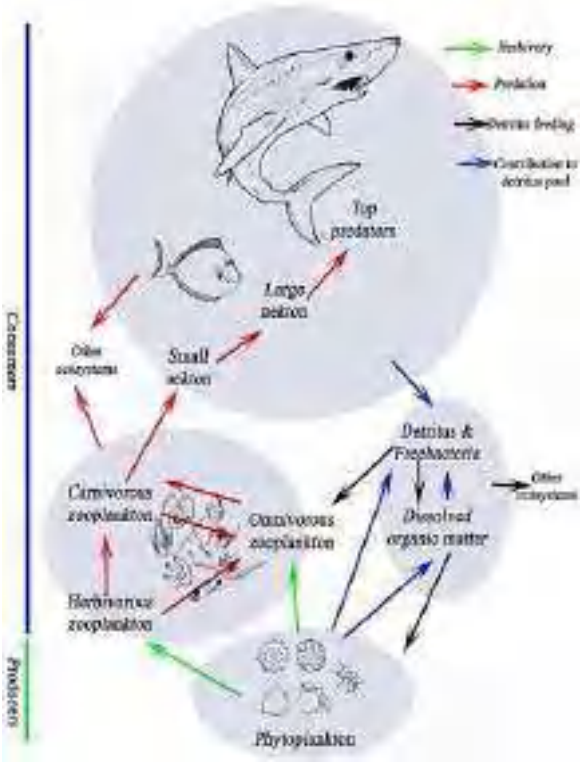
Zooplankton can be subdivided into holoplankton, i.e., permanent members of the plankton (e.g., Calanoid copepods), and meroplankton, i.e., temporary members in the plankton e.g., larvae of fish, shrimp, and crab). The meroplankton group consists of larval and young stages of animals that will adopt a different lifestyle once they mature. In contrast to phytoplankton which consist of a relatively smaller variety of organisms, Zooplankton are extremely divers, consist of a host of larval and adult forms representing many animal phylum.

Among the zooplankton one group always dominate than others; members of sub class copepods (Phylum Athropoda) and Tintinids (Phylum Protozoa) among the net planktons. These small animals are of vital importance in marine ecosystem as one of the primary herbivores animals in the sea, and it is they provide vital

link between primary producer (autotrophs) and numerous small and large marine consumers.

As their community structure and function are highly susceptible to changes in the environmental conditions regular monitoring of their distribution as well as their interactions with various physicochemical parameters is inevitable for the sustainable management of the ecosystem (Kusum et al., 2014) Of all the marine zooplankton groups, copepods mainly

Calanoid copepods are the dominant groups in marine subtropical and tropical waters andexhibit considerable diversity in morphology and habitats they occupy (Madhupratap, 1991;) It has been well established that potential of pelagic fishes viz. finfishes, crustaceans,molluscs and marine mammals either directly or indirectly depend on zooplankton. Theherbivorous zooplankton is efficient grazers of the phytoplankton and is referred to as livingmachines transforming plant material into animal tissue. Hence they play an essential role asthe intermediaries for nutrients/energy transfer between primary and tertiary trophic levels.Due to their large density, shorter lifespan, drifting nature, high group/species diversity anddifferent tolerance to the stress, they used as the indicator organisms for the physical,chemical and biological processes in the aquatic ecosystem (Ghajbhiye, 2002).



Simplified marine food web

Spatial distribution of Plankton:

A characteristic of plankton population is that they tend to occur in patches, which are varying spatially on a scale of few meters to far as few kilometres in distance. They also vary in time scale, season as well as vertically in the water column. It is this patchiness and its constant changes in time and spot, that has made it so difficult for plankton biologist to learn about the ecology of plankton. The biological factors that causes this patchiness is due to the ability of zooplankton to migrate vertically and graze out the phytoplankton at a rapid rate

that can create patchiness. Similarly the active swimming ability by certain zooplankton organisms can cause to aggregate in dense group.

At its most extreme, because the water in which plankton is suspended is constantly moving,each sample taken by the plankton biologists remain a different volume of water, so eachsample is unique and replicate does not exist.

Plankton may also exhibit vertical patchiness. Physical factors contribute to this type ofpatchiness include light intensity, nutrients and density gradients in the water column.

Phytoplankton in particular tends to be unequally distributed vertically, which leads to the existence of different concentration of a chlorophyll value between photic zone and below the photic zone.

Methodology adopted for Plankton sampling:

Mixed plankton sample were obtained from the sub surface layer at each sampling locations by towing the net horizontally with the weight after the tow of about 15-30minutes, plankton net was pulled up and washed down to the tail and collected the plankton adhered to plankton net in the collection bucket at the bottom by springing outer and inner surface of the net with sea water, while the net was hanging with the mouth upward. For quantitative evaluation 50 L water samples were collected from subsurface layer and filtered through 20µm mesh size net by using bucket and filtration assembly.

Preservation and storage:

Both filtered plankton and those collected from the plankton net were preserved with 5% buffered formalin and stored in 1L plastic container for further processing in the laboratory.

Sample concentration:

The collected plankton samples were concentrated by using centrifuge and made up to 50ml with 5% formalin -Glycerine mixture.

Taxonomic evaluation:

Before processing, the sample was mixed carefully and a subsample was taken with a calibrated Stempel-pipette. 1 ml of the concentrated plankton samples were transferred on a glass slide with automatic pipette. The plankton sample on the glass slides were stained by using Lugol's iodine and added glycerine to avoid drying while observation. The plankton samples were identified by using Labex triangular Research microscope with photographic attachment. Microphotographs of the plankton samples were taken for record as well as for confirming the identification. The bigger sized zooplankton was observed through dissecting stereomicroscope with magnification of 20-30 x. Plankton organisms in the whole slide were identified to the lowest axon possible. A thorough literature search was conducted for the identification of the different groups of zooplankton

that were encountered

Cell counts by drop count method:

The common glass slide mounted with a 1ml of concentrated phytoplankton / zooplankton sample in glycerol and covered with cover slip 22 x 60 mm was placed under the compound microscope provided with a mechanical stage. The plankton was then counted from the

microscopic field of the left top corner of the slide. Then slide is moved horizontally along the right side and plankton in each microscopic field was thus counted. When first microscopic field row was finished the next consecutive row was adjusted using the mechanical device of the stage. In this way all the plankton present in entire microscopic field are counted. From this total number in 1ml of the concentrated plankton, total number of plankton in the original volume of sample filtered was calculated as units/L.

BENTHIC ORGANISMS:

Benthos is those organisms that are associated with the sea bed or benthic habitats. Epi- benthic organisms live attached to a hard substratum or rooted to a shallow depth below the surface. In fauna organisms live below the sediment–water interface. Interstitial organisms live and move in pore water among sedimentary grains.

Because the benthic organisms are often collected and separated on sieves, a classification based on the overall size is used. Macro benthos include organisms whose shortest dimension is greater than or equal to 0.5 mm. Meio benthos are smaller than 0.5mm but larger than 42µ in size.

The terms such as macro fauna and Meio fauna generally have little relevance with taxonomic classification. The terms Meio fauna and macro fauna depend on the size. Meio fauna were considered as good bioassay of community health and rather sensitive indicatorsof environmental changes.

SAMPLING METHODOLOGY ADOPTED FOR SUB TIDAL REGION:

Van veen sampler ($0.09m^2$) was used for sampling bottom sediments. Two sets of sediments were sampled from each location, one for macro fauna and other for Meio fauna. The macro fauna in the sediments were sieved on board to separate out the organisms. The fixation of Meio fauna is normally done by bulk fixation of the sediment sample. The bulk fixation is done by using 10% formalin (Buffered with borate). The organisms were preserved with seawater as diluting agent.

Sample sieving:

Sediments samples were sieved to extract the organisms. Sieving was performed carefully as possible to avoid any damage to the animals. The large portion of the sediment was split in to smaller portions and mixed with sea water in a bucket. The cohesive lumps were broken down by continuous stirring. The dis-aggregated sediments were then passed through the sieves.

Sample staining:

Sorting of the Meio fauna from the sieve is difficult task especially in the

preserved material, because organisms are not easily detectable. To facilitate the animal detection the entire sample retained on the sieve after sieving operation were stained by immersing the sieve in

a flat bottom tub with 1% Rose Bangal stain; a protein stain. A staining period of 10-30 minutes is sufficient for sample detection.

DIVERSITY INDICES:

On the whole, diversity indices provide more information about community composition than simply species richness (number of species present); they also, take the relative abundances of different species into account. Based on this fact, diversity indices therefore depend not only on species richness but on the evenness, or equitability, with which individuals are distributed among the different species (Magurram, A. E. (1988).

A diversity index is a measure of species diversity within a community that consists of co- occurring populations of several (two or more) different species. It includes two components: richness and evenness. Richness is the measure of the number of different species within a sample showing that more the types of species in a community, the higher is the diversity or greater is the richness. Evenness is the measure of relative abundance of the different species with in a community.

The basic idea of diversity index is to obtain a quantitative estimate of biological variability that can be used to compare biological entities composed of discrete components in space and time (Carol H.R. *etal*. 1998). Biodiversity is commonly expressed through indices based on species richness and species abundances (Whittaker 1972, Lande 1996, Purvis and Hector 2000). Biodiversity indices are a non-parametric tool used to describe the relationship between species number and abundance. The most widely used bio diversity indices are Shannon Weiner index and Simpson's index.

A diversity Index is a single statistic that incorporates in formation on richness and evenness. The diversity measures that incorporate the two concepts may be termed heterogeneity measures (Magurran, 2004).

Any study intended to interpret causes and effect of adverse impact on Biodiversity of communities require suitable measures to evaluate specie richness and Diversity. The former is number of species in community, while latter is a function of relative frequency of different species. Species richness is the iconic measure of biological diversity (Magurran, 2004). Several indices have been created to measure the diversity of species; however, the most widely used in the last decades are the Shannon (1948) and Simpson (1949) (Buzas and Hayek 1996; Gorelick 2006), with the components of diversity: richness (*S)* and evenness (*J).*

Simpson's diversity index

Simpson's index (**D**) is a measure of diversity, which takes into account both species richness, and evenness of abundance among the species present.. The Simson index is one of the meaningful and robust biodiversity measures available.(Magurran ,2004).

The formula for calculating D is presented as:

$$D \ll \frac{n_i(n_i - 1)}{N(N - 1)}$$

Where n_i = the total number of organisms of each individual species N = the total number of organisms of all species

The value of D ranges from 0 to 1. With this index, 0 represents infinite diversity and, 1, no diversity. When D increases diversity decreases. Simpson's index is therefore usually expressed as 1-D or 1/D. (Magurran, 2004)

Low species diversity suggests:

- relatively few successful species in the habitat
- the environment is quite stressful with relatively few ecological niches and only a feworganisms are really well adapted to that environment
- food webs which are relatively simple
- change in the environment would probably have quite

serious effectsHigh species diversity suggests:

- a greater number of successful species and a more stable ecosystem
- more ecological niches are available and the environment is less likely to be hostilecomplex food webs
- environmental change is less likely to be damaging to the ecosystem as a whole

Species richness indices

The species richness ***(S)*** is simply the number of species present in an ecosystem. Species richness Indices of species richness are widely used to quantify or monitor the effects of anthropogenic disturbance. A decline in species richness may be concomitant with severe orchronic human-induced perturbation (Fair Fair weather 1990). Species richness measures have traditionally been the mainstay in assessing the effects of environmental degradation on the biodiversity of natural assemblages of organisms (Clarke &Warwick, 2001).

Species richness is the iconic measure of biological diversity (Magurran, 2004). The species richness ***(S)*** is simply the number of species present in an ecosystem. This index makes no use of relative abundances. The term species richness was coined by McIntosh (1967) and oldest and most intuitive measure of biological diversity (Magurran, 2004).

Margalef's diversity index is a species richness index. Margalef's Species richness index (d),or indices that describe the evenness of the distribution of the numbers of individuals among species, were derived.

The value of a diversity index increases both when the number of types increases and when evenness increases. For a given number of types, the value of diversity

index is maximised when all types are equally abundant (Rosenzweig, M. L. (1995).

Shannon-Wiener's index:

An index of diversity commonly used in plankton community analyses is the Shannon- Wiener's index **(H),** which emphasizes not only the number of species (richness or variety), but also the apportionment of the numbers of individuals among the species (Odum 1971 and Reish 1984). Shannon-Wiener's index **(H**) reproduces community parameters to a single number by using an equation.

Shannon and Weiner index represents entropy. It is a diversity index taking into account the number of individuals as well as the number of taxa. It varies from 0 for communities with only single taxa to high values for community with many taxa each with few individuals. This index can also determine the pollution status of a water body. Normal values range from 0 to

4. This index is a combination of species present and the evenness of the species. Examining the diversity in the range of polluted and unpolluted ecosystems, Wilham and Dorris (1968) concluded that the values of the index greater than 3 indicate clean water, values in the range of 1 to 3 are characterized by moderate pollution and values less than 1 are characterized as heavily polluted

$$H = -\sum_{i=1}^{s} \frac{n_i}{N} \ln\left(\frac{n_i}{N}\right)$$

RESULTS:

CHLOROPHYLL-a:

Water Samples for the chlorophyll estimation were collected from sub surface layer during high tide and low tide period of the tidal cycle for each sampling locations and analysed for Chlorophyll-a and after acidification for Pheophytin–a. Chlorophyll- a value was used as algal biomass indicator (APHA,1998). Algal biomass was estimated by converting Chlorophyll value.

In the sub surface water chlorophyll-a was varying from 0.597 - 0.951 mg/m^3 with an average value 0.828 mg/m^3 of in harbour region of DPT in Kandla Creek during sampling done in spring tide period of February 2022. In the nearby creeks chlorophyll-a was varying from 0.395 - 1.528 mg/m^3 with an average value 1.007 mg/m^3 Pheophytin–a level was below detectable limit. All the sampling stations during spring tide.

In the sub surface water chlorophyll-a was varying from 0.709 - 1.0546 mg/m^3 with an average value 0.867 mg/m^3 in harbour region of DPT in Kandla Creek during sampling done in neap tide period of February 2022. In the nearby creeks chlorophyll-a was varying from

0.536 - 1.055 mg/m^3 with an average value 0.828mg/m^3. ·Pheophytin–a level was below detectable limit- the all the sampling stations.

In the sub surface water chlorophyll-a was varying from 0.628 - 1.156 mg/m^3 with an average value 0.883 mg/m^3. in harbour region of DPT OOT in path finder Creek during sampling done in spring tide period of February 2022. In the sub surface water chlorophyll- a was varying from 0.833 – 1.039 mg/m^3 with an average value 0.940 mg/m^3.in harbour region of DPT OOT in path finder Creek during sampling done in Neap tide period of February 2022.

TABLE #2 VARIATIONS IN CHLOROPHYLL –a PHEOPHYTIN- a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPT HARBOUR AREA IN KANDLA CREEK,NEAR BY CREEKS AND DPT OOT JETTY IN PATH FINDER CREEK AND SPM NEARVADINAR DURING SPRING TIDE IN FEBRUARY 2022

Sr. No.	Station	Tide		Pheophytin- a (mg/m3)	Algal Biomass (Chlorophyll method) mg/m3
DPT HARBOUR AREA KANDLA CREEK					
1	KPT1	High tide	0.951	BDL	63.72
		Low tide	0.85	BDL	56.95
2	KPT 2	High tide	0.92	BDL	61.64
		Low tide	0.834	BDL	55.88
3	KPT 3	High tide	0.597	BDL	39.99
		Low tide	0.818	BDL	54.81
CREEKS					
4	KPT-4 Khori-I	High tide	1.156	BDL	77.45
		Low tide	0.903	BDL	60.5
5	KPT-5 Nakti-I	High tide	1.528	BDL	102.38
		Low tide	1.053	BDL	70.55
6	KPT-5 Nakti-II	High tide	0.395	BDL	26.46
PATHFINDER CREEK VADINAR					
7	VADINAR-I jetty	High tide	0.833	BDL	55.81

BDL: Below Detectable Limit.

TABLE #3 VARIATIONS IN CHLOROPHYLL –a PHEOPHYTIN- a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKSAND DPT OOT JETTY IN PATH FINDER CREEK AND SPM NEAR VADINAR DURINGNEAP TIDE IN FEBRUARY 2022

Sr. No.	Station	Tide	Chlorophyll-a (mg/m3)	Pheophytin- a (mg/m3)	Algal Biomass (Chlorophyll method) mg/m3
DPT HARBOUR AREA KANDLA CREEK					
1	KPT1	High tide	0.834	BDL	55.88
		Low tide	1.054	BDL	70.62
2	KPT 2	High tide	0.709	BDL	47.5
		Low tide	0.952	BDL	63.78
3	KPT 3	High tide	0.833	BDL	55.81
		Low tide	0.819	BDL	54.87
CREEKS					
4	KPT-4 Khori-I	High tide	1.055	BDL	70.68
		Low tide	0.732	BDL	49.04
5	KPT-5 Nakti-I	High tide	0.865	BDL	57.96
		Low tide	0.953	BDL	63.85
6	KPT-5 Nakti-II	High tide	0.536	BDL	35.91
PATHFINDER CREEK VADINAR					
7	VADINAR-I jetty	High tide	0.63	BDL	42.21
8		Low tide	0.936	BDL	62.71
9	SPM	High tide	0.833	BDL	55.81
10	SPM	Low tide	0.747	BDL	50.05

BDL: Below Detectable Limit.

PHYTOPLANKTON POPULATION:

For the evaluation of the Phytoplankton population in DPT harbour area and within theimmediate surroundings of the port, sampling was conducted from 5 sampling locations (3

in harbour area and two in Nakti creek) during high tide period and low tide period of spring tide and neap tide.

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by, Diatoms blue green algae and dinoflagellates during spring tide period. Diatoms were represented by 20 genera. Blue green were represented by 2 genera and dinoflagellates were represented by 4 genera during the sampling conducted in spring tide in February, 2022. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 87-239 units/ L during high tide period and 163-- 236 units/ L during low tide of Spring Tide.

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by Diatoms. Blue green algae and Dinoflagellates during Neap tide period. Diatoms were represented by 22 genera Blue green algae were represented 3 genera and dinoflagellates with 4 genera during the sampling conducted in Neap tide in February, 2022. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 112-286 units/ L during high tide period and 198-279 units/ L during low tide of Neap Tide.

For the evaluation of the Phytoplankton population in DPT OOT jetty area in Path Finder creek sampling was conducted from two sampling locations; jetty area during high tide period and low tide of spring tide and Neap tide period.

The phytoplankton community of the sub surface water in the path finder creeks was represented by Diatoms, Blue green alage and Dinoflagellates during spring tide period. Diatoms were represented by 15 genera, Blue Green algae by 2 genera and Dinoflagellates

3 genera each during the sampling conducted in spring tide in February, 2022. Phytoplankton of the sampling stations at sub surface layer in the harbour area was varying from 285 units/ L during high tide period and 166 units/ L during low tide of Spring Tide. Phytoplankton of the sampling stations at sub surface layer in the SPM area was varying from 240 units/ L during high tide period and 285 units/ L during low tide of Spring Tide.

The phytoplankton community of the sub surface water in the path finder creeks was represented by Diatoms, Blue green and Dinoflagellates during Neap tide period. Diatoms were represented by 19 genera and Blue green algae 2 genera and dinoflagellates by 3 genera each during the sampling conducted in Neap tide in February, 2022. Phytoplankton of the sampling stations at sub surface path finder creek near OOT Jetty was varying from

125 units/ L during high tide period and 187 units/ L during low tide of Neap Tide. Phytoplankton of the sampling stations at sub surface path finder creek near SPM area was varying from 146 units/ L during high tide period and 144 units/ L during low tide of Neap Tide.

Species Richness Indices and Diversity Indices:

Margalef's diversity index (Species Richness)S

At the organismal level, the most widely used biodiversity measures are those based on the number of species present, perhaps adjusted for the number of individuals sampled, Here Margalef's Species richness index (d), or indices that describe the evenness of the distribution of the numbers of individuals among species, are derived.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek and nearby creeks sampling stations was varying from 3.359 - 4.208 with an average of 3.945 during the sampling conducted in High tide period of spring tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek region and nearby creeks was varying from 3.482 - 3.86 with an average of 3.657 during the consecutive low tide period.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations in Kandla creek and nearby creeks was varying from 3.049 - 4.319 with an average of 3.489 during the sampling conducted in High tide period of Neap tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek region and nearby creeks was varying from 2.56 - 3.382 with an average of 3.091 during consecutivelow tide.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations was 3.008 at OOT jetty area and 2.919 at SPM area during the sampling conducted in High tide period of spring tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the path finder creek near OOT jetty was 2.934 and 3.008 at SPM during the consecutive low tide period.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations was 3.935 at OOT jetty area and 3.411 at SPM area during the sampling conducted in High tide period of Neap tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the path finder creek near OOT jetty was 4.014 and SPM area was 3.823 during the consecutive low tide period.

Shannon-Wiener's index:

Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.962 - 1.057 (H'(log10)) between selected sampling stations with an average value of 1.012 during high tide period of spring tide at Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton

communities in the sampling stations was in the range of 0.963 - 1.137-(H'(log10)) between selected sampling stations with an average value of 1.018 during consecutive low tide at Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.836 - 1.137 (H'(log10)) between selected sampling stations with an average value of

0.934 during high tide period of neap tide at Kandla creek and nearby creeks. Shannon- Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.794 - 0.888 (H'(log10)) between selected sampling stations with an average value of 0.847 during consecutive low tide at Kandla creek and nearby creeks.

Shannon-Wiener's Index (H) of phytoplankton communities in the stations was 0.866 at OOT jetty area and 0.934 at SPM area during the sampling conducted in High tide period of spring tide. While Shannon-Wiener's Index (H) of phytoplankton communities in the path finder creek near OOT jetty was 1.048 and 0.914 at SPM during the consecutive low tide period.

Shannon-Wiener's Index (H) of phytoplankton communities in the stations was 0.868 at OOT jetty area and 0.800 at SPM area during the sampling conducted in High tide period of Neap tide. While Shannon-Wiener's Index (H) of phytoplankton communities in the path finder creek near OOT jetty was 0.861 and at SPM area was 0.990 during the consecutive low tide period.

Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon-Wiener's index increases as both the richness and the evenness of the community increase. This result indicates that diversity of phytoplankton of Kandla Harbour region and nearby creeks is less but with abundant population of few, with relatively few ecological niches and only very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson's diversity index:

Simpson's index (D) is a measure of diversity, which takes into account both species richness, and an evenness of abundance among the species present. The Simson index is one of the meaningful and robust biodiversity measures available. (Magurran,2004).

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks, which was varying from 0.833 - 0.885 between selected sampling stations with an average of 0.854 during high tide period of spring tide. Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks except few, which was varying from 0.846 - 0.905 between selected sampling stations with an average of 0.870 during consecutive low tide.

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations except few in Kandla Harbour region and nearby creeks,

during high tide period and low tide period during neap tide also, which was varying from 0.800 - 0.912 with an average value of 0.831 between selected sampling stations during high tide period and 0.744 - 0.824 varying from with an average value of 0.787 between selected sampling stations during consecutive low tide period Low species diversity suggests a relatively few successful species in this habitat.

Simpson diversity index (1-D) of phytoplankton communities in the stations was 0.738 at OOT jetty area and 0.815 at SPM area during the sampling conducted in High tide period of spring tide at Path finder creek. While Simpson diversity index (1-D) of phytoplankton communities in the path finder creek near OOT jetty was 0.889 and 0.760 at SPM during the consecutive low tide period in the path finder creek.

Simpson diversity index (1-D) of phytoplankton communities in the stations was 0.749 at OOT jetty area and 0.716 at SPM area during the sampling conducted in High tide period of Neap tide at Path finder Creek. While Simpson diversity index (1-D) of phytoplankton communities in the path finder creek near OOT jetty was 0.727 and at SPM area was 0.832 during the consecutive low tide period.

Low species diversity suggests a relatively few successful species in this habitat. The environment is quite stressful with relatively few ecological niches and only a few organisms are really well adapted to that environment. Any change in the environment would probably have quite serious effects.

Table # 4 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND ,NEAR BY CREEKS DURING SPRING TIDE IN FEBRUARY 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log10)	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	218	23/26	88.46	4.086	1.011	0.8464
	3	147	22/26	84.61	4.208	1.057	0.8737
	4	223	22/26	84.61	3.884	1.014	0.8443
	5	239	23/26	88.46	4.017	0.9629	0.8333
	6	87	16/26	61.54	3.359	1.012	0.8851
	1	174	18/26	69.23	3.295	0.9632	0.846
	2	163	23/26	88.46	4.319	1.137	0.9052

LOW TIDE	3	174	19/26	73.07	3.489	1.051	0.8827
	4	190	17/26	65.38	3.049	0.972	0.8635
	5	236	19/26	73.07	3.294	0.9717	0.853

Table # 5 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND, NEAR BY CREEKS DURING NEAP TIDE IN FEBRUARY 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log10)	Diversity Index (Simpson's Index) 1 -D
HIGH TIDE	1	211	17/29	58.62	2.99	0.8661	0.8005
	2	168	17/29	58.62	3.123	0.9041	0.8364
	3	212	21/29	72.41	3.734	0.9227	0.8042
	4	286	21/29	72.41	3.536	0.9378	0.8261
	5	229	18/29	62.07	3.129	0.8368	0.8123
	6	112	20/29	68.96	4.027	1.137	0.9122
LOW TIDE	1	279	19/29	65.52	3.196	0.8887	0.8249
	2	237	15/29	51.72	2.56	0.8066	0.7813
	3	205	19/29	65.51	3.382	0.8768	0.7906
	4	198	18/29	62.07	3.215	0.8716	0.7976
	5	240	18/29	62.07	3.102	0.7941	0.7449

Table # 6 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND, NEAR BY CREEKS DURING SPRING TIDE IN FEBRUARY 2022

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phytoplankton	Taxon Diversity % (Group level)
			DIATOMS	84-225	20/26	76.93
			BLUE GREEN	8-Feb	26-Feb	7.69

HIGH TIDE	Sub surface	6	DINOFLAGELLATES	9-Jan	26-Apr	15.38
			TOTAL PHYTO PLANKTON	87-239	26	
LOW TIDE	Sub surface	5	DIATOMS	152-229	20/26	76.93
			BLUE GREEN	8-Apr	26-Feb	7.69
			DINOFLAGELLATES	4-Jan	26-Apr	15.38
			TOTAL PHYTO PLANKTON	163-236	26	

Table # 7 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND, NEAR BY CREEKS DURING NEAPTIDE IN FEBRUARY 2022

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phytoplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	DIATOMS	108-272	22/29	75.87
			BLUE GREEN	8-Feb	29-Mar	10.34
			DINOFLAGELLATES	8-Feb	29-Apr	13.79
			TOTAL PHYTO PLANKTON	**211-168**	**29**	-
LOW TIDE	Sub surface	5	DIATOMS	192-274	22/29	75.87
			BLUE GREEN	5-Jan	29-Mar	10.34
			DINOFLAGELLATES	8-Feb	29-Apr	13.79
			TOTAL PHYTO PLANKTON	**279-237**	**29**	-

Table # 8 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT OOT AT PATH FINDER CREEK , VADINAR& NEAR BY SPM, DURING SPRING TIDE IN FEBRUARY 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log10)	Diversity Index (Simpson's Index) 1-D
HIG	jetty	285	18/20	90	3.008	0.8666	0.7389

HIGH TIDE	SPM	240	17/20	85	2.919	0.9346	0.8154
LOW TIDE	jetty	166	16/20	80	2.934	1.048	0.8895
	SPM	285	18/20	90	3.008	0.9147	0.7601

Table # 9 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUBSURFACE SAMPLING STATIONS IN DPT OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING NEAP TIDE IN FEBRUARY 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log10)	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	125	20/24	83.33	3.935	0.8681	0.7497
	SPM	146	18/24	75	3.411	0.8008	0.7165
LOW TIDE	Jetty	187	22/24	91.67	4.014	0.8616	0.7277
	SPM	144	20/24	83.33	3.823	0.9907	0.8325

Table # 10 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONSIN DPT DPT OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING SPRING TIDE IN FEBRUARY 2022

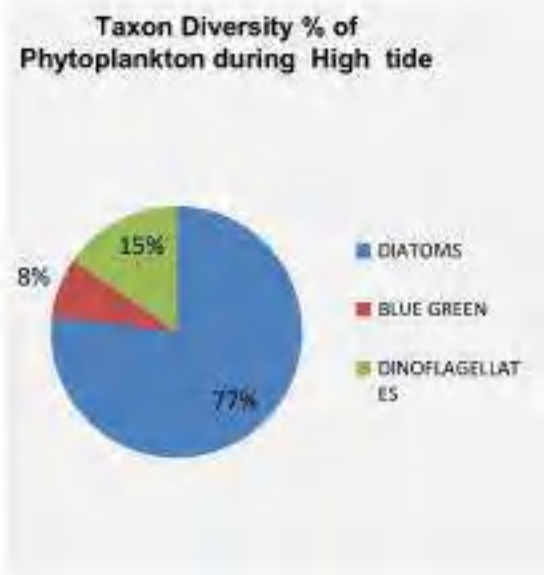
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phytoplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	1	BLUE GREEN	19-27	20-Feb	10
			DIATOMS	212-263	15/20	75
			DINOFLAGELLATES	3-Jan	20-Mar	15
			TOTAL PHYTO PLANKTON	240-285	20	-
			BLUE GREEN	23	20-Feb	10

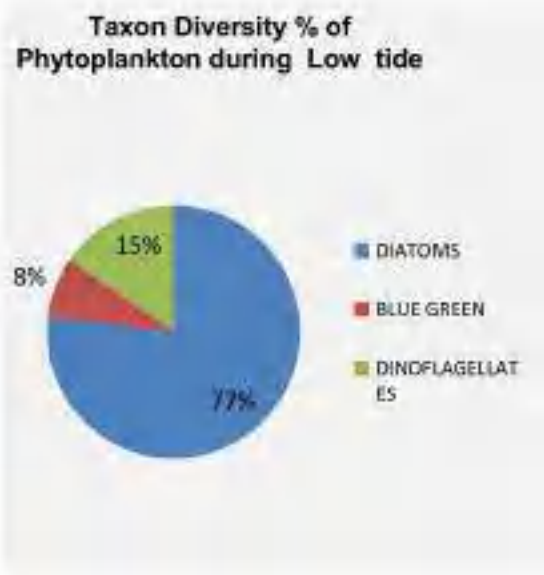
LOW TIDE	Sub surface	1	DIATOMS	143-261	15/20	75
			DINOFLAGELLATES	0-1	20-Mar	15
			TOTAL PHYTO PLANKTON	166-285	20	

Table # 11 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT DPT OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING NEAP TIDE IN FEBRUARY 2022

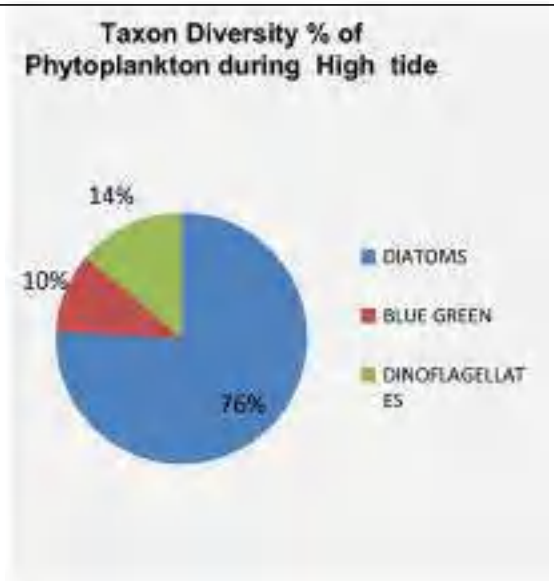
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phytoplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	BLUE GREEN	5-Jan	24-Feb	8.33
			DIATOMS	116-140	19/24	79.17
			DINOFLAGELLATES	5-Apr	24-Mar	12.5
			TOTAL PHYTO PLANKTON	125-146	24	-
LOW TIDE	Sub surface	2	BLUE GREEN	6	24-Feb	8.33
			DIATOMS	129-176	19/24	79.17
			DINOFLAGELLATES	9-May	24-Mar	12.5
			TOTAL PHYTO PLANKTON	144-187	24	-

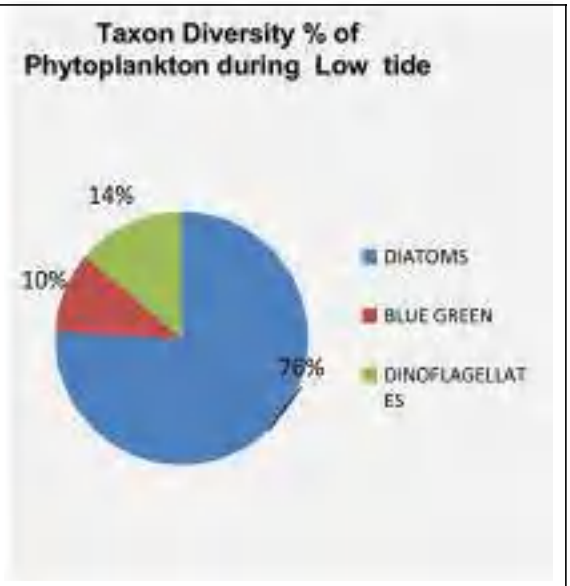
Taxon Diversity % of Phytoplankton during High tide and Low tide period during spring tide in Kandala creek and nearby creeks


Taxon Diversity % of Phytoplankton during High tide
15%
8%
77%
DIATOMS
BLUE GREEN
DINOFLAGELLATES

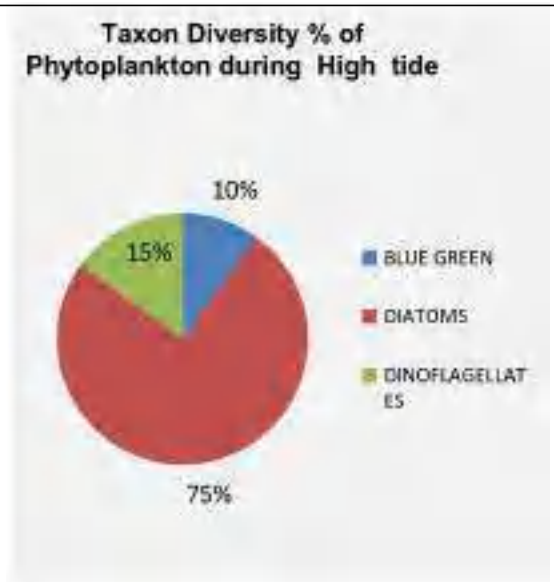

Taxon Diversity % of Phytoplankton during Low tide
15%
8%
77%
DIATOMS
BLUE GREEN
DINOFLAGELLATES

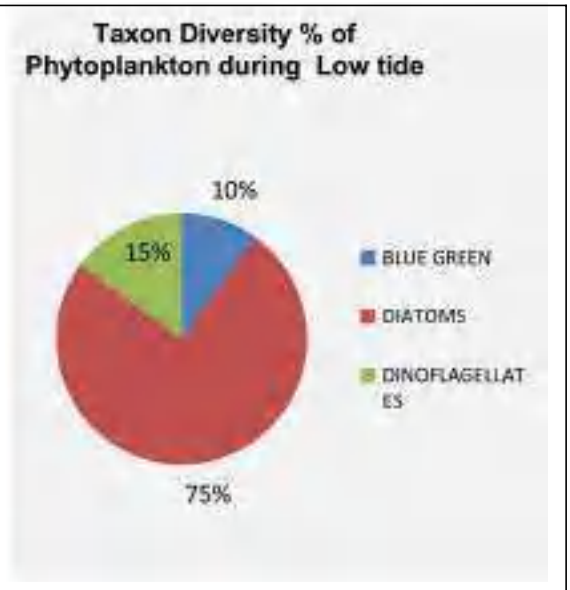
Taxon Diversity % of Phytoplankton during High tide and Low tide period during Neaptide in Kandala creek and nearby creeks



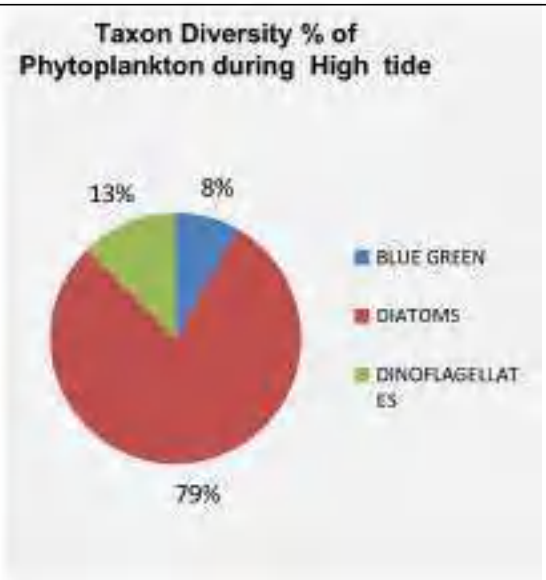


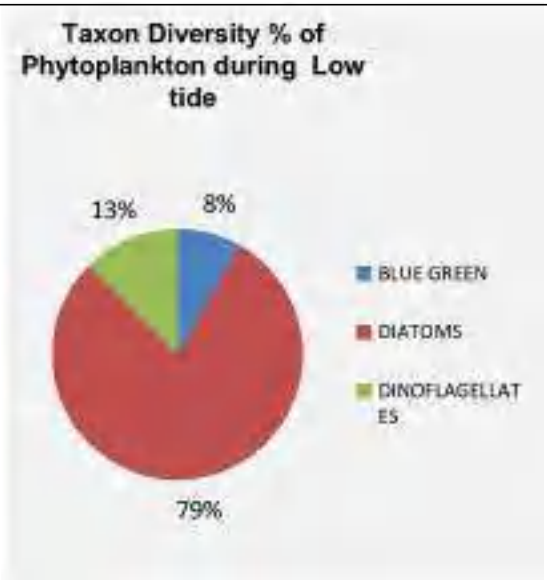
Taxon Diversity % of Phytoplankton during High tide and Low tide period duringspring tide in Path Finder Creek, Vadinar





Taxon Diversity % of Phytoplankton during High tide and Low tide period during Neaptide in Path Finder Creek, Vadinar





ZOOPLANKTON POPULATION:

For the evaluation of the Zooplankton population in DPT harbour area and within the immediate surroundings of the port sampling was conducted from 6 sampling locations (3 in harbour area and two in Nakti creek and one in Khori creek) during high tide period and low tide period of spring tide and Neap tide in February, 2022. The Zooplankton community of the sub surface water in the harbour and nearby creeks during spring tide was represented by mainly 4 groups, and 9 larval forms; Tintinids, Copepods, Arrow worms, Urochordata, Medusa, and 9 larval forms; Nauplius larvae of Copepods, Brachyuran zoea larvae, Cirripede larvae, Cyphonautes larvae, Ophipluutes larvae/ Echinoplutes larvae, Fish larvae, Opisthobranchia larvae, Trochophore larvae and Veliger larvae of bivalves.

The Zooplankton community of the sub surface water in the harbour and nearby creeks during neap tide was represented by mainly 4 groups, Tintinids, Copepods, Urochordata, and , Foraminiferans and 7 larval forms; Nauplius larvae of Copepods, Brachyuran zoea larvae, Cirripede larvae, Cyphonautes larvae, Opisthobranchia larvae, Trochophore larvae and Veliger larvae of bivalves.

Zooplankton of the sampling stations at sub surface layer in the DPT harbour area and nearby creek was varying from 46-122x10^3 N/ m^3 during high tide and 86-102x10^3 N/ m^3 during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPT harbour area and nearby creek was varying from 88-160 x10^3 N/ m^3 during high tide and 123-152x10^3 N/ m^3

during low tide of Neap Tide period.

For the evaluation of the Zoo plankton population in DPT OOT jetty area in Path Finder creek and SPM in Vadinar selected 2 sampling locations (1 in jetty area and one near SPM) During spring tide sampling plankton sample were collected at Jetty area and near SPM during consecutive high tide period and low tide period. During Neap tide sampling Plankton samples were collected from jetty area and SPM during consecutive high tide period and low tide period.
The Zooplankton community of the sub surface water in the path finder creek creeks during spring tide was represented by mainly Titinids, Copepods, Arrow worms and larval forms; Nauplius larvae of Copepods, Brachyuran Zoea larvae, Cirripede larvae, Cyphonautes larvae, Opisthobranchia larvae, and Trochophore larvae .

The Zooplankton community of the sub surface water in the path Finder creeks at Jetty region and SPM during neap tide was represented by mainly four groups, Tintinids, Copepods, Arrow worms , Foraminferans and , 6 Larval forms. Nauplius larvae of Copepods, Cirripede larvae, Cyphonautes larvae, Ophipluutes larvae/ Echinoplutes larvae, Opisthobranchia larvae, and Trochophore larvae.

Zooplankton of the sampling stations at sub surface layer in the DPT OOTJetty area of path finder creek was $91x10^3$ N/ m^3 during high tide and 56 $x10^3$ N/ m^3 during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPT SPM area of path finder creek was 99 $x10^3$ N/ m^3 during high tide and 84 $x10^3$ N/ m^3 during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPT OOT jetty area in path finder creek was recorded $111x10^3$ N/ m^3 during high tide and $125x10^3$ N/m^3 during consecutive low tide period of Neap. Zooplankton of the sampling stations at sub surface layer in the DPT SPM area in path finder creek was recorded $102x10^3$ N/m^3 during high tide and 99 $x10^3$ N/ m^3 during consecutive low tide period of Neap Tide.

Species Richness Indices and Diversity Indices:
Margalef's diversity index (Species Richness)S

At the organismal level, the most widely used biodiversity measures are those based on the number of species present, perhaps adjusted for the number of individuals sampled, Here Margalef's Species richness index (d), or indices that describe the evenness of the distribution of the numbers of individuals among species, are derived.
Margalef's diversity index (Species Richness) S of Zooplankton communities in

the stations Kandla creek region and nearby creeks was varying from 2.873-4.371 with an average of 3.887 during the sampling conducted in High tide period. Margalef's diversity index (Species

Richness) S of Zooplankton communities varying from 3.49 - 4.939 with an average of 4.206during the sampling conducted in low tide period during Spring tide.

Margalef's diversity index (Species Richness) S of Zooplankton communities in the Kandlacreek region and nearby creeks sampling stations was varying from 4.02 - 4.729 with anaverage of 4.342 during the sampling conducted in high tide and varying from 3.782 - 4.954with an average of 4.283 during the sampling conducted in low tide during Neap tide period. Margalef's diversity index (Species Richness) S of Zooplankton communities in the samplingstation near jetty at Path Finder Creek, Vadinar during the sampling conducted inconsecutive High tide period and low tide of spring tide was recorded as 3.99 and 3.478 respectively. Margalef's diversity index (Species Richness) S of Zooplankton communities inthe sampling station near SPM at Path Finder Creek, Vadinar during the sampling conductedin consecutive High tide period and low tide of spring tide was recorded as 3.264 and 3.611respectively.

Margalef's diversity index (Species Richness) S of Zooplankton communities near Jetty at Path finder creek was varying from 3.61 - 3.728 respectively during the sampling conducted in consecutive High tide period and Low tide period of Neap tide. While Margalef's diversity index (Species Richness) S of Zooplankton communities near SPM at Path finder creek was varying from 2.811 - 3.047 respectively during the consecutive High tide and low tide period.

Shannon-Wiener's index:

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.7775 - 1.009 (H'(log10)) between selected sampling stations with an average value of 0.920 (H'(log10)) during high tide period of spring tide. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.958 - 1.134 (H'(log10)) between selected sampling stations with an average value of 1.050 (H'(log10)) during consecutive low tide period.

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 1.035 - 1.177 (H'(log10)) between selected sampling stations with an average value of 1.096 (H'(log10)) during high tide period of Neap tide. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range 1.052 - 1.214 of (H'(log10)) between selected sampling stations with an average value of 1.1036 (H'(log10)) during consecutive

low tide period.

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.916.101 and 0.976 respectively. Shannon-

Wiener's Index (H) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.916 and 1.062 respectively.

Shannon-Wiener's Index (H)of Zooplankton communities near jetty at Path finder creek was varying from 1.075-1.004 during the sampling conducted consecutive High tide period and Low tide period of Neap tide. While Shannon-Wiener's Index (H)of Zooplankton communities near SPM at Path finder creek was varying from 0.867 - 0.925 during the consecutive High tide and low tide period.

Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon-Wiener's index increases as both the richness and the evenness of the community increase. This result indicates that diversity of Zooplankton of Kandla Harbour region and nearby creeks stations is slightly high with very minimum diverse population but very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson's diversity index:

Simpson's index (D) is a measure of diversity, which takes into account both species richness, and an evenness of abundance among the species present. The Simson index is one of the meaningful and robust biodiversity measures available. (Magurran, 2004).

Simpson diversity index (1-D) of Zooplankton communities was below 0.9 most of sampling stations in the Kandla Harbour region and nearby creeks during high tide and low tide of spring tide period, which was varying from 0.761 - 0.866 between selected sampling stations with an average of 0.797 during high tide period and was varying from 0.858 - 0.895 with an average value of 0.879 between selected sampling stations during low tide.

Simpson diversity index (1-D) of Zooplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks during high tide and low tide period of neap tide except few, which was varying from 0.847 - 0.929 between selected sampling stations with an average of 0.884 during high tide period and was varying from 0.861 - 0.922 with an average value of 0.885 0.916between selected sampling stations during consecutive low tide. This species diversity suggests a relatively more successful species in this habitat during February 2022 sampling.

Simpson diversity index (1-D) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in

consecutive High tide period and low tide of spring tide was recorded as 0.820 and 0.874 respectively. Simpson diversity index (1-D) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.825 and 0.898 respectively.

Simpson diversity index (1-D) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of Neap tide was recorded as 0.894 - 0.853 respectively. Simpson diversity index (1-D) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.816 and 0.842 respectively.

Table # 12 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND NEAR BY CREEKS DURING SPRING TIDE IN FEBRUARY 2022

Tide	Sampling Station	Abundance In N x103/ m3	No of Species/ groups observed /total species/ group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log10)	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	97	20/36	55.55	4.153	0.925	0.7734
	2	84	18/36	50	3.837	1.009	0.8663
	3	114	19/36	52.77	3.801	0.8884	0.7614
	4	122	22/36	61.11	4.371	0.9676	0.8147
	5	106	21/36	58.33	4.289	0.9532	0.8102
	6	46	Dec-36	33.33	2.873	0.7775	0.7614
LOW TIDE	1	102	22/36	61.11	4.541	1.106	0.8956
	2	95	20/36	55.55	4.172	1.044	0.8701
	3	86	23/36	63.88	4.939	1.134	0.8949
	4	102	19/36	52.77	3.892	1.008	0.8773
	5	98	17/36	47,22	3.49	0.9581	0.858

Table # 13 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND NEAR BY CREEKS DURING NEAP TIDE IN FEBRUARY 2022

Tide	Sampling Station	Abundance In No x103/ m3	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log10)	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	132	23/31	74.19	4.506	1.061	0.8632
	2	99	21/31	67.74	4.352	1.071	0.8813
	3	160	25/31	80.65	4.729	1.148	0.9039
	4	158	23/31	74.19	4.346	1.035	0.8471
	5	131	21/31	67.74	4.102	1.087	0.8843
	6	88	19/31	61.29	4.02	1.177	0.9297
LOW TIDE	1	128	21/31	67.74	4.122	1.066	0.877
	2	127	25/31	80.64	4.954	1.214	0.9228
	3	123	21/31	67.74	4.156	1.125	0.8996
	4	148	23/31	74.19	4.402	1.061	0.8676
	5	152	20/31	64.52	3.782	1.052	0.8615

Table # 14 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND, NEAR BY CREEKS DURING SPRING TIDE IN FEBRUARY 2022

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton x103 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinids	12-Feb	Jun-36	16.67
			Copepods	19-46	16/36	44.45
			Arrow worms	0-4	Jan-36	2.78
			Urochordata	0-4	Feb-36	5.55
			Foraminferans	6-Jan	Feb-36	5.55
			Larval forms	51-28	Sep-	25

					36	
			TOTAL ZOOPLANKTON N/ M^3	**97-84**	**36**	**-**
LOW TIDE	Sub surface	5	Tintinids	13-Mar	Jun-36	16.67
			Copepods	34-45	16/36	44.45
			Arrow worms	0-4	Jan-36	2.78
			Urochordata	0-4	Feb-36	5.55
			Foraminferans	0-3	Feb-36	5.55
			Larval forms	35-48	Sep-36	25
			TOTAL ZOOPLANKTON N/M^3	**86-102**	**36**	**-**

Table # 15 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONSIN DPT HARBOUR AREA IN KANDLA CREEK AND, NEAR BY CREEKS DURING NEAPTIDE IN FEBRUARY 2022

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton x103 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinids	18-Oct	Jun-31	19.35
			Copepods	21-50	31-Oct	32.26
			Arrow worms	0-4	31-Jan	3.23
			Mysids	0-2	31-Jan	3.23
			Urochordata	0-5	Feb-31	6.45
			Foraminiferans	10-Jan	Feb-31	6.45
			Larval forms	37-83	Sep-31	29.03
			TOTAL ZOOPLANKTON N/M3	**88-160**	**31**	
LOW TIDE	Sub surface	5	Tintinids	15-24	Jun-31	19.35
			Copepods	38-50	31-Oct	32.26
			Arrow worms	0-4	31-Jan	3.23
			Mysids	0-2	31-Jan	3.23
			Urochordata	0-4	Feb-31	6.45
			Foraminiferans	9-Jan	Feb-31	6.45
			Larval forms	43-82	Sep-31	29.03
			TOTAL ZOOPLANKTON N/M3	**123-152**	**31**	

Table # 16 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT OOT AREA AT PATH FINDER CREEK ANDNEAR BY SPM DURING SPRING TIDE IN FEBRUARY 2022

Tide	Sampling Station	Abundance In x103N / m3	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log10)	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	91	19/22	86.36	3.99	0.916	0.82
	SPM	99	16/22	72.73	3.264	0.9164	0.825
LOW TIDE	Jetty	56	15/22	68.18	3.478	0.9767	0.8747
	SPM	84	17/22	77.27	3.611	1.062	0.8985

Table # 17 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING NEAP TIDE IN FEBRUARY 2022

Tide	Sampling Station	Abundance In Nx103/m3	No of Species/groups observed /total species /group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log10)	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	111	18/19	94.74	3.61	1.075	0.8945
	SPM	102	14/19	73.68	2.811	0.867	0.8169
LOW TIDE	Jetty	125	19/19	100	3.728	1.004	0.8534
	SPM	99	15/19	78.95	3.047	0.9252	0.8423

Table # 18 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING SPRING TIDE IN FEBRUARY 2022

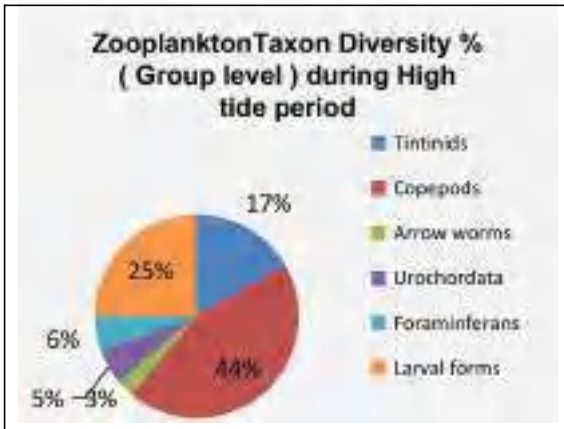
Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton x103 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	Tintinids	11-Sep	22-Apr	18.18
			Copepods	43-50	22-Sep	40.91
			Arrow worms	0-1	22-Jan	4.55
			Foraminferans	0-1	22-Feb	9.09
			Larval forms	37	22-Jun	27.27
			TOTAL ZOOPLANKTON NO/L	**91-99**	**22**	
			Tintinids	9-Jun	22-Apr	18.18
			Copepods	31-46	22-Sep	40.91

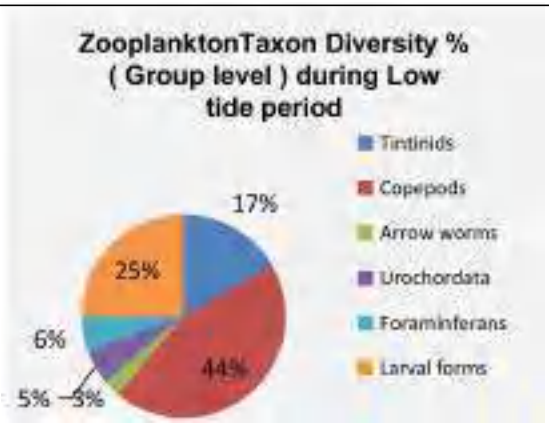
LOW TIDE	Sub surface	2	Arrow worms	0-1	22-Jan	4.55
			Foraminferans	6-Jan	22-Feb	9.09
			Larval forms	18-23	22-Jun	27.27
			TOTAL ZOOPLANKTON NO/M3	**56-84**	**22**	

Table # 19 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONSIN DPT OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING NEAP TIDE IN FEBRUARY 2022

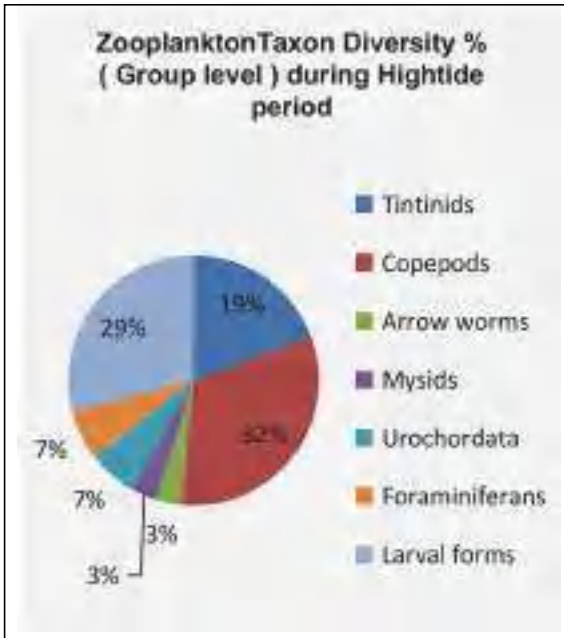
Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton x103 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	Tintinids	9-May	19-Mar	15.79
			Copepods	35-37	19-Jun	31.58
			Urochordata	0-2	19-Jan	5.26
			Foraminferans	5-Apr	19-Feb	10.53
			Larval forms	58	19-Jul	36.84
			TOTAL ZOOPLANKTON	**102-111**	**19**	
LOW TIDE	Sub surface	2	Tintinids	9-May	19-Mar	15.79
			Copepods	36-49	19-Jun	31.58
			Urochordata	2-Jan	19-Jan	5.26
			Foraminferans	5-Mar	19-Feb	10.53
			Larval forms	49-65	19-Jul	36.84
			TOTAL ZOOPLANKTON NO/M3	**99-125**	**19**	

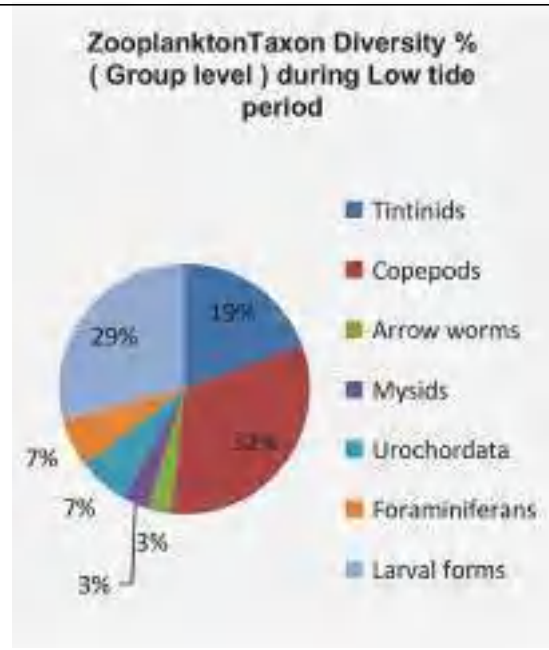
Taxon Diversity % of Zooplankton during High tide and Low tide period of Spring tideIn Kandla Creek and nearby Creeks



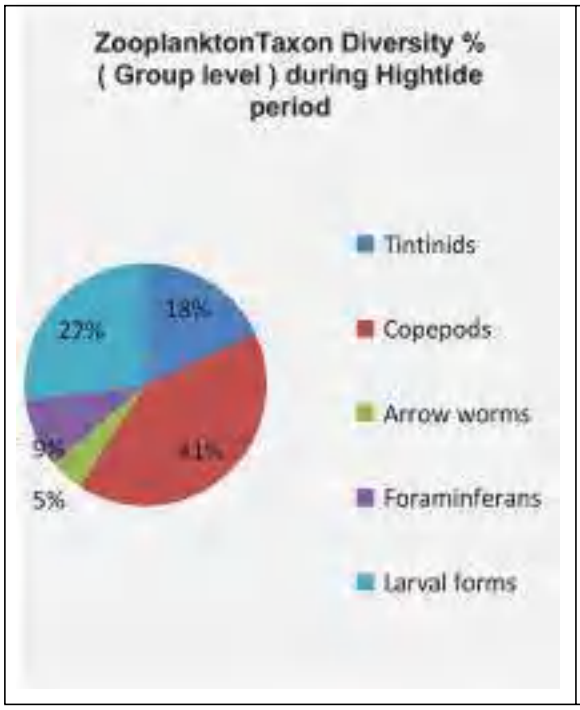


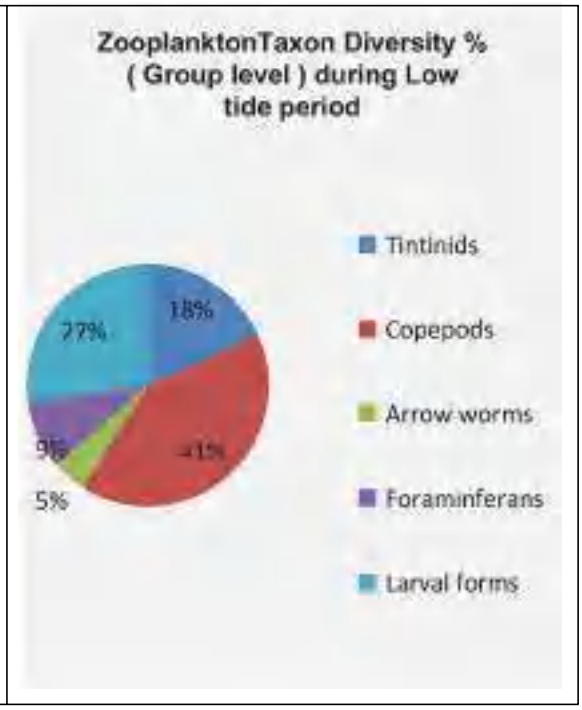
Taxon Diversity % of Zooplankton during High tide and Low tide period of Neap tide InKandla Creek and nearby Creeks



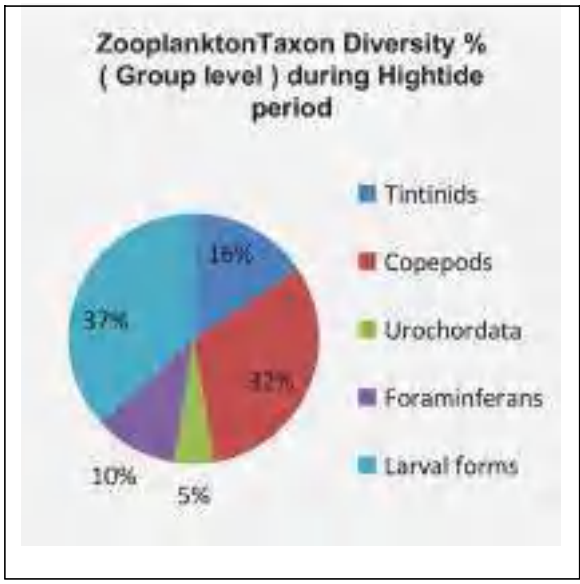


Taxon Diversity % of Zooplankton during High tide and Low tide period of Spring tideIn Path Finder Creek and near Jetty





Taxon Diversity % of Zooplankton during High tide and Low tide period of Neap tide InPath Finder Creek near jetty and nearby SPM



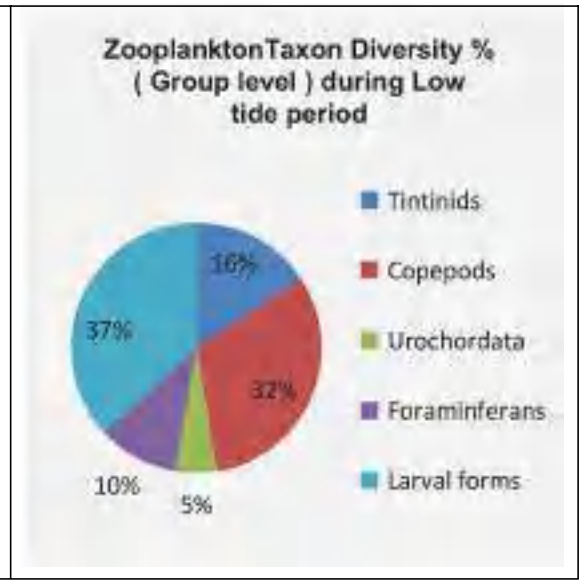


TABLE # 20 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS OF DPT HARBOUR AREA AT KANDLA CREEKAND NEARBY CREEKS DURING SPRING TIDE OF FEBRUARY 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAE	Cyanophyta	Cyanophyceae	Nostocales	Oscillatoriaceae	*Oscillatoria sp.*	B1	Very sparse
			Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B2	Very sparse
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Thalassiosirales	Thalassiosiraceae	*Planktoniella* sp	D1	Very sparse
			Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D2	Dominant
			Triceratiales	Triceratiaceae	*Triceratium* sp.	D3	Very sparse
			Biddulphiales	Biddulphiaceae	*Biddulphia* sp	D4	Sparse
			Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D5	Sparse
				Hemiaulaceae	*Cerataulina sp.*	D6	Very sparse
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D7	Scattered
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp	D8	Abundant
			Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D9	Scattered
		Bacillariophyceae	Naviculales	Pleurosigmataceae	*Navicula* sp	D10	Very sparse
					Pleurosigma sp	D11	Sparse
			Bacillariales	Bacillariaceae	*Bacillaria* sp.	D12	Sparse
					Nitzschia sp	D13	Sparse
					Pseudo-nitzschia sp	D14	Very sparse
			Surirellales	Surirellaceae	*Surirella* sp	D15	Very sparse
		Fragilariophyceae	Climacospheniales	Climacospheniaceae	*Climacosphenia sp.*	D16	Very sparse
			Thalassionematales	Thalassionemataceae	*Thalassiothrix sp.*	D17	Scattered
					Thalassionema sp.	D18	Very sparse
			Fragilariales	Fragilariaceae	*Fragilaria* sp	D19	Very sparse
					Synedra sp	D20	Sparse
DINO FLAGELLATES	Dinoflagellata /Dinozoa	Noctilucea / Noctiluciphyceae (Dinokaryota)	Noctilucales	Noctilucaceae	*Noctiluca* sp.	DF1	Very sparse
		Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF2	Very sparse
			Gonyaulacales	Ceratiaceae	*Ceratium furca*	DF3	Sparse

					Ceratium tripos	DF4	Very sparse

TABLE # 21 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPT HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING AND NEAP TIDE OF FEBRUARY 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAE	Cyanophyta	Cyanophyceae	Nostocales	Oscillatoriaceae	*Oscillatoria sp.*	B1	Very sparse
					Planktothrix sp.	B2	Very sparse
			Oscillatoriales	Phormidiaceae	Planktoniella sp	D1	Very sparse
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Thalassiosirales	Thalassiosiraceae	*Coscinodiscus sp.*	D2	Dominant
					Triceratium sp.	D3	Very sparse
			Coscinodiscales	Coscinodiscaceae	Biddulphia sp	D4	Sparse
			Triceratiales	Triceratiaceae	*Bellerochea* sp	D5	Sparse
			Biddulphiales	Biddulphiaceae	Cerataulina sp.	D6	Very sparse
			Hemiaulales	Bellerocheaceae	*Rhizosolenia sp.*	D7	Scattered
				Hemiaulaceae	*Chaetoceros* sp	D8	Abundant
			Rhizosoleniales	Rhizosoleniaceae	*Ditylum sp*	D9	Scattered
			Chaetocerotales	Chaetocerotaceae	*Navicula* sp	D10	Very sparse
			Lithodesmiales	Lithodesmiaceae	*Pleurosigma* sp	D11	Sparse
		Bacillariophyceae	Naviculales	Pleurosigmataceae	*Bacillaria* sp.	D12	Sparse
			Bacillariales	Bacillariaceae	Nitzschia sp	D13	Sparse
					Pseudo-nitzschia sp	D14	Very sparse
					Surirella sp	D15	Very sparse

				Climacosphenia sp.	D16	Very sparse
				Thalassiothrix sp.	D17	Scattered
				Thalassionema sp.	D18	Very sparse

			Surirellales	Surirellaceae	Fragilaria sp	D19	Very sparse
		Fragilariophyceae	Climacospheniales	Climacospheniaceae	Synedra sp	D20	Sparse
					Noctiluca sp.	DF1	Very sparse
			Thalassionematales	Thalassionemataceae	*Protoperidinium sp.*	DF2	Very sparse
					Ceratium furca	DF3	Sparse
			Fragilariales	Fragilariaceae	*Ceratium tripos*	DF4	Very sparse
DINO FLAGELLATES	Dinoflagellata / Dinozoa	Noctilucea / Noctiluciphyceae (Dinokaryota)	Noctilucales	Noctilucaceae	*Oscillatoria sp.*	B1	Very sparse
		Dinophyceae	Peridiniales	Protoperidiniaceae	*Planktothrix sp.*	B2	Very sparse
					Planktoniella sp	D1	Very sparse

TABLE # 22 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPT OOT AREA AT PATH FINDER CREEKAND NEARBY SPM AT VADINAR DURING SPRING TIDE OF FEBRUARY 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAE	Cyanophyta	Cyanophyceae	Nostocales	Oscillatoriaceae	*Lyngbya sp.*	B1	Sparse
					Oscillatoria sp.	B2	Sparse
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D1	Dominant
			Biddulphiales	Biddulphiaceae	Biddulphia sp	D2	Sparse
			Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D3	Sparse
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D4	Abundant
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp	D5	Sparse
			Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D6	Sparse
		Bacillariophyceae	Naviculales	Pleurosigmataceae	*Pleurosigma* sp	D7	Very sparse
			Bacillariales	Bacillariaceae	*Bacillaria* sp.	D8	Scattered
					Nitzschia sp	D9	Sparse
					Pseudo-nitzschia sp	D10	Sparse
		Fragilariophyceae	Fragilariales	Fragilariaceae	Fragilaria sp	D11	Very sparse
					Synedra sp.	D12	Sparse
			Climacosphenia les	Climacospheniaceae	*Climacosphenia sp.*	D13	Sparse
			Licmophorales	Licmophoraceae	*Licmophora sp.*	D14	Sparse
			Thalassionematales	Thalassionemataceae	*Thalassiothrix sp.*	D15	Scattered
[illegible]	Dinoflagella	Noctilucea / Noctiluciphyceae (Dinokaryota)	Noctilucales	Noctilucaceae	*Noctiluca* sp.	DF1	Very sparse

	ta / Dinozoa	Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF 1	Very sparse
			Gonyaulacales	Ceratiaceae	*Ceratium furca*	DF 2	Very sparse

TABLE # 23 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPT OOT AREA AT PATH FINDER CREEKAND NEARBY SPM AT VADINAR DURING AND NEAP TIDE OF FEBRUARY 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAE	Cyanophyta	Cyanophyceae	Nostocales	Oscillatoriaceae	*Lyngbya sp.*	B1	Very sparse
					Oscillatoria sp.	B2	Very sparse
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Thalassiosirales	Thalassiosiraceae	Planktoniella sp	D1	Very sparse
					Thalassiosira sp	D2	Sparse
			Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D3	Dominant
			Triceratiales	Triceratiaceae	Odontella sp	D4	Sparse
					Triceratium sp	D5	Sparse
			Biddulphiales	Biddulphiaceae	Biddulphia sp	D6	Sparse
			Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D7	Very sparse
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D8	Sparse
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp	D9	Scattered
			Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D10	Sparse
			Melosirales	Melosiraceae	*Melosira sp*	D11	Very sparse
		Bacillariophyceae	Naviculales	Pleurosigmataceae	*Pleurosigma* sp	D12	Very sparse
			Bacillariales	Bacillariaceae	*Bacillaria* sp.	D13	Abundant
					Nitzschia sp	D14	Sparse
		Fragilariophyceae	Fragilariales	Fragilariaceae	Fragilaria sp	D15	Sparse
					Synedra sp.	D16	Sparse
			Thalassionematales	Thalassionemataceae	*Thalassiothrix sp.*	D17	Sparse

			Climacosphenia les	Climacospheniac eae	*Climacosphenia sp.*	D1 8	Sparse
			Licmophorales	Licmophoraceae	*Licmophora sp.*	D1 9	Sparse
DINO FLAGELLATES	Dinoflagella ta / Dinozoa	Noctilucea / Noctiluciphyc eae (Dinokaryota)	Noctilucales	Noctilucaceae	*Noctiluca* sp.	DF 1	Very sparse
		Dinophyceae	Peridiniales	Protoperidiniacea e	*Protoperidinium sp.*	DF 2	Very sparse
			Gonyaulacales	Ceratiaceae	*Ceratium furca*	DF 3	Very sparse

TABLE # 24 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPT HARBOUR AREA AT KANDLA CREEKAND NEARBY CREEKS DURING SPRING TIDE OF FEBRUARY 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnus sp.*	T1	Sparse
				Codonellidae	*Tintinnopsis accuminata*	T2	Very sparse
					Tintinnopsis failakkaensis	T3	Sparse
					Tintinnopsis gracilis	T4	Very sparse
					Tintinnopsis radix	T5	Sparse
				Xystonellidae	*Favella* sp.	T6	Very sparse
COPEPODS	ATHROPODA	Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Scattered
					Parvocalanus sp.	C2	Sparse
				Eucalanidae	*Pareucalanus sp.*	C3	Very sparse
					Subeucalanus sp.	C4	Very sparse
				Clausocalanidae	*Clausocalanus sp.*	C5	Very sparse
				Euchaetidae	*Euchaeta sp.*	C6	Very sparse
				Centropagidae	*Centropages sp.*	C7	Sparse
				Acartiidae	*Acartia sp.*	C8	Sparse
				Temoridae	*Temora sp.*	C9	Very sparse
			Cyclopoida	Oithonidae	*Oithona sp.*	C10	Abundant
			Harpacticoida	Ectinosomatidae	*Microsetella* sp.	C11	Scattered
				Clytemnestridae	*Clytemnestra sp.*	C12	Very sparse
				Euterpinidae	*Euterpina sp.*	C13	Very sparse

				Canthocamptidae	*Canthocamptus sp*	C14	Very sparse
			Poicilostomatatoida	Corycaeidae	*Corycaeus sp.*	C15	Very sparse
				Oncaeidae	*Oncaea sp.*	C16	Very sparse
ARROW WORMS	CHAETOGNATHA	Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse
UROCHORDATA	CHORDATA SUB	Appendicularia		Oikopleuridae	*Oikopleura sp.*	U1	Very sparse

	PHYLUM UROCHORDATA			Fritillariidae	*Fritillaria sp.*	U2	Very sparse
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of copepods	L1	Dominant
BRACHYURA LARVAE	ARTHROPODA (CRUSTACEA)	Malacostraca Decapoda			Brachyuran zoea larvae	L2	Abundant
BARNACLE LARVAE	ATHROPODA CRUSTACEA	Maxillopo da Thecostra ca			Cirripede larvae	L3	Very sparse
CYPHONAUTES LARVAE	BRYOZOA				Cyphonautes larvae	L4	Very sparse
ECHINODERMATA LARVAE	ECHINODERMATA				Ophipluutes larvae/ Echinoplutes larvae	L5	Very sparse
FISH LARVAE	CHORDATA SUBPHYLUM: VERTEBRATA	Superclass: Pisces			Fish larvae	L6	Very sparse
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L7	Sparse
POLYCHAETE LARVAE	ANNELIDA	Polychaeta			Trochophore larvae	L8	Very sparse
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of bivalves	L9	Very sparse
FORAMINIFERA	FORAMINIFERA	Globothalamea	Rotaliida	Globigerinidae	*Globigerina* sp.	F1	Very sparse
				Rotalliidae	*Rotalia* sp.	F2	Very sparse

TABLE # 25 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING OF DPT HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING NEAP TIDE OF FEBRUARY 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnus sp.*	T1	Sparse
				Codonellidae	*Tintinnopsis accuminata*	T2	Very sparse
					Tintinnopsis gracilis	T3	Sparse
					Tintinnopsis radix	T4	Scattered
					Tintinnopsis failakkaensis	T5	Sparse
				Dictyocystidae	*Luminella sp.*	T6	Very sparse
COPEPODS	ATHROPODA	Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Scattered
					Parvocalanus sp.	C2	Sparse
				Eucalanidae	*Subeucalanus sp.*	C3	Very sparse
				Clausocalanidae	*Clausocalanus sp.*	C4	Very sparse
				Centropagidae	*Centropages sp.*	C5	Very sparse
			Cyclopoida	Oithonidae	*Oithona sp.*	C6	Abundant
			Harpacticoida	Ectinosomatidae	*Microsetella* sp.	C7	Abundant
				Euterpinidae	*Euterpina sp.*	C8	Very sparse
			Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C9	Very sparse
				Corycaeidae	*Corycaeus sp.*	C10	Very sparse
ARROW WORMS	CHAETOGNATHA	Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse

MYSIDS	ATHROPODA CRUSTACEA	Malacostraca	Mysida, Decapoda	Solenocerida e	*Solenocera sp.*	M1	Very sparse

UROCHORDATA	CHORDATA SUBPHYLUM UROCHORDATA	Appendicularia		Oikopleuridae	*Oikopleura sp.*	U1	Sparse
				Fritillariidae	*Fritillaria sp.*	U2	Very sparse
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of copepods	L1	Dominant
BRACHYURA LARVAE	ARTHROPODA (CRUSTACEA)	Malacostraca Decapoda			Brachyuran zoea larvae	L2	Sparse
BARNACLE LARVAE	ATHROPODA CRUSTACEA	Maxillopoda Thecostraca			Cirripede larvae	L3	Scattered
CYPHONAUTES LARVAE	BRYOZOA				Cyphonautes larvae	L4	Very sparse
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L5	Sparse
ECHINODERMATA LARVAE	ECHINODERMATA				Ophipluutes larvae/	L6	Very sparse
					Echinoplutes larvae		
FISH LARVAE	CHORDATA SUBPHYLUM: VERTEBRATA	Superclass: Pisces			Fish larvae	L7	Very sparse
POLYCHAETE LARVAE	ANNELIDA	Polychaeta			Trochophore larvae	L8	Sparse
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of bivalves	L9	Sparse

TABLE # 26 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPT OOT AREA AT PATH FINDER CREEKAND NEARBY SPM AT VADINAR DURING SPRING TIDE OF FEBRUARY 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnus sp.*	T1	Very sparse
				Codonellidae	*Tintinnopsis accuminata*	T2	Very sparse
					Tintinnopsis failakkaensis	T3	Very sparse
					Tintinnopsis gracilis	T4	Very sparse
COPEPODS	ATHROPODA	Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Scattered
					Parvocalanus sp.	C2	Sparse
				Clausocalanidae	*Clausocalanus sp.*	C3	Very sparse
				Centropagidae	*Centropages sp.*	C4	Very sparse
			Cyclopoida	Oithonidae	*Oithona sp.*	C5	Abundant
			Harpacticoida	Canthocamptidae	*Canthocamptus sp*	C6	Very sparse
				Ectinosomatidae	*Microsetella* sp.	C7	Sparse
				Euterpinidae	*Euterpina sp.*	C8	Sparse
			Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C9	Sparse
ARROW WORMS	CHAETOGNATHA	Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of copepods	L1	Dominant
BRACHYURA LARVAE	ARTHROPODA (CRUSTACEA)	Malacostraca	Decapoda		Brachyuran zoea larvae	L2	Very sparse

BARNACLE LARVAE	ATHROPODA CRUSTACEA	Maxillopoda Thecostraca			Cirripede larvae	L3	Sparse
CYPHONAUTES LARVAE	BRYOZOA				Cyphonautes larvae	L4	Very sparse
MOLLUSCAN	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L5	Sparse

LARVAE							
POLYCHAETE LARVAE	ANNELIDA	Polychaeta			Trochophore larvae	L6	Very sparse
FORAMINIFERA	FORAMINIFERA	Globothalamea	Rotaliida	Globigerinidae	*Globigerina* sp.	F1	Very sparse
				Rotalliidae	*Rotalia* sp.	F2	Very sparse

TABLE # 27 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPT OOT AREA AT PATH FINDER CREEKAND NEARBY SPM AT VADINAR DURING NEAP TIDE OF FEBRUARY 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAE	Cyanophyta	Cyanophyceae	Nostocales	Oscillatoriaceae	*Oscillatoria sp.*	B 1	Very sparse
					Planktothrix sp.	B 2	Very sparse
			Oscillatoriales	Phormidiaceae	Planktoniella sp	D1	Very sparse
DIATOMS	Bacillariophyta	Coscinodiscophyce ae	Thalassiosirales	Thalassiosiraceae	*Coscinodiscus sp.*	D2	Dominant
					Triceratium **sp.**	D3	Very sparse
			Coscinodiscales	Coscinodiscaceae	Biddulphia sp	D4	Sparse
			Triceratiales	Triceratiaceae	*Bellerochea* **sp**	D5	Sparse
			Biddulphiales	Biddulphiaceae	Cerataulina sp.	D6	Very sparse
			Hemiaulales	Bellerocheaceae	*Rhizosolenia sp.*	D7	Scattered
				Hemiaulaceae	*Chaetoceros* **sp**	D8	Abundant
			Rhizosoleniales	Rhizosoleniaceae	*Ditylum sp*	D9	Scattered
			Chaetocerotales	Chaetocerotaceae	*Navicula* **sp**	D10	Very sparse
			Lithodesmiales	Lithodesmiaceae	*Pleurosigma* **sp**	D11	Sparse
		Bacillariophyceae	Naviculales	Pleurosigmataceae	*Bacillaria* **sp.**	D12	Sparse

			Bacillariales	Bacillariaceae	Nitzschia sp	D13	Sparse
					Pseudo-nitzschia sp	D14	Very sparse
					Surirella **sp**	D15	Very sparse
						Climacosphenia sp.	D16
						Thalassiothrix sp.	D17

BENTHIC ORGANISMS:

Few Benthic organisms were observed in the collected sediments by using the Van-veen grabs during the sampling conducted during spring tide period and Neap tide period from DPT harbour region and nearby creek. The meiobenthic organisms during spring tide were represented by Polychaetes *Dasybranchus* sp., *and Notomastus* sp., During Neap tide Polychates observed were *Dasybranchus* sp and *Prinispo*.sp

Table # 28 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPT HARBOURAREA CREEKS DURING SPRING TIDE IN FEBRUARY 2022

Benthic fauna	ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS					
	REPRESENTATION BY GROUP					
	DPT HARBOUR			CREEKS		
POLYCHAETES	KPT-1	KPT-2	KPT-3	KPT-4	KPT-5	KPT-6
Family : Capitellidae Dasybranchus sp.	10	100	10	20	40	NS
	20	0	0	0	20	NS
Family : Capitellidae Notomastus sp	30	100	10	20	60	

NS : No sample

Table # 29 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPT HARBOURAREA CREEKS DURING NEAP TIDE IN FEBRUARY 2022

Benthic fauna	ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS REPRESENTATION BY GROUP					
	DPT HARBOUR			CREEKS		
POLYCHAETES	KPT-1	KPT-2	KPT-3	KPT-4	KPT-5	KPT-6
Family Spionidae Prinispo sp.	0	10	20	0	0	NS
Family : Capit*ellidae* *Dasybranchus sp*	0	30	40	20	40	NS

Total Polychaetes	0	40	60	20	40	NS
Un identified Amphipods	10					
TOTAL Benthic Fauna NUMBER/ M^2	10	40	60	20	40	

6. Meteorological Data

Automatic Weather station have been installed in Seva Sadan - 3 at the Deendayal Port which records the data on Temperature (°C), Humidity (%),Wind (mph), Dew Point (°C), Wind Direction (°), Pressure, Solar radiation, heat Index and UVI.

Temperature

The mean day time temperature for Deendayal Port was 19.8 °C. The day-time maximum temperature was 29.2°C. The minimum mean night time temperature recorded was 12.6 °C.

Air Pressure

The mean absolute air pressure for the month of February was 1006.3 hpa, whereas the mean relative pressure was 10064 hpa. The maximum absolute air pressure recorded for the month of February was 1022 hpa.

Heat Index

The mean day-time heat index for the month of February was 27.77 ^{o}C. The maximum heat index recorded was 33°C.

Solar Radiation

The mean Solar Radiation in February was 119.20 w/m^2. The maximum solar radiation recorded in the month of February was 530.7 w/m^2.

Humidity

The mean day-time humidity was 60.22 % for the month of February and mean night time humidity was 45.60 %. Maximum humidity recorded during day-time was 98.0 % and maximum humidity recorded during night-time was 69.0%.

Wind Velocity and Wind Direction

The mean wind velocity for the entire month of February was 4.8 km/hour. Maximum wind velocity recorded was 34.6 Km/hr . The wind direction was mostly N to NW.

Conclusive Summary and Remedial measures Suggested

The AAQ monitoring at six locations of Deendayal Port indicates that the mean PM_{10} values at four locations viz. Coal storage area, Marine Bhavan, Gopalpuri, Tuna Port, Kandla Colony and Oil Jetty area were found above the permissible standards (100 µg/m^3) and $PM_{2.5}$ was above permissible limits at Coal storage location(Limit 60 µg/m^3).
The AAQ monitoring Vadinar at Admin building found above the permissible standards
for both PM_{10} (Limit 100 µg/m^3) & $PM_{2.5}$ (Limit 60 µg/m^3)

Drinking water at all the twenty locations was found potable and was within permissible limits of BIS standards (IS 10500).

Noise quality was also within the set permissible standards of an Industrial Area. The noise level observed during day time was >75 dB (A) and at night time was >70 dB (A) during the entire monitoring period.

The sewage treated water of Deendayal Port Colony (Gopalpuri) was in line with the standards set by the Gujarat Pollution Control Board.

Reasons for higher Values of PM_{10}

Large amount of coal is handled at Berth No. 6, 7, 8 and 9. The unloading of coal directly in the truck, using grabs cause coal to spread in air as well as coal dust to fall on ground. This settled coal dust again mixes with the air while trucks travel through it.

Also, the coal laden trucks are not always covered with tarpaulin sheets and these results in spillage of coal from trucks/dumpers during its transit from vessel to yard or storage site. This also increased PM values around marine Bhavan & Coal storage area.

Remedial Measures

The values of PM10 & PM2.5 during the month of February, 2022 were observed beyond the permissible limit at all locations mentioned above Except Vadinar Signal building for PM10 . Given below are the remedial measures suggest to minimize the Air pollution at Deendayal Port.

Guidelines for Coal Handling by GPCB should be strictly followed. (http://gpcb.gov.in/pdf/coal-handling-guidelines.pdf)

Except for the higher values of PM10 & PM2.5 at Coal storage site, Oil Jetty, Tuna Port and Marine Bhavan locations, the monitoring results for the present month suggest that the overall Environment Quality of Deendayal Port is satisfactory.

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ENVIRONMENTAL MONITORING REPORT FOR DEENDAYAL PORT AUTHORITY

REPORT	**:**	**DCPL/DPT/21-22/23**
Mont	**:**	**March**
Issue	**:**	**01**
Revision	**:**	**00**
Prepare	**:**	**DETOX CORPORATION PVT. LTD., SURAT**

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ENVIRONMENTAL MONITORING PLAN FOR DEENDAYAL PORT ENVIRONMENTAL MONITORING REPORT- MARCH 2022

1. EXECUTIVE SUMMARY

Monitoring of various environmental aspects of the Deendayal port by M/s Detox Corporation Pvt. Ltd. has been carried out through collection of samples, analysis of the same, comparing results with respect to the national standards and any other relevant standards by GBCB/CPCB/MoEF & CC to identify non conformity in the Environment of the Deendayal Port. The results shall address the identified impacts and suggest measures to minimize the environmental impact due to various operations at Deendayal Port.

A) Ambient Air

Average concentration of PM_{10},$PM_{2.5}$,SO2,NO2,NH3 for 24-hr & other parameters were measured at Six locations with continuous viz. Gopalpuri Tuna Port, marine Bhavan building, Coal storage area, Estate building, and Oil jetty, and at Vadinar port, Vadinar Jetty and vadinar colony area using high volume air samplers, respirable dust sampler (RDS 10 PM and FPS 2.5 PM) and gaseous sampler and at using continuous air quality monitoring station.

The overall values for March of TSPM, PM10 & PM2.5. The TSPM values were found from 416 µg/m^3 To 173 µg/m^3 . The PM10 values were found from 304 µg/m^3 To 98 µg/m^3, The PM2.5 values were found from 111 µg/m^3 To 69 µg/m^3. All values are found for all locations to above the permissible limit.

The overall values of March for SO_2 were found 4.98 µg/m^3 to 3.48 µg/m^3 , NOx were found 20.96 µg/m^3 to 13.02 µg/m^3, NH3 were found 10.74 µg/m^3 to 8.13µg/m^3, C6H6 were found 1.25µg/m^3 to 1.12µg/m^3, CO were found 2.04mg/m^3 to 1.70 mg/m^3 , CO2 were found 658 ppm to 446 ppm and there is reported result for NMHC were BQL (Below Quantification Limit).

B) Marine Ecology (Flora and Fauna):

The results obtained from the study for the month of March, 2022. Physic-chemical parameters were observed as per prescribed standards limits of ecological parameters

for Arabian Sea at Kachchh Creek. Net Primary Productivity and Chlorophyll-a were well for ecological parameters for Arabian Sea. However, considering the activities in DPT Harbour, it is seen that the marine ecosystem is not adversely affected by Port activities.

C) Drinking Water Quality

Drinking water is water intended for human consumption for drinking and cooking purposes from any source. It includes water (treated or untreated) supplied by any means for human consumption.The drinking water being supplied to Deendayal Port is safe for drinking purpose. At all drinking water monitoring stations around port area are found to be as per the drinking water specifications given in IS 10500:2012 and also on the basis of analysis parameter.

The average results for 20 locations as per below.PH were found Min 7.1 to 7.6, TDS were found min 950mg/l to Max found 1220 mg/l, Chloride were found Min 496.1 mg/l to Max 656.46 mg/l, Total Hardness were found Min 410mg/l to Max 470 mg/l and Calcium were found Min 48.1 mg/l to Max 76.15 mg/l. colour found colourless and odour were odourless. All water sample found for BOD, Heavy metal like manganese, Hexavalent chromium, Copper, Cadmium, Arsenic, Mercury, Lead, zinc all are found BQL (Below Quantification Limit). The bacterial count is absent in all drinking water samples.

D) Monitoring Performance of Sewage Treatment Plant

It is seen that the performance of STP at Deendayal Township, KPT STP Plant and Vadinar STP plant is satisfactory by overall. The treatment plant was well maintained during [March 2022] with considerable removal efficiency achieving the standards prescribed for final disposal.

Table : a - March Result of Sewage Treatment Plant

Location			Kandla STP				Gopalpuri STP				Vadinar STP				
Date			04.03.22	07.03.22	14.03.22	21.03.22	04.03.22	07.03.22	14.03.22	21.03.22	04.03.22	07.03.22	14.03.22	21.03.22	GPCB Prescribed Limit
Sr. No.	Parameters	Unit	STP O/L	STP O/L	STP O/L	STP O/L	STP O/L	STP O/L	STP O/L	STP O/L	STP O/L	STP O/L	STP O/L	STP O/L	
1	pH	pH unit	7.2	7.18	7.32	7.38	7.38	7.29	7.12	7.26	7.28	7.41	7.4	7.31	6.5 - 8.5
2	Total Suspended Solids	mg/l	37.7	93.4	77	85	85	70	88	59.4	47.70	54	39.1	44	100
3	Residual Chlorine	mg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-
4	COD	mg/l	99	98	97	100	96	91	98	100	96	98	98	100	100
5	BOD @ 27 °C	mg/l	28	28	28	30	27	26	28	30	27	28	26	28	30
6	Fecal Coliform	MPN Index / 100 ml	865	780	920	840	340	280	540	630	7.8	21	32	220	< 1000

E) Weather

The historical data collected from Automatic weather station have been installed and other secondary sources to represent the metrological conditions of the project area has been reviewed and presented below for various attributes such as Temperature, Wind, Cloud cover, Humidity, Rainfall, and Visibility.

The predominant wind direction (blowing from) was the Southeast in the port area. Average values of wind speed, temperature, relative humidity and solar radiation recorded were wind velocity for the predominant entire month.

The Day maximum Temperature of March was 32.8^{0}C and min 19.8^{0}C.

Pressure recorded at min of 1013.21 hpa and Max 1021.9 hpa.Heat Index was recorded Min 30.030C and Max 42.0^{0}C. Humidity was recorded Mean at day 44.54 % and at night 58.77%. Solar Radiation was recorded 118.58 w/m2 and maximum of 530.7 w/m^2. The mean wind velocity for the entire month was 5.20 km/hour. Maximum wind velocity recorded was 34.6 Km/hr . The wind direction was mostly SouthEast.

F) Noise

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. The Day Time Noise Level (SPL)in all 13 locations at Deendayal Port ranged from 47.1 dB(A) to 74.4 dB(A) and it was within the permissible limits of 75 dB(A) for the industrial area for the daytime. The Night Time Average Noise Level (SPL) in all 13 locations of Deendayal Port ranged from 45.30 dB to 68.40 dB(A) and it was within the permissible limits of 70 dB(A) for the industrial area for the night time.

2.0 Introduction

About Deendayal Port

The Deendayal Port is situated in the Kandla Creek and is 90 kms. From the mouth of Gulf of Kachchh. **Latitude: 23° 01" N Longitude: 70° 13"E**. Deendayal Port's journey began in 1931 with construction of RCC Jetty by Maharao Khengarji. After partition, Deendayal Port's success story has continued and it rise to the No. 1 Port in India in the year 2007-08 and since then retained the position for the 14" consecutive year. On 31.03.2016, Deendayal Port created history by handling 100 MMT cargoes in a year, the first Major Port to achieve the milestone. Kandla, also known as the Deendayal Port Authority is a seaport in Kutch District of Gujarat state in western India, near the city of Gandhidham. Located on the Gulf of Kutch, it is one of major ports on west coast. Kandla was constructed in the 1950s as the chief seaport serving western India, after the partition of India from Pakistan left the port of Karachi in Pakistan. The Port of Deendayal is located on the Gulf of Kutch on the northwestern coast of India some 256 nautical miles southeast of the Port of Karachi in Pakistan and over 430 nautical miles north-northwest of the Port of Mumbai (Bombay). It is the largest port of India by volume of cargo handled. Kandla history Deendayal Port Authority, India's busiest major port in recent years, is gearing to add substantial cargo handling capacity with private sector participation. The west coast port handled 72,225 million tonnes of cargo in 2008-09, over 11% more than 64,920 million tonnes handled in2007-08. Even as much of this growth has come from handling of crude oil imports, mainly for Essar Oil's Vadinar refinery in Gujarat, the port is also taking measures to boost non-POL cargo. Last fiscal, POL traffic accounted for 63 per cent of the total cargo handled at Deendayal Port, as against 59% in 2007-08. Although Deendayal Port Authority officials declined to elaborate given the ongoing election code of conduct, it is reliably learnt that the port will soon initiate the process of selecting developers for four clean cargo berths that together aim to handle 8 million tonnes of cargo. The four berths will be supported by a 14 m draft capable of handling 75,000 dwt vessels. The port has already received encouraging response from prospective bidders, for the project that is estimated to cost nearly 5,000 million INR.

The Deendayal Port Authority had commissioned the Off-shore Oil Terminal facilities at Vadinar in the year 1978, for which M/s. Indian Oil Corporation Limited (IOCL) provided Single Bouy Mooring (SBM) system, having a capacity of 54 MMTPA, which was first of its kind in India. Further, significant. Quantum of infrastructural upgradation has. been affected & excellent maritime infrastructure has been created at Vadinar for the 32MMTPA Essar Oil Refinery in Jamnagar District.

Monitoring of various environmental aspects of the Deendayal port by M/s Detox Corporation Pvt. Ltd. has been carried out through collection of samples, analysis of the same, comparing results with respect to the national standards and any other relevant standards by GBCB/CPCB/MoEF & CC to identify non conformity in the Environment of the Deendayal Port. The results shall address the identified impacts and suggest measures to minimize the environmental impact due to various operations at Deendayal Port.

The environmental monitoring is carried out as per the Environment Management and Monitoring Plan submitted by Detox Corporation Pvt. Ltd

3. Introduction

Air pollutants are added in the atmosphere from variety of sources that change the composition of atmosphere and affect the biotic environment. The concentration of air pollutants depend not only on the quantities that are emitted from air pollution sources but also on the ability of the atmosphere to either absorb or disperse these emissions. The air pollution concentration vary spatially and temporarily causing the air pollution pattern to change with different locations and time due to changes in meteorological and topographical condition. The sources of air pollutants include vehicles, industries, domestic sources and natural sources. Because of the presence of high amount of air pollutants in the ambient air, the health of the population and property is getting adversely affected. In order to arrest the deterioration in air quality, Govt. of India has enacted Air (Prevention and Control of Pollution) Act in 1981. The responsibility has been further emphasized under Environment (Protection) Act, 1986. It is necessary to assess the present and anticipated air pollution through continuous air quality survey/monitoring programs. Therefore, Central Pollution Control Board had started National Ambient Air Quality Monitoring (NAAQM) Network during 1984 - 85 at national level. The programme was later renamed as National Air Quality Monitoring Programme (NAMP).

3.1 Ambient Air Quality Monitoring

As per the Environmental Monitoring Plan of Deendayal Port Authority, Air monitoring was carried out at six identified locations at Deendayal Port and two locations at Vadinar Port.

Air Quality Monitoring Methodology

Air quality is measured in all the stations, for 24 hour for Total Suspended Particulate Matter (TSPM), PM_{10}, $PM_{2.5}$, SO_2, NO_X, NH_3, HC & Benzene, and Grab-sampling for CO & CO_2 measurements. The Air samplers are operated for a period of 24 hours and after a continuous operation of 8 hours of the sampler, the reagents were replaced to obtain 3 samples per day for each parameter namely, SO_2, NO_X. The EPM 2000 filter paper and PTFE Membrane bound filter paper are used for a period of 24 hours to obtain one sample each of TSPM, PM_{10} & $PM_{2.5}$. The AAQ samples are collected twice a week from all the eight locations as per the EMP.

3.2 Results

The ambient air quality monitoring data for six stations, viz. Marine Bhavan, Oil Jetty, Port Colony, Gopalpuri Hospital, Tuna Port and Nr. Coal Storage Area for the month of March 2022 are given in Tables 1 to 6. The ambient air quality monitoring data for two stations at Vadinar (Nr. Admin Building & Nr. Signal Building) are given in Tables 7 to 8.

Note:AL1 To AL8 are Air Monitoring Location 1 to 8. Where AL1 Marine Bhavan, AL2 Oil Jetty, AL3 Estate Office, AL4 Gopalpuri Hospital, AL5 Coal Storage, AL6 Tuna Port, AL7 Signal Building (Vadinar) and AL8 Admin Building (Vadinar).

Location 1: Marine Bhavan (AL1)

Table 1 : Results of Air Pollutant Concentration at Marine Bhavan

Parameter	Date	TSPM [µg/m³]	PM10 [µg/m³]	PM2.5 [µg/m³]	SO_2 [µg/m³]		NOx [µg/m³]		NH_3[µg/m³]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit		NS	100 [µg/m3]	60 [µg/m3]		80 [µg/m3]		80 [µg/m3]		400 [µg/m³]
AL1 – 1	01.03.2022	260	183	69	2.64	2.40	20.33	21.17	9.45	9.87
					0.62		19.05		9.70	
					3.96		24.14		10.47	
AL1 – 2	04.03.2022	272	189	72	7.03	6.15	14.61	20.11	13.79	13.70
					5.71		15.88		13.53	
					5.71		29.85		13.79	
AL1 – 3	07.03.2022	292	197	87	8.35	7.03	29.85	27.10	12.00	11.49
					7.91		31.76		13.02	
					4.84		19.69		9.45	
AL1 – 4	10.03.2022	412	301	101	2.20	2.05	18.42	17.15	14.55	15.68
					1.76		15.88		17.69	
					2.20		17.15		14.81	
AL1 – 5	14.03.2022	408	315	106	3.96	3.66	19.69	21.38	5.36	9.62
					4.40		20.33		12.00	
					2.64		24.14		11.49	
AL1 - 6	21.03.2022	339	251	92	3.08	3.22	17.78	16.51	10.47	6.13
					4.40		21.60		5.36	
					2.20		10.16		2.55	
AL1 - 7	24.03.2022	352	259	95	2.64	2.64	13.34	18.00	14.81	11.57
					3.52		22.23		10.47	
					1.76		18.42		9.45	
AL1 – 8	28.03.2022	234	178	65	3.08	2.93	27.31	26.25	10.98	7.83
					1.76		30.49		5.62	
					3.96		20.96		6.89	
Monthly Average		321	234	86		3.76		20.96		10.74
Standard Deviation		67	55	15		1.83		3.96		3.08

Table 1 : Results of Air Pollutant Concentration at Marine Bhavan					
Sampling Period	**Date**	**C6H6 [µg/m3]**	***NMHC**	**CO [mg/m3]**	**CO2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**	**ppm**	**4.0 mg/m3**	**-**
AL1 – 1	01.03.2022	1.145	BQL	2.01	678
AL1 – 2	04.03.2022	1.201	BQL	1.94	588
AL1 – 3	07.03.2022	1.245	BQL	2.06	601
AL1 – 4	10.03.2022	1.016	BQL	2.08	456
AL1 – 5	14.03.2022	1.035	BQL	1.90	421
AL1 - 6	21.03.2022	1.051	BQL	1.78	535
AL1 - 7	24.03.2022	1.156	BQL	1.88	490
AL1 - 8	28.03.2022	1.089	BQL	2.20	396
Monthly Average		**1.12**	**-**	**1.98**	**521**
Standard Deviation		**0.08**	**-**	**0.13**	**97.5**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

At Marine Bhavan, the overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_X and NH_3 is attributed mainly by motor vehicle emission produced from various types of automobiles (both diesel and petrol driven). Moreover, the loading and unloading of Food Grains and Timber at Jetty no. 1 and 2 also contributes to the high levels of TSPM and PM_{10}. The mean TSPM value at Marine Bhavan was 321.00 µg/m^3,The mean PM_{10} values were 234.0 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were 86.0 µg/m^3. The average values of SO_2, NO_x and NH_3 were within the permissible limit. The average values of SO_2, NO_x and NH3 were 3.76 µg/ m^3, 20.96 µg/ m^3 & 10.74 µg/ m^3 respectively. These were within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Marine Bhavan. The mean Benzene concentration was 1.12 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.98 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 2: Oil Jetty (AL2)

Table 2 : Results of Air Pollutant Concentration at Oil Jetty

Paramete	Date	TSPM [µg/m³]	PM10 [µg/m³]	PM2.5 [µg/m³]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period		24hr	24hr	Table 1 :	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit		NS	100 [µg/m3]	60 [µg/m3]		80 [µg/m3]		80 [µg/m3]		400 [µg/m³]
AL2 – 1	01.03.2022	236	148	80	3.17	3.28	15.20	17.72	13.34	11.70
					3.22		18.77		13.11	
					3.45		19.19		8.65	
AL2 – 2	04.03.2022	272	172	92	2.56	2.74	17.78	17.56	7.56	7.30
					2.43		18.47		9.45	
					3.24		16.45		4.90	
AL2 – 3	07.03.2022	266	168	90	5.54	4.94	12.34	14.65	8.76	9.48
					4.61		15.30		9.24	
					4.67		16.33		10.45	
AL2 – 4	10.03.2022	282	199	75	3.78	3.30	18.31	16.65	8.89	9.18
					2.98		14.32		11.44	
					3.15		17.34		7.21	
AL2 – 5	14.03.2022	265	164	93	3.55	3.70	18.25	18.25	7.44	8.48
					3.46		20.76		8.44	
					4.09		15.74		9.56	
AL2 – 6	21.03.2022	359	253	98	5.16	4.86	15.61	14.49	10.19	8.74
					5.55		14.54		6.78	
					3.89		13.33		9.25	
AL2 – 7	24.03.2022	240	152	80	3.40	4.17	17.39	18.40	8.45	9.95
					4.12		16.35		10.88	
					5.01		21.45		10.54	
AL2 – 8	28.03.2022	382	278	96	5.65	4.67	17.77	17.28	9.19	8.49
					4.47		18.33		8.49	
					3.90		15.76		7.79	
Monthly Average		288	192	88		3.96		16.88		9.17
Standard Deviation		54	48	9		0.82		1.52		1.29

Table 2 : Results of Air Pollutant Concentration at Oil Jetty					
Sampling Period	**Date**	**C6H6 [µg/m3]**	***NMHC**	**CO [mg/m3]**	**CO2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL2 -1	01.03.2022	1.11	BQL	1.34	675
AL2 -2	04.03.2022	1.44	BQL	1.87	666
AL2 -3	07.03.2022	1.26	BQL	2.11	456
AL2 -4	10.03.2022	1.18	BQL	1.68	670
AL2 – 5	14.03.2022	1.27	BQL	1.98	835
AL2 – 6	21.03.2022	1.16	BQL	1.24	589
AL2 -7	24.03.2022	1.13	BQL	1.94	423
AL2 -8	28.03.2022	1.43	BQL	1.45	587
Monthly Average		**1.25**	**-**	**1.70**	**612.62**
Standard Deviation		**0.128**	**-**	**0.32**	**131.57**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Oil Jetty area was mainly by motor vehicle emission produced from various types of vehicles Oil Jetty Area. The mean TSPM values at Oil Jetty were 288 µg/m^3. The mean PM_{10} values were 192 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were 88 µg/m^3. The average values of SO_2, NO_x and NH_3 were within the permissible limit, The mean concentration of SO_2, NO_x and NH3 were 3.96 µg/m^3, 16.88 µg/m^3 and 9.17 µg/m^3 respectively.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Oil Jetty. The mean Benzene concentration was 1.25 µg/m^3. Well below the permissible limit of 5.0 µg/m^3. , NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.70 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 3: Kandla Colony – Estate Office (AL-3)

Table 3 : Results of Air Pollutant Concentration at Estate Office

Parameter	Date	TSPM [µg/m³]	PM10 [µg/m³]	PM2.5 [µg/m³]	SO2 [µg/m³]		NOx [µg/m³]		NH_3 [µg/m³]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit		NS	100 [µg/m3]	60 [µg/m3]		80 [µg/m3]		80 [µg/m3]		400 [µg/m³]
AL3 – 1	01.03.2022	259	177	78	3.44	3.95	12.33	14.22	12.33	12.48
					3.19		15.61		12.23	
					5.24		14.74		12.87	
AL3 – 2	04.03.2022	203	142	57	6.44	5.27	17.25	17.41	13.76	11.54
					4.78		18.11		12.32	
					4.59		16.88		8.55	
AL3 – 3	07.03.2022	352	259	89	3.48	4.12	15.22	14.85	9.12	10.53
					5.46		15.77		11.45	
					3.44		13.56		11.02	
AL3 – 4	10.03.2022	320	225	91	4.87	5.14	17.55	17.52	9.13	8.56
					4.77		18.68		8.02	
					5.80		16.34		8.54	
AL3 – 5	14.03.2022	240	156	80	5.34	4.96	16.53	16.66	7.35	9.22
					5.10		17.12		11.65	
					4.45		16.34		8.67	
AL3 – 6	21.03.2022	262	176	82	4.55	4.94	19.15	17.91	9.45	10.71
					4.67		16.61		11.33	
					5.61		17.98		11.34	
AL3 – 7	24.03.2022	262	168	90	4.78	4.96	14.54	15.88	10.67	9.82
					6.66		17.43		9.67	
					3.45		15.67		9.11	
AL3 – 8	28.03.2022	309	200	105	5.58	5.35	16.13	17.51	11.89	9.56
					4.45		17.81		8.18	
					6.02		18.61		8.60	
Monthly Average		276	188	84		4.84		16.50		10.30
Standard Deviation		48	38	14		0.52		1.37		1.28

Table 3 : Results of Air Pollutant Concentration at Estate Office					
Sampling Period	**Date**	**C6H6 [µg/m3]**	***NMHC**	**CO [mg/m3]**	**CO2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL3 -1	01.03.2022	1.110	BQL	2.11	715
AL3 -2	04.03.2022	1.241	BQL	1.71	465
AL3 -3	07.03.2022	1.051	BQL	2.17	456
AL3 -4	10.03.2022	1.181	BQL	1.96	802
AL3 – 5	14.03.2022	1.065	BQL	1.85	651
AL3 – 6	21.03.2022	1.11	BQL	1.78	643
AL3 – 7	24.03.2022	1.085	BQL	1.81	734
AL3 – 8	28.03.2022	1.121	BQL	2.18	421
Monthly Average		**1.12**	**-**	**1.95**	**611**
Standard Deviation		**0.063**	**-**	**0.18**	**144.66**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Kandla Port Colony was attributed by vehicle emission produced from trucks and heavy duty vehicles that pass through the road outside Kandla Port Colony. The mean TSPM values at Oil Jetty were 276 µg/m^3, The mean PM_{10} values were 188 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were 84 µg/m^3. The average values of SO_2, NO_x and NH_3 were 4.84 µg/m^3, 16.50 µg/m^3 and 10.30 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Kandla Port Colony. The mean Benzene concentration was 1.12 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.95 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 4: Gopalpuri Hospital (AL-4)

Table 4 : Results of Air Pollutant Concentration at Gopalpuri Hospital

Paramete	Date	TSPM [µg/m³]	PM10 [µg/m³]	PM2.5 [µg/m³]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit		NS	100 [µg/m3]	60 [µg/m3]		80 [µg/m3]		80 [µg/m3]		400 [µg/m³]
AL4 -1	01.03.2022	178	120	55	3.6	3.99	10.67	11.51	7.54	8.21
					3.85		12.31		8.65	
					4.51		11.56		8.43	
AL4 -2	04.03.2022	189	119	67	4.01	3.28	12.43	12.59	6.76	7.80
					2.51		12.11		7.76	
					3.31		13.24		8.89	
AL4 -3	07.03.2022	230	144	83	3.12	3.55	13.41	14.31	7.67	8.06
					3.42		14.51		8.98	
					4.12		15.01		7.54	
AL4 -4	10.03.2022	273	178	92	3.02	3.25	10.87	12.5	7.45	8.66
					3.32		12.65		8.65	
					3.41		13.98		9.89	
AL4 – 5	14.03.2022	231	148	80	2.98	3.53	12.87	13.29	7.56	7.67
					3.41		12.23		8.15	
					4.21		14.76		7.31	
AL4 – 6	21.03.2022	310	211	96	3.21	3.28	14.15	13.19	6.89	7.81
					2.76		12.65		8.67	
					3.87		12.76		7.87	
AL4 – 7	24.03.2022	185	110	72	2.98	3.40	14.78	13.29	7.61	7.39
					3.45		13.12		6.98	
					3.76		11.98		7.57	
AL4 – 8	28.03.2022	205	122	80	2.96	3.57	12.65	13.54	8.61	9.46
					3.24		13.54		9.65	
					4.51		14.41		10.11	
Monthly Average		225	144	78		3.48		13.02		8.13
Standard Deviation		46	35	13		0.24		0.83		0.66

Table 4 : Results of Air Pollutant Concentration at Gopalpuri Hospital					
	Date	**C6H6 [µg/m3]**	***NMHC**	**CO [mg/m3]**	**CO2 [ppm]**
Sampling Period		**8 hr**		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL4 -1	01.03.2022	1.096	BQL	2.23	572
AL4 -2	04.03.2022	1.135	BQL	1.88	537
AL4 -3	07.03.2022	1.23	BQL	1.79	607
AL4 -4	10.03.2022	1.132	BQL	2.32	651
AL4 – 5	14.03.2022	1.243	BQL	1.78	741
AL4 – 6	21.03.2022	1.212	BQL	2.09	756
AL4 – 7	24.03.2022	1.312	BQL	1.81	634
AL4 – 8	28.03.2022	1.223	BQL	2.01	765
Monthly Average		**1.20**	**-**	**1.99**	**658**
Standard Deviation		**0.071**	**-**	**0.21**	**87**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Gopalpuri Hospital was attributed by vehicle emission produced from light motor vehicles of the colony residents. The mean TSPM values at Gopalpuri Hospital were 225 µg/m^3, The mean PM_{10} values were 144 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were 78 µg/m^3. The average values of SO_2, NO_x and NH_3 were 3.48 µg/m^3, 13.02 µg/m^3 and 8.13 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Gopalpuri Hospital. The mean Benzene concentration was 1.20 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.99 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 5: Coal Storage Area (AL-5)

Table 5 : Results of Air Pollutant Concentration at Coal Storage Area

Parameter	Date	TSPM [µg/m³]	PM10 [µg/m³]	PM2.5 [µg/m³]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit		NS	100 [µg/m3]	60 [µg/m3]		80 [µg/m3]		80 [µg/m3]		400 [µg/m³]
AL5 – 1	01.03.2022	396	292	102	3.65	4.16	19.32	17.59	10.89	8.91
					4.21		20.01		7.32	
					4.61		13.43		8.51	
AL5 – 2	04.03.2022	337	237	98	3.12	3.61	15.21	16.39	7.98	8.80
					4.01		16.33		9.67	
					3.71		17.63		8.76	
AL5 – 3	07.03.2022	524	392	130	4.21	3.95	17.35	15.51	9.46	8.52
					3.43		16.64		7.56	
					4.21		12.54		8.55	
AL5 – 4	10.03.2022	358	258	98	3.43	3.62	13.01	13.66	10.09	8.94
					3.31		14.21		8.65	
					4.12		13.76		8.09	
AL5 – 5	14.03.2022	442	309	111	3.09	3.81	15.43	17.29	10.43	11.03
					4.11		17.11		11.11	
					4.23		19.32		11.55	
AL5 – 6	21.03.2022	445	322	121	3.21	3.67	13.21	16.91	10.43	9.84
					3.67		18.21		9.34	
					4.13		19.32		9.76	
AL5 – 7	24.03.2022	432	313	117	3.78	3.79	12.32	14.52	7.87	8.57
					4.43		12.56		8.87	
					3.15		18.67		8.98	
AL5 – 8	28.03.2022	415	306	107	3.42	3.99	17.65	14.95	10.34	9.73
					4.22		13.12		9.87	
					4.32		14.09		8.98	
Monthly Average		416	304	111		3.82		15.85		9.29
Standard Deviation		57	46	12		0.19		1.41		0.86

Table 5 : Results of Air Pollutant Concentration at Coal Storage Area					
Sampling Period	**Date**	**C6H6 [µg/m3]**	***NMHC**	**CO [mg/m3]**	**CO2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL5 – 1	01.03.2022	1.123	BQL	1.97	878
AL5 – 2	04.03.2022	1.223	BQL	2.12	544
AL5 – 3	07.03.2022	1.121	BQL	1.99	521
AL5 – 4	10.03.2022	1.243	BQL	1.81	588
AL5 – 5	14.03.2022	1.034	BQL	2.0	621
AL5 – 6	21.03.2022	1.143	BQL	2.26	609
AL5 – 7	24.03.2022	1.231	BQL	2.13	655
AL5 – 8	28.03.2022	1.012	BQL	2.01	543
Monthly Average		**1.14**	**-**	**2.04**	**620**
Standard Deviation		**0.09**	**-**	**0.13**	**114**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Coal Storage Area was comparatively highest among all the locations of Air Quality monitoring in Kandla Port. High values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_X at this location was due to lifting of coal with grab and other coal handling processes near Berth no. 6 & 7. Moreover, the traffic was also heavy around this place for transport of coal thus emissions produced from heavy vehicles. The mean TSPM values at Coal storage were 416 µg/m^3. The mean PM_{10} values were 304 µg/m^3, which is well above the permissible limit. $PM_{2.5}$ values were 111 µg/m^3. The average values of SO_2, NO_x and NH_3 were 3.82 µg/m^3, 15.85 µg/m^3 and 9.29 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Coal Storage Area. The mean Benzene concentration was 1.14 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 2.04 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 6: Tuna Port (AL-6)

Table 6 : Results of Air Pollutant Concentration atTuna Port

Parameter	Date	TSPM [µg/m³]	PM10 [µg/m³]	PM2.5 [µg/m³]	SO_2 [µg/m³]		NOx [µg/m³]		NH_3 [µg/m³]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit		NS	100 [µg/m3]	60 [µg/m3]		80 [µg/m3]		80 [µg/m3]		400 [µg/m³]
AL6 -1	01.03.2022	221	141	70	4.55 4.44 5.34	4.78	16.77 15.19 12.56	14.84	11.33 11.54 8.78	10.55
AL6 – 2	04.03.2022	173	106	57	4.76 4.12 4.66	4.51	15.70 16.18 14.37	15.42	8.76 9.18 7.46	8.47
AL6 – 3	07.03.2022	229	152	67	5.78 5.89 5.11	5.59	15.45 18.48 20.62	18.18	8.11 9.80 8.59	8.83
AL6 – 4	10.03.2022	277	169	98	5.79 4.17 5.69	5.21	14.66 16.80 14.89	15.45	8.51 7.90 8.35	8.25
AL6 – 5	14.03.2022	296	196	90	3.64 5.60 4.12	4.45	18.12 15.89 16.34	16.78	12.57 10.34 11.87	11.59
AL6 – 6	21.03.2022	275	185	80	4.78 6.26 5.64	5.56	18.35 18.54 21.23	19.37	8.55 13.44 14.06	12.01
AL6 – 7	24.03.2022	247	150	87	5.80 5.17 4.55	5.17	18.57 17.32 17.89	17.93	7.53 11.52 10.75	9.93
AL6 – 8	28.03.2022	268	172	86	4.57 4.52 4.68	4.59	19.21 14.66 15.22	16.36	11.55 8.57 8.78	9.63
Monthly Average		248	159	79		4.98		16.79		9.91
Standard Deviation		40	28	14		0.46		1.58		1.40

Table 6 : Results of Air Pollutant Concentration at Tuna Port					
	Date	**C6H6 [µg/m3]**	***NMHC**	**CO [mg/m3]**	**CO2 [ppm]**
Sampling Period		**8 hr**		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL6 -1	01.03.2022	1.123	BQL	2.08	554
AL6 -2	04.03.2022	1.213	BQL	1.89	623
AL6 -3	07.03.2022	1.056	BQL	1.96	585
AL6 -4	10.03.2022	1.214	BQL	2.0	532
AL6 -5	14.03.2022	1.188	BQL	1.69	711
AL6 -6	21.03.2022	1.008	BQL	1.88	687
AL6 -7	24.03.2022	1.087	BQL	1.79	677
AL6 -8	28.03.2022	1.154	BQL	2.09	511
Monthly Average		**1.13**	**-**	**1.92**	**610**
Standard Deviation		**0.08**	**-**	**0.14**	**76**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The mean TSPM values at Tuna Port were 248 µg/m^3, The mean PM_{10} values were 159 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were 79 µg/m^3. The average values of SO_2, NO_x and NH_3 were 4.98 µg/m^3, 16.79 µg/m^3 and 9.91 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Tuna Port. The mean Benzene concentration was 1.13 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.92 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 7: Signal Building (Vadinar) (AL-7)

Table 7 : Results of Air Pollutant Concentration at Signal Building

Parameter	Date	TSPM [µg/m³]	PM10 [µg/m³]	PM2.5 [µg/m³]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit		NS	100 [µg/m3]	60 [µg/m3]		80 [µg/m3]		80 [µg/m3]		400 [µg/m³]
AL7 -1	01.03.2022	175	101	68	3.86	3.81	14.11	13.34	7.98	8.34
					3.25		13.98		9.01	
					4.01		12.98		8.56	
AL7 -2	04.03.2022	193	114	73	4.12	4.10	20.98	18.42	7.42	7.32
					3.67		21.12		8.31	
					4.02		18.65		6.98	
AL7 -3	08.03.2022	156	86	64	4.32	5.28	13.53	14.61	8.12	9.79
					3.99		15.21		9.45	
					4.98		17.54		10.01	
AL7 -4	11.03.2022	215	119	90	5.02	4.84	20.12	16.94	8.12	8.34
					4.32		18.91		7.89	
					3.78		17.12		8.43	
AL7 -5	14.03.2022	157	86	65	3.98	4.69	19.67	19.90	9.32	8.00
					4.32		20.21		8.67	
					3.89		17.89		8.23	
AL7 -6	21.03.2022	170	94	70	3.54	3.66	13.21	13.97	7.66	9.45
					5.09		14.32		10.21	
					4.76		15.89		10.47	
AL7 -7	24.03.2022	157	93	58	4.43	3.52	13.65	16.51	10.72	9.36
					3.43		15.67		8.93	
					4.12		14.92		8.42	
AL7 -8	28.03.2022	163	89	68	4.98	4.25	14.44	15.46	9.87	9.87
					5.09		15.03		10.23	
					3.98		16.65		8.65	
Monthly Average		173	98	69		4.21		16.49		8.82
Standard Deviation		21	13	9		0.33		2.51		0.71

Table 7: Results of Air Pollutant Concentration at Signal buil vdr.					
	Date	**C6H6 [µg/m3]**	***NMHC**	**CO [mg/m3]**	**CO2 [ppm]**
Sampling Period		**8 hr**		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL7 -1	01.03.2022	1.23	BQL	1.52	376
AL7 -2	04.03.2022	1.18	BQL	1.67	598
AL7 -3	08.03.2022	1.09	BQL	1.76	612
AL7 -4	11.03.2022	1.34	BQL	1.98	456
AL7 -5	14.03.2022	1.05	BQL	1.71	576
AL7 -6	22.03.2022	1.21	BQL	2.12	487
AL7 -7	25.03.2022	1.19	BQL	2.09	587
AL7 -8	28.03.2022	1.21	BQL	1.96	453
Monthly Average		**1.22**	**-**	**1.85**	**518**
Standard Deviation		**0.14**	**-**	**0.22**	**87**

*NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The mean TSPM values at Vadinar Port were 173 µg/m^3. The mean PM_{10} values were 98 µg/m^3, which is below the permissible limit. $PM_{2.5}$ values were 69 µg/m^3. The average values of SO_2, NO_x and NH_3 were 4.21 µg/m^3, 16.49 µg/m^3 and 8.82 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Vadinar Port. The mean Benzene concentration was 1.22 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.85 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 8: Admin Building (Vadinar) (AL-8)

Table 8: Results of Air Pollutant Concentration at Admin Building

Parameter	Date	TSPM [µg/m³]	PM10 [µg/m³]	PM2.5 [µg/m³]	SO_2 [µg/m³]		NOx [µg/m³]		NH_3 [µg/m³]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit		NS	100 [µg/m3]	60 [µg/m3]		80 [µg/m3]		80 [µg/m3]		400 [µg/m³]
AL8 -1	01.03.2022	120	74	43	3.63	3.73	16.67	17.34	7.67	7.10
					3.54		17.89		6.08	
					4.01		17.45		7.56	
AL8 -2	04.03.2022	189	111	75	3.65	3.55	15.43	16.50	8.01	8.07
					2.88		16.76		7.98	
					4.12		17.32		8.23	
AL8 -3	08.03.2022	190	108	79	3.81	3.23	15.87	15.62	7.21	7.83
					3.12		16.01		7.87	
					2.76		14.98		8.42	
AL8 -4	11.03.2022	168	96	69	4.01	4.03	12.54	14.80	7.98	8.87
					3.86		15.34		8.87	
					4.23		16.51		9.77	
AL8 -5	14.03.2022	206	113	90	3.19	3.46	13.53	14.40	7.62	8.22
					2.87		14.65		8.32	
					4.32		15.01		8.72	
AL8 -6	22.03.2022	198	107	88	4.09	4.66	18.65	19.51	9.12	8.66
					4.87		20.01		8.87	
					5.01		19.87		7.98	
AL8 -7	25.03.2022	197	109	85	3.56	3.85	17.65	17.62	8.22	7.92
					4.01		18.23		7.98	
					3.98		16.99		7.56	
AL8- 8	28.03.2022	197	114	80	4.12	4.47	19.21	19.30	9.12	8.74
					4.76		20.01		8.88	
					4.54		18.67		8.21	
Monthly Average		183	104	76		3.87		16.89		8.18
Standard Deviation		28	13	15		0.49		1.92		0.58

Table 8 : Results of Air Pollutant Concentration at Admin Building					
Sampling Period	**Date**	**C6H6 [µg/m3]**	***NMHC**	**CO [mg/m3]**	**CO2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL8 -1	01.03.2022	1.43	BQL	1.83	365
AL8 -2	04.03.2022	1.11	BQL	2.09	465
AL8 -3	08.03.2022	1.21	BQL	1.91	575
AL8 -4	11.03.2022	1.19	BQL	1.76	441
AL8 -5	14.03.2022	1.02	BQL	1.71	515
AL8 -6	22.03.2022	1.23	BQL	2.0	398
AL8 -7	25.03.2022	1.31	BQL	1.99	423
AL8 -8	28.03.2022	1.18	BQL	1.71	387
Monthly Average		**1.24**	**-**	**1.88**	**446**
Standard Deviation		**0.12**	**-**	**0.14**	**70.36**

* NMHC- Non- Methane Hydrocarbon
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Admin Building Vadinar was comparatively low among all the locations of Air Quality monitoring in Kandla Port and Vadinar Port. The mean TSPM values at Vadinar Port were 183 µg/m^3. The mean PM_{10} values were 104 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were 76.0 µg/m$^{3.}$ The average values of SO_2, NO_x and NH_3 were 3.87 µg/m^3, 16.89 µg/m^3 and 8.18 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Admin Building, Vadinar Port. The mean Benzene concentration was 1.24 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.88 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

3.3 Observations and Conclusion

During the monitoring period, the overall Ambient Air Quality of the port area was found to be well within the desired levels for various gaseous pollutants. However, Particulate matter as PM_{10} and $PM_{2.5}$ was found to exceed the limits at locations like Near Coal storage area, Marine Bhavan, Estate Office, Tuna Port , Oil Jetty area, and Gopalpuri.

4.0 Drinking Water Quality Monitoring

Drinking Water Quality Monitoring was carried out at twenty stations at Kandla, Vadinar & Township Area of Deendayal Port.

4.1 Drinking Water Monitoring Methodology

Drinking water samples were collected from 20 locations as prescribed in the tender document. Samples for physico-chemical analysis were collected in 1 liter carboys and samples for microbiological parameters were collected in sterilized bottles. These samples were then analyzed in laboratory for various drinking water parameters at Kandla Lab/Surat.

The Sampling and Analysis was done as per standard methods - IS 10500:2012. The water samples were analyzed for various parameters, viz. Color , Odor, Turbidity , Conductivity , pH , Chlorides , TDS, Total Hardness, Iron , Sulphate , Salinity , DO, BOD, Na, K, Ca, Mg, F, NO_3, NO_2, Mn, Cr-6, Cu, Cd, As, Hg, Pb, Zn, Bacterial Count (cfu) .

4.2 Results

The Drinking Water Quality monitoring data for 20 stations are given in below from table No. 9 to Table No. 15

Table 9: Drinking Water Quality Monitoring Parameters for Nirman Building 1 (23° 0' 27"E, 70° 13' 21"N) P & C building (23° 0' 33"E 70° 13' 20"N) & Main Gate (North) at Kandla (23° 0' 26.97"E, 70° 13' 21.87"N)

Sr. No.	Parameter	Unit	Nirman Building	P & C building	Main Gate	Acceptable Limits as per	Permissible Limits in the absence of
1	pH	pH Unit	7.2	7.1	7.3	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved	mg/l	950	1120	1020	500	2000
3	Turbidity	NTU	0	0	1	1	5
4	Odor	-	Odourless	Odourless	Odourless	Agreeable	Agreeable
5	Color	Hazen Units	Colourless	Colourless	Colourless	5	15
6	Conductivity	µs/cm	1720	2130	1820	NS*	NS*
7	BOD	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	561.2	606.35	546.21	250	1000
9	Total Hardness	mg/l	430	440	460	200	600
10	Calcium	mg/l	60.12	64.13	68.14	75	200
11	Salinity	%	1.01	1.095	0.98	NS*	NS*
12	Mg as Mg	mg/l	68.04	68.04	70.47	30	100
13	Fluorides as F	mg/l	0.74	0.69	0.81	1	1.5
14	Sulphate as SO_4	mg/l	254.4	222	206.4	200	400
15	Nitrite as NO_2	mg/l	0.0056	0.00574	0.006	NS*	NS*
16	Nitrate as NO_3	mg/l	7.18	6.89	7.88	45	No Relaxation
17	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
18	Sodium as Na	mg/l	202.5	201.8	232.5	NS*	NS*
19	Potassium as K	mg/l	3.18	4.07	5.38	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	0.003
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	0.001
26	Lead	mg/l	BQL	BQL	BQL	0.01	0.01
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe- 0.009 mg/l, Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu- 0.004 mg/l, Cd- 0.003 mg/l, As- 0.003mg/l, Hg- 0.001 mg/l, Pb- 0.006mg/l, Zinc- 0.021 mg/l).

Table 10: Drinking Water Quality Monitoring Parameters for Canteen, (23° 2' 17.2674"E, 70° 13' 18.2814"N) West Gate – I(23° 59' 40.48"E, 70° 12' 50.96"N) & Wharf Area (22° 59' 52.2"E,70° 13' 22.95"N) at Kandla

Sr. No.	Parameter	Unit	Canteen	West Gate – I	Wharf Area	Acceptable Limits as	Permissible Limits in the absence of
1	pH	pH Unit	7.4	7.5	7.3	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1160	970	1060	500	2000
3	Turbidity	NTU	1	1	0	1	5
4	Odor	-	Odourless	Odourless	Odourless	Agreeable	Agreeable
5	Color	Hazen Units	Colourless	Colourless	Colourless	5	15
6	Conductivity	µs/cm	2160	1790	1950	NS*	NS*
7	BOD	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	626.39	586.30	616.37	250	1000
9	Total Hardness	mg/l	450	420	410	75	600
10	Calcium	mg/l	56.11	52.10	60.12	30	200
11	Salinity	%	1.13	1.06	1.11	200	NS*
12	Mg as Mg	mg/l	75.33	70.47	63.18	0.3	100
13	Fluorides as F	mg/l	0.82	0.41	0.52	1	1.5
14	Sulphate as SO_4	mg/l	246	217.2	214.8	200	400
15	Nitrite as NO_2	mg/l	0.006	0.006	0.006	NS*	NS*
16	Nitrate as NO_3	mg/l	8.66	9.5	9.92	45	No Relaxation
17	Iron as Fe	mg/l	1.13	1.06	1.11	0.3	No Relaxation
18	Sodium as Na	mg/l	217.8	240.9	251.7	NS*	NS*
19	Potassium as K	mg/l	4.28	5.3	5.76	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	0.003
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	0.001
26	Lead	mg/l	BQL	BQL	BQL	0.01	0.01
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100 ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 11: Drinking Water Quality Monitoring Parameters for Sewa sadan – 3,(23° 0' 22.55"E, 70° 13' 15.34"N) Workshop I (23° 0' 33.74"E, 70° 13' 20.05"N)&Custom Building (23° 1' 8.70"E, 70° 12' 52.0"N) at Kandla

Sr. No.	Parameter	Unit	Sewa Sadan – 3	Workshop	Custom Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.2	7.6	7.2	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	980	1120	1210	500	2000
3	Turbidity	NTU	0	0	1	1	5
4	Odor	-	Odourless	Odourless	Odourless	Agreeable	Agreeable
5	Color	Hazen Units	Colourless	Colourless	Colourless	5	15
6	Conductivity	µs/cm	1730	2090	2230	NS*	NS*
7	BOD	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	546.21	581.29	611.36	250	1000
9	Total Hardness	mg/l	440	450	420	200	600
10	Calcium	mg/l	72.14	56.11	48.10	75	200
11	Salinity	%	0.98	1.05	1.10	NS*	NS*
12	Mg as Mg	mg/l	63.18	75.33	72.90	30	100
13	Fluorides as F	mg/l	0.55	0.85	0.92	1	1.5
14	Sulphate as SO_4	mg/l	231.6	252	265.2	200	400
15	Nitrite as NO_2	mg/l	0.0066	0.007	0.0073	NS*	NS*
16	Nitrate as NO_3	mg/l	12.32	10.77	11.33	45	100
17	Iron as Fe	mg/l	0.98	1.05	1.1	0.3	1.0
18	Sodium as Na	mg/l	249.8	315.6	183.8	NS*	NS*
19	Potassium as K	mg/l	5.17	5.92	2.08	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	0.003
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	0.001
26	Lead	mg/l	BQL	BQL	BQL	0.01	0.01
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 12:Drinking Water Quality Monitoring Parameters for Port Colony Kandla(23° 11' 14.9"E, 70° 12' 48.4"N) Hospital Kandla 23° 1' 5.02"E, 70° 12' 44.38"N)& A.O. Building (23° 3' 42.89"E, 70° 8' 41.5"N) at Gandhidham

Sr. No.	Parameter	Unit	Port Colony Kandla	Hospital Kandla	A.O. Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.3	7.5	7.2	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1130	1210	960	500	2000
3	Turbidity	NTU	1	1	0	1	5
4	Odour	-	Odourless	Odourless	Odourless	Agreeable	Agreeable
5	Color	Hazen Units	Colourless	Colourless	Colourless	5	15
6	Conductivity	µs/cm	2040	2360	1750	NS*	NS*
7	BOD	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	656.46	646.43	576.28	250	1000
9	Total Hardness	mg/l	410	440	450	200	600
10	Calcium	mg/l	52.10	60.12	64.13	75	200
11	Salinity	%	1.18	1.16	1.04	NS*	NS*
12	Mg as Mg	mg/l	68.04	70.47	70.47	30	100
13	Fluorides as F	mg/l	0.81	0.73	0.86	1	1.5
14	Sulphate as SO_4	mg/l	184.8	195.6	202.8	200	400
15	Nitrite as NO_2	mg/l	0.0063	0.0067	0.007	NS*	NS*
16	Nitrate as NO_3	mg/l	8.87	12.32	12.742	45	100
17	Iron as Fe	mg/l	1.18	1.16	1.04	0.3	1.0
18	Sodium as Na	mg/l	228.1	236.9	356.8	NS*	NS*
19	Potassium as K	mg/l	3.15	4.65	6.18	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	0.003
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	0.001
26	Lead	mg/l	BQL	BQL	BQL	0.01	0.01
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 13: Drinking Water Quality Monitoring Parameters for School Gopalpuri,(23° 5' 1.03"E, 70° 7' 55.42"N) Guest House (23° 4' 43.14"E, 70° 7' 51.92"N) & E - Type Quarter(23° 4' 59.90"E, 70° 7' 56.72"N) at Gopalpuri, Gandhidham

Sr. No.	Parameter	Unit	Gopalpuri School	Guest House	E - Type Quarter	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.3	7.6	7.5	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1060	1220	1130	500	2000
3	Turbidity	NTU	0	1	1	1	5
4	Odor	-	Odourless	Odourless	Odourless	Agreeable	Agreeable
5	Color	Hazen	Colourless	Colourless	Colourless	5	15
6	Conductivity	µs/cm	1850	2360	2100	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	616.37	531.18	516.14	250	1000
9	Total Hardness	mg/l	470	460	450	200	600
10	Calcium	mg/l	68.14	60.12	64.13	75	200
11	Salinity	%	1.11	0.95	0.93	NS*	NS*
12	Mg as Mg	mg/l	72.90	75.33	70.47	30	100
13	Fluorides as F	mg/l	0.63	0.69	0.74	1	1.5
14	Sulphate as SO_4	mg/l	206.4	198	174	200	400
15	Nitrite as NO_2	mg/l	0.0055	0.0057	0.0061	NS*	NS*
16	Nitrate as NO_3	mg/l	9.99	10.98	9.50	45	100
17	Iron as Fe	mg/l	1.11	0.95	0.93	0.3	1.0
18	Sodium as Na	mg/l	229.8	265.9	31.14	NS*	NS*
19	Potassium as K	mg/l	3.29	5.89	5.9	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	0.003
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	0.001
26	Lead	mg/l	BQL	BQL	BQL	0.01	0.01
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100 ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 14:Drinking Water Quality Monitoring Parameters for F - Type Quarter, (23° 4' 38.45"E, 70° 8' 8.63"N) Hospital Gopalpuri (23° 4' 54.09"E, 70° 8' 7.5"N) & Tuna Port (23° 58' 23.06"E, 70° 5' 35.6"N)

Sr. No.	Parameter	Unit	F - Type Quarter	Hospital Gopalpuri	Tuna Port	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.4	7.3	7.2	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1080	1100	980	500	2000
3	Turbidity	NTU	1	0	0	1	5
4	Odor	-	Odourless	Odourless	Odourless	Agreeable	Agreeable
5	Color	Hazen Units	Colourless	Colourless	Colourless	5	15
6	Conductivity	µs/cm	1830	2140	1920	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	566.25	616.37	594.32	250	1000
9	Total Hardness	mg/l	410	430	420	200	600
10	Calcium	mg/l	68.14	72.14	76.15	75	200
11	Salinity	%	1.02	1.11	0.93	NS*	NS*
12	Mg as Mg	mg/l	58.32	60.75	55.89	30	100
13	Fluorides as F	mg/l	0.95	0.86	0.66	1	1.5
14	Sulphate as SO_4	mg/l	181.2	213.6	218.4	200	400
15	Nitrite as NO_2	mg/l	0.0062	0.0065	0.0068	NS*	NS*
16	Nitrate as NO_3	mg/l	10.77	8.51	7.60	45	100
17	Iron as Fe	mg/l	1.02	1.11	0.93	0.3	1.0
18	Sodium as Na	mg/l	244.9	273.8	281.4	NS*	NS*
19	Potassium as K	mg/l	5.05	5.38	4.19	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	0.003
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	0.001
26	Lead	mg/l	BQL	BQL	BQL	0.01	0.01
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 15: Drinking Water Quality Monitoring Parameters for Vadinar Jetty(22° 25' 51.73"E, 69° 41' 36.62"N) & Port Colony (22° 30' 26.25"E, 69° 39' 45.03"N) at Vadinar

Sr. No.	Parameter	Unit	Vadinar Jetty	Port Colony Vadinar	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.5	7.3	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1070	1030	500	2000
3	Turbidity	NTU	0	1	1	5
4	Odor	-	Odourless	Odourless	Agreeable	Agreeable
5	Color	Hazen Units	Colourless	Colourless	5	15
6	Conductivity	µs/cm	2010	1030	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	496.10	511.13	250	1000
9	Total Hardness	mg/l	460	450	200	600
10	Calcium	mg/l	64.13	56.11	75	200
11	Salinity	%	0.89	0.92	NS*	NS*
12	Mg as Mg	mg/l	72.90	75.33	30	100
13	Fluorides as F	mg/l	0.87	0.80	1	1.5
14	Sulphate as SO_4	mg/l	19.44	19.08	200	400
15	Nitrite as NO_2	mg/l	0.0059	0.0060	NS*	NS*
16	Nitrate as NO_3	mg/l	7.95	8.52	45	100
17	Iron as Fe	mg/l	0.89	0.92	0.3	1.0
18	Sodium as Na	mg/l	51.49	49.05	NS*	NS*
19	Potassium as K	mg/l	4.39	3.76	NS*	NS*
20	Manganese	mg/l	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	0.003	0.003
24	Arsenic	mg/l	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	0.001	0.001
26	Lead	mg/l	BQL	BQL	0.01	0.01
27	Zinc	mg/l	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

4.3 Results & Discussion

The colour of all drinking water samples was <5 Hazen unit and odour of the samples was also agreeable. All parameters are found to be within the specified limit of the Drinking water Standard.

pH

The limit of pH value for drinking water is specified as 7.1 to 7.6. pH value in the studied area varied from 7.1 to 7.6 pH unit. All the sampling points showed pH values within the prescribed limit by Indian Standards.

Total Dissolved Solids (TDS)

TDS values in the studied area varied between 950 - 1220 mg/l. None of the sampling points showed higher TDS values than the prescribed limit by Indian standards.

Conductivity

Electrical Conductivity is the ability of a solution to transfer (conduct) electric current. Conductivity is used to measure the concentration of dissolved solids which have been ionized in a polar solution such as water. The conductivity in the samples collected during the month of March ranged from 1030-2360 µs/cm. Electrical conductivity standards do not appear in BIS standards for drinking water.

BOD

BOD value in the studied area was found Below Quantification Limit (2.0 mg/l). Indian standards does not show any standard values for BOD in drinking water.

Chlorides

Excessive chloride concentration increase rates of corrosion of metals in the distribution system. This can lead to increased concentration of metals in the supply. Chloride value in the studied area varied between 496.1- 656.4 mg/l and is found to be within the Permissible limit of the Drinking Water Standard.

Calcium

Calcium value in the studied area varied between 48.09 - 76.15 mg/l and is found to be within the Permissible limit of the Drinking Water Standard. If calcium is present beyond the maximum acceptable limit, it causes incrustation of pipes.

Magnesium

Magnesium value in the studied area varied between 55.89 - 75.33 mg/l. All the locations had Magnesium within the prescribed limits of 30-100 mg/L.

Total Hardness

Hardness value in the studied area varied between 410 - 470 mg/l and is found to be within the Permissible limit of the Drinking Water Standard. The prescribed limit by Indian Standards is 200-600 mg/L.

Iron

Iron value in the studied area was found Below Quantification Limit (0.009 mg/l) and hence well below the permissible limit as per Indian Standards is 0.3 mg/L. The excess amount of iron causes slight toxicity; gives stringent taste to water.

Fluoride

Fluoride value in the studied area varied between 0.42 – 0.95 mg/l and hence well below the permissible limit as per Indian Standards is 1.0-1.5 mg/L. Moderate amounts lead to dental effects, but long-term ingestion of large amounts can lead to potentially severe skeletal problems.

Sulphates

Sulphate value in the studied area varied between 19.08 – 265.2 mg/l. All the sampling points showed sulphate values within the prescribed limits by Indian Standards (200-400 mg/L). Sulphate content in drinking water exceeding the 400 mg/L imparts bitter taste.

Nitrites (NO_2) and Nitrates (NO_3)

Nitrite values in all the water samples were found Below Quantification Limit (0.1 mg/l). There are no specified standard values for Nitrites in Drinking water. The minimum Nitrate value in drinking water of KPT was 0.0055 mg/l which is well within the permissible limit of the Drinking water Standard.

Salinity

Salinity in drinking water in the present samples collected ranged from 0.89 to 1.1%.There are no prescribed Indian standards for salinity in Drinking water.

Sodium and Potassium Salts

Sodium values in the samples collected ranged from 31.14 - 356.8 mg/l and Potassium salts ranged from 2.08 to 6.18 mg/l. There are no prescribed limits of Sodium and Potassium in Indian standards for Drinking water**.**

Heavy Metals in Drinking Water

In the present study period drinking water samples were analyzed for Mn, Cr, Cu, Cd, As, Hg, Pb and Zn. All these heavy metals were well Below the Quantification limits prescribed by the Indian Standards.

Bacteriological Study

Analysis of the bacteriological parameter at all location shows that Bacteria is not present and hence Bacterial count is in line with the permissible limit of drinking water. This shows that all the drinking water samples were safe from any bacteriological contamination.

4.4 Conclusions

These results are compared with acceptable limits as prescribed in IS 10500:2012 – Drinking Water Specification. It is seen from the analysis data that during the study period the water was safe for human consumption at all drinking water monitoring stations.

5.0 Noise Level Monitoring

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. Noise Monitoring was done at 13 stations at Kandla, Vadinar and Township area.

5.1 Method of Monitoring

Sampling was done at all stations for 24 hour period. Data was recorded using automated sound level meter. The intensity of sound was measured in sound pressure level (SPL) and common unit of measurement is decibel (dB).

5.2 Results

Table 16: Noise Monitoring data for ten locations of Deendayal Port and three locations of Vadinar Port

Sr. No.	Location	Day Time Average Noise Level (SPL) in dB(A)	Night Time Average Noise Level (SPL) in dB(A)
	Sampling Time	**6:00 am to 10:00 PM**	**10:00PM to 6:00 AM**
1	Marine Bhavan	67.5	66.0
2	Nirman Building 1	65.2	61.7
3	Tuna Port	47.1	45.3
4	Main Gate North	64.4	61.2
5	West Gate I	55.2	54.9
6	Canteen Area	63.4	55.2
7	Main Road	60.7	53.2
8	ATM Building	69.8	68.4
9	Wharf Area /Jetty Area	74.4	62.8
10	Port & Custom Office	57.9	56.5
Vadinar Port			
11	Entrance Gate of Vadinar Port	66.8	53.7
12	Nr. Port Colony, Vadinar	60.4	52.8
13	Nr. Vadinar Jetty	72.5	63.7

5.3 Conclusions

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. The Day Time Noise Level (SPL)in all 13 locations at Deendayal Port ranged from 47.1 dB(A) to 74.4 dB(A) and it was within the permissible limits of 75 dB(A) for the industrial area for the daytime. The Night Time Average Noise Level (SPL) in all 13 locations of Deendayal Port ranged from 45.30 dB to 68.40 dB(A) and it was within the permissible limits of 70 dB(A) for the industrial area for the night time.

6.0 Soil Monitoring

Sampling and analysis of soil samples were undertaken at six locations within the study area (Deendayal Port and Vadinar Port) as a part of EMP. The soil sampling locations are initially decided based on the locations as provided in the tender document of the Deendayal Port.

6.1 Methodology

The soil samples were collected in the month of March 2022. The samples collected from the all locations are homogeneous representative of each location. At random locations were identified at each location and soil was dug from 30 cm below the surface. It was uniformly mixed before homogenizing the soil samples. The samples were filled in polythene bags, labeled in the field with number and site name and sent to laboratory for analysis.

6.2 Results

Table-17: Chemical Characteristics of Soil in the Study Area for Tuna port, (22° 58' 10.18"E, 70° 6' 3.7"N) IFFCO plant (23° 26' 8.37"E, 70° 13' 4.4"N), Khori creek, (22° 58' 10.18"E, 70° 6' 3.7"N) Nakti Creek,(23° 2' 1.10"E, 70° 9' 33.6"N) KPT admin site,(22° 26' 30.9"E, 69° 40' 37.03"N) KPT colony(22° 23' 57.09"E, 69° 42' 49.42"N)

Sr. No.	Parameter	Unit	Station Name					
			SL1	SL2	SL3	SL4	SL5	SL6
			Tuna Port	IFFCO Plant	Khori Creek	Nakti Creek	KPT Admin	KPT Colony
			Near main gate of	10 m away	Sand from creek at low tide			Vadinar
1	Texture		Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	pH	-	8.59	8.6	8.68	8.47	7.67	7.85
3	Electrical Conductivity	µs/cm	12,839.00	11,442.00	10,950.00	14,848.00	545	600
4	Moisture	%	22	28.37	21	24.88	4.99	10.65
5	Total Organic Carbon	%	0.96	0.71	0.98	0.84	1.74	0.62
6	Alkalinity	mg/kg	40.04	40.04	40.04	40.04	80.08	80.08
7	Total Nitrogen	%	BQL	BQL	BQL	BQL	BQL	BQL
8	Chloride	mg/kg	3,545.00	2,481.50	2,836.00	3,190.50	35.5	28.4
9	Sulphate	mg/kg	3,891.18	1,650.89	1,292.27	4,950.89	BQL	BQL
10	Phosphorus	mg/kg	10.87	5.33	8.87	8.5	1.88	1.96
11	Potassium	mg/kg	192.3	155.01	160.36	178.48	31.3	33.61
12	Sodium	mg/kg	2,466.12	1,500.32	1,839.79	2,450.29	32.56	35.2
13	Calcium	mg/kg	284.57	432.86	232.46	492.9	637.27	581.1
14	Copper as Cu	mg/kg	43.4	18.1	20	15.4	85.5	76.2
15	Lead as Pb	mg/kg	7.8	5.4	5.7	5.8	1.4	ND
16	Nickel as Ni	mg/kg	17.4	35.4	40.9	30.2	42.1	42.2
17	Zinc as Zn	mg/kg	110.6	48.8	50.4	42.6	85.4	58.4
18	Cadmium as Cd	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (TN: 0.001%, Cd: 1.0mg/kg).

6.3 Discussion

The data shows that value of pH ranges from 7.85 at KPT Colony (Vadinar) to 8.68 at Khori Creek indicating that all soil samples are neutral to slight basic. Nakti creek samples showed maximum conductivity of 14,848.00 µmhos/cm, while KPT Colony (Vadinar) location showed minimum conductivity of 10950. µmhos/cm. Conductivity at Vadinar Port was 545 and 600 µmhos/cm at Admin site and Vadinar Port colony respectively.

Total organic Carbon ranged from 0.71 % to 0.98 at Deendayal Port. At Vadinar Port, organic Carbon range from 0.62 % to 1.74.

The concentration of Phosphorus and Potassium in the soil samples varies from 5.33 to 10.87 mg/kg and 155.1 to 192.3 mg/kg respectively at Deendayal Port. The mean concentration of Phosphorous at Vadinar site was 1.92 mg/kg and mean concentration of Potassium at Vadinar site was 32.46 mg/kg.

These differences in NPK in soil at different locations are due to the dissimilar nature of soil at each of the locations. Samples SL3 & SL4 (Khori Creek & Nakti Creek) are of saline nature as they are coastal soil; where as other locations are inland locations and have different chemical properties.

Heavy Metals in the Soil

Traces of Copper, Lead, Nickel and Zinc were observed in the soil samples collected from all the four locations of Deendayal Port and two locations of Vadinar Port. Cadmium metal was below detection limit in the Soil.

6.4 Conclusion

The soils of Deendayal Port and Vadinar Port appears to be neutral to basic with varying levels of Chloride, Sulphate, NPK and Calcium. As the nature of soil at different locations are different with respect to its proximity to the sea, the samples showed high degree of variations in their chemical properties.

7.0 Sewage Treatment Plant Monitoring

This involves safe collection of waste water (spent/used water) from wash areas, bathroom, industrial units, etc., waste from toilets of various buildings and its conveyance to the treatment plant and final disposal in conformity with the requirement and guide lines of State Pollution Control Board and other statutory bodies.

7.1 Methodology for STP Monitoring

To monitor the working efficiency of Sewage Treatment Plant (STP), STP Inlet and Outlet Samples were collected once a week. Locations selected are namely Gopalpuri Township, Deendayal Port and Vadinar. Samples were collected in 1 lit. Carboys and were analyzed in laboratory for various parameters.

7.2 Results

Kandla STP

Table 18: Sewage Water Monitoring at Kandla STP (1st Week)

Date of Sampling	04.03.22

Sr. No.	**Parameters**	**Unit**	**Results**		**GPCB Prescribed Limit**
			KPT STP I/L	**KPT STP O/L**	
1	pH	pH unit	7.45	7.2	6.5 - 8.5
2	Total Suspended	mg/l	398.4	37.7	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	304	99	100
5	BOD @ 27 °C	mg/l	101	28	30
6	Fecal Coliform	MPN Index /	-	865	< 1000
Aeration Tank					
7	MLSS	mg/l		140	
8	MLVSS	%		49	

Table 19: Sewage Water Monitoring at Kandla STP (2nd Week)

Date of Sampling	07.03.22

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			KPT STP I/L	KPT STP O/L	
1	pH	pH unit	7.43	7.18	6.5 - 8.5
2	Total Suspended Solids	mg/l	121.2	93.4	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	282	98	100
5	BOD @ 27 °C	mg/l	101	28	30
6	Fecal Coliform	MPN Index / 100 ml	-	780	< 1000
Aeration Tank					
7	MLSS	mg/l	215		
8	MLVSS	%	56		

Table 20: Sewage Water Monitoring at Kandla STP (3rd Week)

Date of Sampling	14.03.22

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			KPT STP I/L	KPT STP O/L	
1	pH	pH unit	7.55	7.32	6.5 - 8.5
2	Total Suspended Solids	mg/l	105.4	77	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	253.5	97	100
5	BOD @ 27 °C	mg/l	89	28	30
6	Fecal Coliform	MPN Index / 100 ml	-	920	< 1000
Aeration Tank					
7	MLSS	mg/l	45		
8	MLVSS	%	81		

Table 21: Sewage Water Monitoring at Kandla STP (4th Week)

Date of Sampling	21.03.22

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			KPT STP I/L	KPT STP O/L	
1	pH	pH unit	7.65	7.38	6.5 - 8.5
2	Total Suspended Solids	mg/l	224.4	85	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	332	100	100
5	BOD @ 27 °C	mg/l	110	30	30
6	Fecal Coliform	MPN Index / 100 ml	-	840	< 1000
Aeration Tank					
7	MLSS	mg/l	32		
8	MLVSS	%	88		

Table 22: Sewage Water Monitoring at Gopalpuri STP (1st Week)

Date of Sampling	04.03.22

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Gopalpuri STP I/L	Gopalpuri STP O/L	
1	pH	pH unit	7.65	7.38	6.5 - 8.5
2	Total Suspended Solids	mg/l	224.4	85	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	332	96	100
5	BOD @ 27 °C	mg/l	110	27	30
6	Fecal Coliform	MPN Index / 100 ml	-	340	< 1000
Aeration Tank					
7	MLSS	mg/l	32		
8	MLVSS	%	88		

Table 23: Sewage Water Monitoring at Gopalpuri STP (2nd Week)

Date of Sampling	07.03.22

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Gopalpuri STP I/L	Gopalpuri STP O/L	
1	pH	pH unit	7.55	7.29	6.5 - 8.5
2	Total Suspended Solids	mg/l	280.4	70	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	303	91	100
5	BOD @ 27 °C	mg/l	106	26	30
6	Fecal Coliform	MPN Index / 100 ml	-	280	< 1000
Aeration Tank					
7	MLSS	mg/l	30		
8	MLVSS	%	71		

Table 24: Sewage Water Monitoring at Gopalpuri STP (3rd Week)

Date of Sampling	14.03.22

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Gopalpuri STP I/L	Gopalpuri STP O/L	
1	pH	pH unit	7.36	7.12	6.5 - 8.5
2	Total Suspended Solids	mg/l	380.4	88	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	303	98	100
5	BOD @ 27 °C	mg/l	106	28	30
6	Fecal Coliform	MPN	-	540	< 1000
Aeration Tank					
7	MLSS	mg/l	198		
8	MLVSS	%	62		

Table 25: Sewage Water Monitoring at Gopalpuri STP (4th Week)

Date of Sampling	21.03.22

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Gopalpuri STP I/L	Gopalpuri STP O/L	
1	pH	pH unit	7.43	7.26	6.5 - 8.5
2	Total Suspended Solids	mg/l	268.8	59.4	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	290	100	100
5	BOD @ 27 °C	mg/l	102	30	30
6	Fecal Coliform	MPN Index / 100 ml	-	630	< 1000
Aeration Tank					
7	MLSS	mg/l	25		
8	MLVSS	%	90		

Vadinar STP

Table 26: Sewage Water Monitoring at Vadinar STP (1st Week)

Date of Sampling	04.03.22

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar O/L	
1	pH	pH unit	7.51	7.28	6.5 - 8.5
2	Total Suspended Solids	mg/l	101.5	47.7	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	253	96	100
5	BOD @ 27 °C	mg/l	90	27	30
6	Fecal Coliform	MPN Index / 100 ml	-	7.8	< 1000

Table 27: Sewage Water Monitoring at Vadinar STP (2nd Week)

Date of Sampling	07.03.22

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar O/L	
1	pH	pH unit	7.76	7.41	6.5 - 8.5
2	Total Suspended	mg/l	105.4	54	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	240	98	100
5	BOD @ 27 °C	mg/l	82	28	30
6	Fecal Coliform	MPN Index / 100 ml		21	< 1000

Table 28: Sewage Water Monitoring at Vadinar STP (3rd Week)

Date of Sampling	14.03.22

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar O/L	
1	pH	pH unit	7.61	7.4	6.5 - 8.5
2	Total Suspended Solids	mg/l	100.4	39.1	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	233	98	100
5	BOD @ 27 °C	mg/l	78	26	30
6	Fecal Coliform	MPN Index / 100 ml		32	< 1000

Table 29: Sewage Water Monitoring at Vadinar STP (4th Week)

Date of Sampling	21.03.22

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar O/L	
1	pH	pH unit	7.5	7.31	6.5 - 8.5
2	Total Suspended Solids	mg/l	93.5	44	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	230	100	100
5	BOD @ 27 °C	mg/l	76	28	30
6	Fecal Coliform	MPN Index / 100 ml	-	220	< 1000

7.3 Conclusions:

The GPCB standards of BOD, TSS, PH, COD and Fecal Coliform for STP outlet are 30 mg/lit, 100 mg/lit 6.5 - 8.5 , 100 & < 1000 mg/lit respectively. All results are found within permissible limits.

8.0 Marine Water Monitoring

Marine Water Quality

The Forty Second Amendment to the Constitution in 1976 underscored the importance of 'green thinking'. Article 48A enjoins the state to protect and improve the environment and safeguard the forests and wildlife in the country. Further, Article 51A(g) states that the "fundamental duty of every citizen is to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures".

Policy Statement for Abatement of Pollution (1992) has suggested developing relevant legislation and regulation, fiscal incentives, voluntary agreements and educational programs and information campaigns. It emphasizes the need for integration by incorporating environmental considerations into decision making at all levels by adopting frameworks namely, pollution prevention at source, application of best practicable solution, ensure polluter pays for control of pollution, focus on heavily polluted areas and river stretches and involve public in decision-making. The National Conservation Strategy and Policy Statement on Environment and Development, (1992) aimed at "integrating environmental concerns with developmental imperatives to meet the challenges by redirecting the thrust of our developmental process so that the basic needs of our people could be fulfilled by making judicious and sustainable use of natural resources." The priorities mentioned in this policy document include the sustainable use of land and water resources, prevention and control of pollution and preservation of biodiversity.

The National Water Policy, (2002) contains provisions for developing, conserving, sustainable utilizing and managing this important water resources and need to be governed by national perspectives.

Sampling Stations

The monitoring of marine environment for the study of biological and ecological parameters was carried out on 03rd & 04th March-2022 in harbor regions of KPT and on 03rd March-2022 at Vadinar during spring tide period of New moon phase of Lunar Cycle. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 10th&

11th March 2022 in harbor regions of KPT. 10th March -2022 in Vadinar during Neap tide period first quarter of Lunar Cycle..

Plankton samples from sub surface layer was collected both during high tide period and low tide period from 3 water quality monitoring stations of KPT harbour area and two stations in Nakti creek and one station in Khori creek. The same sampling schedule was repeated during consecutive spring tide and neap tide in same month. Plankton samples from sub surface layer was collected both during high tide period and low tide period from 1 water quality monitoring stations near Vadinar jetty area during spring tide and neap tide in this month. Collected water samples were processed for estimation of Chlorophyll- a, Pheophytin- a, qualitative & quantitative evaluation of phytoplankton, qualitative & quantitative evaluation zooplanktons (density and their population).

Sampling Locations

Offshore monitoring requirement	Number of locations
Offshore Installations	3 in Kandla creek 2 in Nakti creek 1 in Khori creek 1 near Vadinar Jetty 1 near 1st SBM
Total Number of locations	**8**

8.1 Marine Water Quality and Results

Marine water quality of marine waters of Deendayal Port Harbor waters, Khori & Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each month. The results of marine water quality from table no 30 to 37.

Table 30: Marine Water Quality Monitoring Parameters for location near KPT colony

Sr. No.	Parameters	Unit	Kandla Creek Near KPT colony (1)			
			23°0'58"N 70°13'22."E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.3	7.32	7.4	7.35
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31	32	31.3	32.0
5	Turbidity	NTU	34	31	36	32
6	Total Dissolved Solids	mg/l	15406	16523	20796	22487
7	Total Suspended Solids	mg/l	532	643	663.9	659.2
8	Total Solids	mg/l	16000	17233	21470.0	23220.0
9	DO	mg/l	4.1	4.2	4.3	4.2
10	COD	mg/l	78	80	82	80
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.75	0.69	0.82	0.71
13	Phosphate	mg/l	0.25	0.23	0.23	0.22
14	Sulphate	mg/l	2676	2304	2256	2340
15	Nitrate	mg/l	2.68	2.53	3.03	2.75
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	681.36	721.44	641.28	601.2
18	Magnesium	mg/l	1652.4	1603.8	1628.1	1628.1
19	Sodium	mg/l	9486	9013	9038	9181
20	Potassium	mg/l	370.6	315.9	338.1	341.8
21	Iron	mg/l	BQL	1.08	0.62	0.25
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 31: Marine Water Quality Monitoring Parameters for location near passenger Jetty One at Kandla

Sr. No.	Parameters	Unit	Near passenger Jetty One (2)			
			23° 0'18 "N 70°13'31"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.4	7.26	7.45	7..38
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31.8	31.3	31.8	31.9
5	Turbidity	NTU	30	28	29	35
6	Total Dissolved Solids	mg/l	18960	20901	19303	19608
7	Total Suspended Solids	mg/l	656	706	657.3	558.1
8	Total Solids	mg/l	19640	21620	20010.0	20280.0
9	DO	mg/l	4.3	4.4	4.6	4.7
10	COD	mg/l	82	82	78	76
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.65	0.6	0.75	0.65
13	Phosphate	mg/l	0.24	0.21	0.22	0.21
14	Sulphate	mg/l	2544	2520	2412	2544
15	Nitrate	mg/l	2.89	3.17	3.17	3.59
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	641.28	601.2	521.04	681.36
18	Magnesium	mg/l	1628.1	1628.1	1725.3	1676.7
19	Sodium	mg/l	9707	9001	9530	9408
20	Potassium	mg/l	388.6	318.9	378.6	370.8
21	Iron	mg/l	0.3	0.5	0.04	0.2
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	0.02	0.02

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Nitrite: 0.05mg/lCu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 32: Marine Water Quality Monitoring Parameters for location Near Coal Berth

Sr. No.	Parameters	Unit	Near Coal Berth			
			22°59'12"N 70°13'40"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.36	7.4	7.28	7.31
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31.2	32.0	32.2	31.0
5	Turbidity	NTU	29	32	34	31
6	Total Dissolved	mg/l	20799	18680	24634	22504
7	Total Suspended	mg/l	599	709	599.5	614
8	Total Solids	mg/l	21460	19482	25316.0	23210.0
9	DO	mg/l	4.5	4.7	4.8	4.4
10	COD	mg/l	68	70	70	72
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.78	0.82	0.84	0.93
13	Phosphate	mg/l	0.19	0.2	0.21	0.2
14	Sulphate	mg/l	2220	2268	2100	2184
15	Nitrate	mg/l	3.94	3.59	3.87	4.01
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	561.12	641.28	721.44	641.28
18	Magnesium	mg/l	1749.6	1676.7	1676.7	1676.7
19	Sodium	mg/l	9059	8889	9030	9278
20	Potassium	mg/l	350.1	334.6	337.1	348.7
21	Iron	mg/l	0.05	0.06	0.21	1.36
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	0.04	4.28

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 33: Marine Water Quality Monitoring Parameters for location Khori creek at Kandla

Sr. No.	Parameters	Unit	KPT 4			
			Near 15/16 Berth			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.41	7.36	7.41	7.46
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31.0	30.8	32.2	31.4
5	Turbidity	NTU	38	36	30	28
6	Total Dissolved Solids	mg/l	20160	22448	29993	29941
7	Total Suspended Solids	mg/l	661	720	715.9	723.9
8	Total Solids	mg/l	20840	23268	30810	30666
9	DO	mg/l	4.6	4.3	4.5	4.6
10	COD	mg/l	86	88	82	80
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.93	0.89	0.89	0.71
13	Phosphate	mg/l	0.21	0.2	0.23	0.23
14	Sulphate	mg/l	1872	1944	2652	2700
15	Nitrate	mg/l	4.36	4.58	4.44	4.29
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	681.36	601.2	601.2	561.12
18	Magnesium	mg/l	1676.7	1749.6	1676.7	1652.4
19	Sodium	mg/l	9226	8808	9390	9725
20	Potassium	mg/l	356.2	320	356.8	387.1
21	Iron	mg/l	BQL	0.96	1.13	0.52
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	0.04	BQL

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 34: Marine Water Quality Monitoring Parameters for location Nakti Creek near Tuna Port

Sr. No.	Parameters	Unit	Nakti Creek Near Tuna Port			
			22°57'49."N 70° 7'0.67"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.4	7.48	7.33	7.39
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31.2	31.9	31.8	32.2
5	Turbidity	NTU	35	37	37	38
6	Total Dissolved Solids	mg/l	18698	21456	28575	23050
7	Total Suspended Solids	mg/l	674	789	704.4	733.2
8	Total Solids	mg/l	19420	22366	29340	23820
9	DO	mg/l	4.4	4.5	4.3	4.4
10	COD	mg/l	96	90	90	92
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.65	0.67	0.67	0.73
13	Phosphate	mg/l	0.22	0.21	0.19	0.2
14	Sulphate	mg/l	2100	2172	2628	2580
15	Nitrate	mg/l	5	4.86	5.07	4.93
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	721.44	761.52	521.04	480.96
18	Magnesium	mg/l	1579.5	1530.9	1701	1773.9
19	Sodium	mg/l	10145	10395	9831	9748
20	Potassium	mg/l	408.9	392.5	390.8	387.6
21	Iron	mg/l	0.84	0.13	1.12	0.46
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	0.02

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 35: Marine Water Quality Monitoring Parameters for location Nakti Creek Near NH-8A at Kandla

Sr. No.	Parameters	Unit	Nakti Creek Near NH-8A			
			23° 02'01"N 70° 09'31"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	31.9	Sampling not possible during Low Tide	31.0	Sampling not possible during Low Tide
2	Color	-	Colorless		Colorless	
3	Odor	-	Odorless		Odorless	
4	Salinity	ppt	20.8		18.1	
5	Turbidity	NTU	41		40	
6	Total Dissolved Solids	mg/l	25179		21035	
7	Total Suspended Solids	mg/l	614		678.5	
8	Total Solids	mg/l	25810		21812	
9	DO	mg/l	4.3		4.5	
10	COD	mg/l	98		96	
11	BOD	mg/l	BQL		BQL	
12	Silica	mg/l	0.82		0.85	
13	Phosphate	mg/l	0.21		0.21	
14	Sulphate	mg/l	2340		2376	
15	Nitrate	mg/l	5.07		4.65	
16	Nitrite	mg/l	BQL		BQL	
17	Calcium	mg/l	641.28		641.28	
18	Magnesium	mg/l	1676.7		1725.3	
19	Sodium	mg/l	10517		9631	
20	Potassium	mg/l	408		375.6	
21	Iron	mg/l	1.38		1.07	
22	Chromium	mg/l	BQL		BQL	
23	Copper	mg/l	BQL		BQL	
24	Arsenic	mg/l	BQL		BQL	
25	Cadmium	mg/l	BQL		BQL	
26	Mercury	mg/l	BQL		BQL	
27	Lead	mg/l	BQL		BQL	
28	Zinc	mg/l	BQL		0.02	

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 36: Marine Water Quality Monitoring Parameters for locations Nr. Vadinar Jetty

Sr. No.	Parameters	Unit	Nr.Vadinar Jetty			
			22°26'25.26"N 69°40'20.41"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.42	7.38	7.45	7.39
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31.4	31.9	31.6	32.0
5	Turbidity	NTU	42	40	42	43
6	Total Dissolved Solids	mg/l	29706	25972	22652	24202
7	Total Suspended Solids	mg/l	549	552	690.6	741.7
8	Total Solids	mg/l	30316	26601	23462	25105
9	DO	mg/l	4.5	4.6	4.6	4.7
10	COD	mg/l	60	62	68	66
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.69	0.75	0.93	0.89
13	Phosphate	mg/l	0.2	2520	0.22	0.2
14	Sulphate	mg/l	2652	2628	2508	2388
15	Nitrate	mg/l	4.15	3.94	3.17	2.89
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	601.2	521.04	561.12	601.2
18	Magnesium	mg/l	1652.4	1725.3	1798.2	1725.3
19	Sodium	mg/l	10598	10614	10236	10486
20	Potassium	mg/l	416.1	437	415.6	421.7
21	Iron	mg/l	BQL	BQL	BQL	BQL
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	0.13	BQL	BQL

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 37: Marine Water Quality Monitoring Parameters for locations Nr. Vadinar SPM

Sr. No.	Parameters	Unit	Nr.Vadinar SPM			
			22°30'56.15"N 69°42'12.07"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.4	7.38	7.44	7.4
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	32	31.9	31.8	32.2
5	Turbidity	NTU	36.0	40	44	46
6	Total Dissolved Solids	mg/l	24560.0	23452	24955	25966
7	Total Suspended Solids	mg/l	620	580	710	686
8	Total Solids	721.44	25240	24130	25721	26712
9	DO	mg/l	4.0	3.9	4.8	4.5
10	COD	mg/l	72.0	70	74.0	76
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.86	0.77	0.76	0.82
13	Phosphate	mg/l	0.3	0.28	0.33	0.36
14	Sulphate	mg/l	2777.0	2492	2622	2596
15	Nitrate	mg/l	5.86	6.22	4.86	4.92
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	660	580	729.46	713.42
18	Magnesium	mg/l	1594.08	1545.48	1550.34	1511.46
19	Sodium	mg/l	10868.0	10879.0	10527.0	10486
20	Potassium	mg/l	441.8	442.0	440.8	438.6
21	Iron	mg/l	BQL	BQL	BQL	BQL
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

8.2 Discussion of Marine water samples

Marine water quality of marine waters of Deendayal Port Harbor waters, Khori and Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each month. The Heavy metal analyzed and found below quantification limit

Similar BOD is also under the BQL as analyzed for 5 days.

9.0 Marine Sediments

Sediment samples were collected with Van Veen Grab from the six locations in Kandla Port Waters and two locations in Vadinar Port. Samples were collected and preserved in silver foil in ice box to prevent the contamination/decaying of the samples.

9.1 Results

The Sediment Quality results are given in below from table no. 38 & 39.

Table 38: Results of Analysis of Sediment of Kandla & Vadinar Port (Spring Tide)

Sr. No.	Parameters	Unit	KPT - 1	KPT - 2	KPT - 3	KPT - 4	KPT - 5	Jetty	SPM
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	1.59	3.53	1.26	1.36	0.9	5.5	6.95
3	Organic Carbon	mg/kg	0.92	2.05	0.73	0.79	0.52	3.19	4.03
4	Inorganic Phosphate	mg/kg	112	110	126	130	126	115	134
5	Moisture	%	7.08	26.95	9.48	3.72	10.4	9.89	6.89
6	Aluminium	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
7	Silica	mg/kg	8.00	8.80	10.30	9.60	7.80	8.20	9.06
8	Phosphate	mg/kg	2.58	BQL	1.41	3.29	3.83	BQL	0.93
9	Sulphate	mg/kg	443.16	670.92	360.39	157.33	327.68	864.14	1077.88
10	Nitrite	mg/kg	0.11	.10	0.11	0.12	.13	0.12	0.11
11	Nitrate	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
12	Calcium	mg/kg	228.46	220.44	184.37	192.38	156.31	244.49	256.51
13	Magnesium	mg/kg	36.45	143.37	38.88	31.59	51.03	148.23	196.83
14	Sodium	mg/kg	396.04	4929.97	344.61	288.9	438.5	1139.94	1448.75
15	Potassium	mg/kg	23.35	104.88	19.53	14.05	34.98	148.03	254.96
16	Chromium	mg/kg	11.3	19.1	3.7	6.6	20.3	17.2	16.3
17	Nickel	mg/kg	5.1	35.4	BQL	1.9	14.5	28.5	110.5
18	Copper	mg/kg	2.4	12.6	BQL	BQL	1.3	36.7	40.6
19	Zinc	mg/kg	8.3	49.4	4.2	5	22.9	61.9	58.9
20	Cadmium	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
21	Lead	mg/kg	1.9	4.8	1.3	1.8	4.7	16.1	BQL
22	Mercury	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
23	Arsenic	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL

*ND - Not Detected, BQL: Below Quantification Limit (NO3:10.0mg/kg, Cd: 1.0mg/kg, Hg: 1.0mg/kg, As: 1.0mg/kg).

Table 39 : Results of Analysis of Sediment of Kandla & Vadinar Port (Neap Tide)

Sr. No.	Parameters	Unit	KPT - 1	KPT - 2	KPT - 3	KPT - 4	KPT - 5	Jetty	SPM
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	1.59	3.53	1.26	1.36	0.9	5.5	6.95
3	Organic Carbon	mg/kg	0.92	2.05	0.73	0.79	0.52	3.19	4.03
4	Inorganic Phosphate	mg/kg	110	106	130	128	1269	117	130
5	Moisture	%	7.08	26.95	9.48	3.72	10.4	6.20	5.80
6	Aluminium	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
7	Silica	mg/kg	7.80	8.78	10.01	9.72	7.49	8.44	9.16
8	Phosphate	mg/kg	2.58	BQL	1.41	3.29	3.83	BQL	0.93
9	Sulphate	mg/kg	443.16	670.92	360.39	157.33	327.68	864.14	1077.88
10	Nitrite	mg/kg	0.12	0.11	0.13	0.12	0.11	0.10	0.11
11	Nitrate	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
12	Calcium	mg/kg	228.46	220.44	184.37	192.38	156.31	244.49	256.51
13	Magnesium	mg/kg	36.45	143.37	38.88	31.59	51.03	148.23	196.83
14	Sodium	mg/kg	396.04	4929.97	344.61	288.9	438.5	1139.94	1448.75
15	Potassium	mg/kg	23.35	104.88	19.53	14.05	34.98	148.03	254.96
16	Chromium	mg/kg	11.3	19.1	3.7	6.6	20.3	17.2	16.3
17	Nickel	mg/kg	5.1	35.4	BQL	1.9	14.5	28.5	110.5
18	Copper	mg/kg	2.4	12.6	BQL	BQL	1.3	36.7	40.6
19	Zinc	mg/kg	8.3	49.4	4.2	5	22.9	61.9	58.9
20	Cadmium	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
21	Lead	mg/kg	1.9	4.8	1.3	1.8	4.7	16.1	BQL
22	Mercury	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
23	Arsenic	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL

*ND - Not Detected, BQL: Below Quantification Limit (NO3:10.0mg/kg,Cd: 1.0mg/kg,Hg: 1.0mg/kg, As: 1.0mg/kg)

9.2 Discussion of Marine Sediment samples

Marine Sediments of Deendayal Port Harbor waters, Khori and Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each month. The Heavy metal analyzed and found below quantification limit.

The soil types is majority Sandy loamy. Also many of the parameters found below Quantification limit wise NO3, Cd, Hg, AS etc.

10.1 INTRODUCTION:

Sampling Stations:

The monitoring of marine environment for the study of biological and ecological Parameters was carried out on 03rdMarch 2022 in harbour region of DPT at Kandla Creek, and on 04thMarch 2022 in creeks near by the port during spring tide. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 25thMarch,2022 in harbour region of DPT at Kandla Creek and on 26th March, 2022 in creeks near by the port during neap tidal condition.

Plankton samples from sub surface layer was collected both during high tide period and low tide period from 3 water quality monitoring stations of KPT harbour area and two stations in Nakti creek and one station in Khori creek. Sampling at second sampling station of Nakti creek was possible only during high tide period. The same sampling schedule was repeated duringconsecutive Neap tide and spring tide in same month.

Plankton samples from sub surface layer were collected during high tide period and low tide period from monitoring station near Vadinar jetty at Path Finder Creek during spring tide on 03/03/2022 and Neap tide period on 10/03/2022. Collected water samples were processed for estimation of Chlorophyll- a, Pheophytin - a, qualitative & quantitative evaluation of phytoplankton, qualitative & quantitative evaluation zooplanktons(density and their population).

TABLE #1 SAMPLING LOCATIONS

monitoring requirement	Number of locations
Kandla creek Nakti creek Khori Creek Vadinar jetty SPM	3 in Kandla creek 2 in Nakti creek 1 in Khori creek 1 near Vadinar Jetty 1 near I stSPM
Total Number of locations	**8**

Sampling methodology adopted:

A marine sampling is an estimation of the body of information in the population. The theory of the sampling design is depending upon the underlying frequency distribution of the population of interest. The requirement for useful water

sampling is to collect a representative sample of suitable volume from the specified depth and retain it free from contamination during retrieval.

50 litres of the water sample were collected from Sub surface by using bucket. From the collected water sample 1 litres of water sample were taken in an opaque plastic bottle for chlorophyll estimation, thereafter plankton samples were collected by using filtration assembly with nilyobolt cloth of 20µm mesh size.

Samples Processing for chlorophyll estimation:

Samples for the chlorophyll estimation were preserved in ice box on board in darkness to avoid degradation in opaque container covered with aluminium foil. Immediately after reaching the shore after sampling, 1 litre of collected water sample was filtered through GF/F filters (pore size 0.45 µm) by using vacuum filtration assembly. After vacuum filtration the glass micro fiber filter paper was grunted in tissue grinder, macerating of glass fiber filter paper along with the filtrate was done in 90% aqueous Acetone in the glass tissue grinder with glass grinding tube. Glass fiber filter paper will assist breaking the cell during grinding and chlorophyll content was extracted with 10 ml of 90% Acetone, under cold dark conditions along with saturated magnesium carbonate solution in glass screw cap tubes. After an extraction period of 24 hours, the samples were transferred to calibrated centrifuge tubes and adjusted the volume to original volume with 90% aqueous acetone solution to make up the evaporation loss. The extract was clarified by using centrifuge in closed tubes. The clarified extracts were then decanted in clean cuvette and optical density was observed at wavelength 664, 665 nm. By using corrected optical density, Chlorophyll-a value was calculated as given in (APHA, 1998).

PLANKTON:

The entire area open water in the sea is the pelagic realm. Pelagic organisms live in the open sea. In contrast to the pelagic realm, the benthic realm comprises organisms and zone of the bottom of the sea. Vertically the pelagic realm can be dividing into two zones based on light penetration; upper photic or euphotic zone and lower dark water mass, aphotic zone below the photic zone.

The term plankton is general term for organisms have such limited powers of locomotion that they are at the mercy of the prevailing water movement. Plankton is subdivided to phytoplankton and zooplankton. Phytoplankton is free floating organisms that are capable of photosynthesis and zooplankton is the various free floating animals.

Pelagic zone, represents the entire ocean water column from the surface to the deepest depths, is home to a diverse community of organisms. Differences in their locomotive ability categorize the organisms in the pelagic realm into two, ***plankton*** and ***nekton*** (Lalli and Parsons, 1997). ***Plankton*** consists of all organisms drifting in the water and is unable to swim against water currents, whereas ***Nekton*** includes organisms having strong locomotive power. Ecological studies on the plankton community, which form the base of the aquatic food chain, help in the better understanding of the dynamics and functioning of the marine ecosystem. The term 'Plankton' first coined by Victor Hensen (1887), Plankton, (Greek word: *planktos* meaning "passively drifting or wandering") is defined as drifting or free-floating organisms that inhabit the pelagic zone of water. Based on their mode of nutrition planktonic organisms are categorised into phytoplankton (organisms having an autotrophic mode of nutrition) and zooplankton (organisms having a heterotrophic mode of nutrition).

Phytoplankton in the marine environment:

Phytoplankton is free floating unicellular, filamentous and colonial eutrophic organisms that grow in aquatic environments whose movement is more or less dependent upon water currents. These micro flora acts as primary producers as well as the basis of food chain, source of protein, bio purifier and bio indicators of the aquatic ecosystems of which diverse array of the life depends. They are considered as an important component of aquatic flora, play a key role in maintaining equilibrium between abiotic and biotic components of aquatic ecosystem.

The phytoplankton includes a wide range of photosynthetic and phototrophic organisms. Marine phytoplankton is mostly microscopic and unicellular floating flora, which are the primary producers that support the pelagic food-chain. The two most prominent groups of phytoplankton are diatoms (Bacillariophyceae) and dinoflagellates (Dinophyceae).The phytoplankton those normally captured in the net from the Gulf of Kutch is normally dominated by these two major groups; diatoms and dinoflagellates. Phytoplankton also include numerous and diverse collection of extremely small, motile algae which are termed micro flagellates (naked flagellates) as well as and Cyanophytes (blue-green algae).

Algae are an ecologically important group in most aquatic ecosystems and have been an important component of biological monitoring programs. Algae are ideally suited for water quality assessment because they have rapid reproduction

rates and very short life cycles, making them valuable indicators of short-term impacts.

Aquatic populations are impacted by anthropogenic stress, resulting in a variety of alterations in the biological integrity of aquatic systems. Algae can serve as an indicator of the degree of deterioration of water quality, and many algal indicators have been used to assess environmental status.

Zooplankton in the marine environment:

Zooplankton includes a taxonomically and morphologically diverse community of heterotrophic organisms that drift in the waters of the world's oceans. Qualitative and quantitative studies on zooplankton community are a prerequisite to delineate the ecological processes active in the marine ecosystem. Zooplankton community plays a pivotal role in the pelagic food web as the primary consumers of phytoplankton and act as the food source for organisms in the higher trophic levels, particularly the economically essential groups such as fish larvae and fishes. They also function in the cycling of elements in the marine ecosystem. The dynamics of the zooplankton community, their reproduction, and growth and survival rate are all significant factors determining the recruitment and abundance of fish stocks as they form an essential food for larval, juvenile and adult fishes (Beaugrand et al., 2004). Zooplankton grazing in the marine environment controls the primary Production and helps in determining the pelagic ecosystem (Banse, 1995). Through grazing in surface waters and following the production of sinking faecal matters and also by the active transportation of dissolved and particulate matter to deeper waters via vertical migration, they help in the transport of organic carbon to deep ocean layers and thus act as key drivers of biological pump in the marine ecosystem. Zooplankton grazing and metabolism also, transform particulate organic matter into dissolved forms, promoting primary producer community, microbial demineralization, and particle export to the ocean’s interior.

The categorisation of zooplankton into various ecological groups is based on several factors such as duration of planktonic life, size, food preferences and habitat. As they vary significantly in size from microscopic to metazoic forms, the classification of zooplankton based on size has paramount importance in the field of quantitative plankton research.

Based on the duration of planktonic life, zooplankton are categorised into Holoplankton (organisms which complete their entire lifecycle as plankton) and Meroplankton (organisms which are planktonic during the early part of their lives

such as the larval stages of benthic and nektonic organisms). Tychoplankton are organisms which live a brief planktonic life, such as the benthic crustaceans (Cumaceans, mysids, isopods) which ascend to the water column at night for feeding and certain ectoparasitic copepods, they leave the host and spend their life as plankton during their breeding cycle.

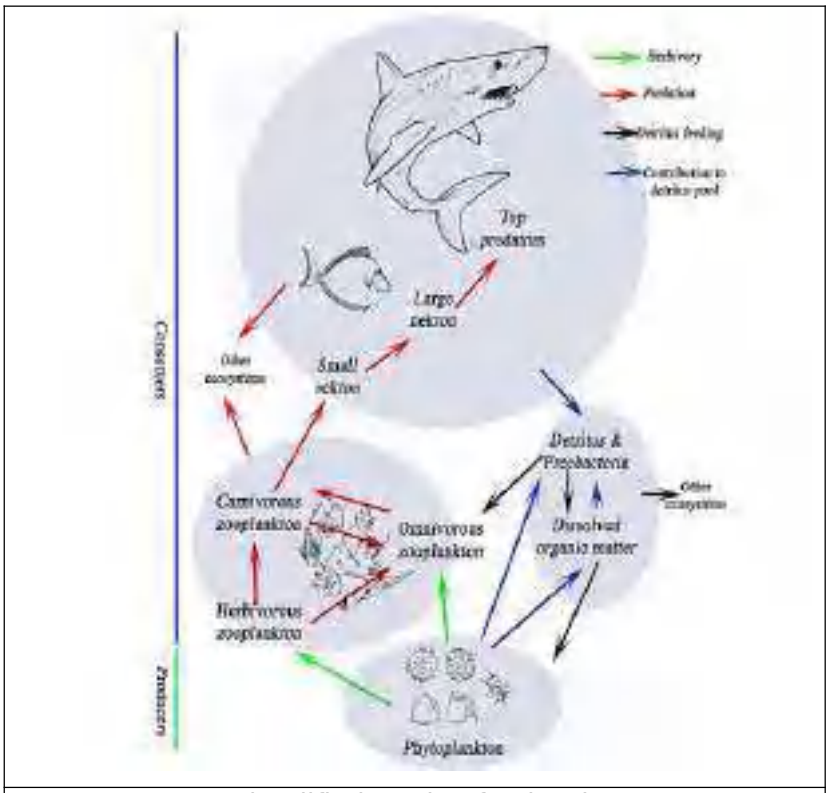
Zooplankton can be subdivided into holoplankton, i.e., permanent members of the plankton (e.g., Calanoid copepods), and meroplankton, i.e., temporary members in the plankton e.g., larvae of fish, shrimp, and crab). The meroplankton group consists of larval and young stages of animals that will adopt a different lifestyle once they mature. In contrast to phytoplankton which consist of a relatively smaller variety of organisms, Zooplankton are extremely divers, consist of a host of larval and adult forms representing many animal phylum.

Among the zooplankton one group always dominate than others; members of sub class copepods (Phylum Athropoda) and Tintinids (Phylum Protozoa) among the net planktons. These small animals are of vital importance in marine ecosystem as one of the primary herbivores animals in the sea, and it is they provide vital link between primary producer (autotrophs) and numerous small and large marine consumers.

As their community structure and function are highly susceptible to changes in the environmental conditions regular monitoring of their distribution as well as their interactions with various physicochemical parameters is inevitable for the sustainable management of the ecosystem (Kusum et al., 2014). Of all the marine zooplankton groups, copepods mainly Calanoid copepods are the dominant groups in marine subtropical and tropical waters and exhibit considerable diversity in morphology and habitats they occupy (Madhupratap, 1991;)

It has been well established that potential of pelagic fishes viz. finfishes, crustaceans, molluscs and marine mammals either directly or indirectly depend on zooplankton. The herbivorous zooplankton is efficient grazers of the phytoplankton and is referred to as living machines transforming plant material into animal tissue. Hence they play an essential role as the intermediaries for nutrients/energy transfer between primary and tertiary trophic levels. Due to their large density, shorter lifespan, drifting nature, high group/species diversity and different tolerance to the stress, they used as the indicator organisms for the

physical, chemical and biological processes in the aquatic ecosystem (Ghajbhiye, 2002).



Simplified marine food web

Spatial distribution of Plankton:

A characteristic of plankton population is that they tend to occur in patches, which are varying spatially on a scale of few meters to far as few kilometers in distance. They also vary in time scale, season as well as vertically in the water column. It is this patchiness and its constant changes in time and spot, that has made it so difficult for plankton biologist to learn about the ecology of plankton. The biological factors that causes this patchiness is due to the ability of zooplankton to migrate vertically and graze out the phytoplankton at a rapid rate that can create patchiness. Similarly the active swimming ability by certain zooplankton organisms can cause to aggregate in dense group.

At its most extreme, because the water in which plankton is suspended is constantly moving, each sample taken by the plankton biologists remain a different volume of water, so each sample is unique and replicate does not exist.

Plankton may also exhibit vertical patchiness. Physical factors contribute to this type of patchiness include light intensity, nutrients and density gradients in the water column.

Phytoplankton in particular tends to be unequally distributed vertically, which leads to the existence of different concentration of a chlorophyll value between photic zone and below the photic zone.

Methodology adopted for Plankton sampling:

Mixed plankton sample were obtained from the sub surface layer at each sampling locations by towing the net horizontally with the weight. After the tow of about 15-30minutes, plankton net was pulled up and washed down to the tail and collected the plankton adhered to plankton net in the collection bucket at the bottom by springing outer and inner surface of the net with sea water, while the net was hanging with the mouth upward. For quantitative evaluation 50 L water samples were collected from subsurface layer and filtered through 20µm mesh size net by using bucket and filtration assembly.

Preservation and storage:

Both filtered plankton and those collected from the plankton net were preserved with 5% buffered formalin and stored in 1L plastic container for further processing in the laboratory.

Sample concentration:

The collected plankton samples were concentrated by using centrifuge and made up to 50 ml with 5% formalin -Glycerine mixture.

Taxonomic evaluation:

Before processing, the sample was mixed carefully and a sub sample was taken with a calibrated Stempel-pipette. 1 ml of the concentrated plankton samples were transferred on a glass slide with automatic pipette. The plankton sample on the glass slides were stained by using Lugol's iodine and added glycerine to avoid drying while observation. The plankton samples were identified by using Labex triangular Research microscope with photographic attachment. Microphotographs of the plankton samples were taken for record as well as for confirming the identification. The bigger sized zooplankton was observed through dissecting stereomicroscope with magnification of 20-30 x. Plankton organisms in the whole slide were identified to the lowest axon possible. A thorough literature search was conducted for the identification of the different groups of zooplankton that were encountered

Cell counts by drop count method:

The common glass slide mounted with a 1ml of concentrated phytoplankton/zooplankton sample in glycerol and covered with cover slip 22 x 60mm was placed under the compound microscope provided with a mechanical

stage. The plankton was then counted from the microscopic field of the left top corner of the slide. Then slide is moved horizontally along the right side and plankton in each microscopic field was thus counted. When first microscopic field row was finished the next consecutive row was adjusted using the mechanical device of the stage. In this way all the plankton present in entire microscopic field are counted. From this total number in 1ml of the concentrated plankton, total number of plankton in the original volume of sample filtered was calculated as units/L.

BENTHIC ORGANISMS:

Benthos is those organisms that are associated with the sea bed or benthic habitats. Epi- benthic organisms live attached to a hard substratum or rooted to a shallow depth below the surface. In fauna organisms live below the sediment–water interface. Interstitial organisms live and move in pore water among sedimentary grains.

Because the benthic organisms are often collected and separated on sieves, a classification based on the overall size is used. Macro benthos include organisms whose shortest dimension is greater than or equal to 0.5 mm. Meio benthos are smaller than 0.5mm but larger than 42µ in size.

The terms such as macro fauna and Meio fauna generally have little relevance with taxonomic classification. The terms Meio fauna and macro fauna depend on the size. Meio fauna were considered as good bioassay of community health and rather sensitive indicators of environmental changes.

SAMPLING METHODOLOGY ADOPTED FOR SUB TIDAL REGION:

Van veen sampler ($0.09m^2$) was used for sampling bottom sediments. Two sets of sediments were sampled from each location, one for macro fauna and other for Meio fauna. The macro fauna in the sediments were sieved on board to separate out the organisms. The fixation of Meio fauna is normally done by bulk fixation of the sediment sample. The bulk fixation is done by using 10% formalin (Buffered with borate). The organisms were preserved with seawater as diluting agent.

Sample sieving:

Sediments samples were sieved to extract the organisms. Sieving was performed carefully as possible to avoid any damage to the animals. The large portion of the sediment was split in to smaller portions and mixed with sea water in a bucket. The cohesive lumps were broken down by continuous stirring. The dis-aggregated sediments were then passed through the sieves.

Sample staining:

Sorting of the Meio fauna from the sieve is difficult task especially in the preserved material, because organisms are not easily detectable. To facilitate the animal detection the entire sample retained on the sieve after sieving operation were stained by immersing the sieve in a flat bottom tub with 1% Rose Bangal stain; a protein stain. A staining period of 10-30 minutes is sufficient for sample detection.

DIVERSITY INDICES:

On the whole, diversity indices provide more information about community composition than simply species richness (number of species present); they also, take the relative abundances of different species into account. Based on this fact, diversity indices therefore depend not only on species richness but on the evenness, or equitability, with which individuals are distributed among the different species (Magurram, A.E. (1988).

A diversity index is a measure of species diversity within a community that consists of co-occurring populations of several (two or more) different species. It includes two components: richness and evenness. Richness is the measure of the number of different species within a sample showing that more the types of species in a community, the higher is the diversity or greater is the richness. Evenness is the measure of relative abundance of the different species within a community.

The basic idea of diversity index is to obtain a quantitative estimate of biological variability that can be used to compare biological entities composed of discrete components in space and time (Carol H.R. *etal*. 1998). Biodiversity is commonly expressed through indices based on species richness and species abundances (Whittaker 1972, Lande 1996, Purvis and Hector 2000). Biodiversity indices are a non-parametric tool used to describe the relationship between species number and abundance. The most widely used bio diversity indices are Shannon Weiner index and Simpson’s index.

A diversity Index is a single statistic that incorporates in formation on richness and evenness. The diversity measures that incorporate the two concepts may be termed heterogeneity measures (Magurran, 2004).

Any study intended to interpret causes and effect of adverse impact on Biodiversity of communities require suitable measures to evaluate specie richness and Diversity. The former is number of species in community, while latter is a function of relative frequency of different species. Species richness is

the iconic measure of biological diversity (Magurran, 2004). Several indices have been created to measure the diversity of species; however, the most widely used in the last decades are the Shannon (1948) and Simpson (1949) (Buzas and Hayek 1996; Gorelick 2006), with the components of diversity: richness (*S)* and evenness (*J)*

Simpson's diversity index

Simpson's index (**D**) is a measure of diversity, which takes into account both species richness, and evenness of abundance among the species present. The Simson index is one of the meaningful and robust biodiversity measures available.(Magurran ,2004).

Low species diversity suggests:

Relatively few successful species in the habitat

The environment is quite stressful with relatively few ecological niches and only a few organisms are really well adapted to that environment

Food webs which are relatively simple

Change in the environment would probably have quite serious effects

High species diversity suggests:

A greater number of successful species and a more stable ecosystem

More ecological niches are available and the environment is less likely to be hostile complex food webs

Environmental change is less likely to be damaging to the ecosystem as a whole

Species richness indices

The species richness***(S)*** is simply the number of species present in an ecosystem. Species richness Indices of species richness are widely used to quantify or monitor the effects of anthropogenic disturbance. A decline in species richness may be concomitant with severe or chronic human-induced perturbation (Fair Fair weather 1990,) Species richness measures have traditionally been the mainstay in assessing the effects of environmental degradation on the biodiversity of natural assemblages of organisms (Clarke &Warwick, 2001)

Species richness is the iconic measure of biological diversity (Magurran, 2004). The species richness ***(S)*** is simply the number of species present in an ecosystem. This index makes no use of relative abundances. The term species richness was coined by McIntosh (1967) and oldest and most intuitive measure of biological diversity (Magurran, 2004).

Margalef's diversity index is a species richness index. Margalef's Species richness index (d), or indices that describe the evenness of the distribution of the numbers of individuals among species, were derived.

The value of a diversity index increases both when the number of types increases and when evenness increases. For a given number of types, the value of diversity index is maximized when all types are equally abundant (Rosenzweig, M. L. (1995).

Shannon-Wiener's index:

An index of diversity commonly used in plankton community analyses is the Shannon-Wiener's index **(H),** which emphasizes not only the number of species (richness or variety), but also the apportionment of the numbers of individuals among the species (Odum 1971 and Reish 1984). Shannon-Wiener's index **(H**) reproduces community parameters to a single number by using an equation.

$$H' = -\sum_{j=1}^{s} \frac{n_j}{N} \ln\left(\frac{n_j}{N}\right)$$

Shannon and Weiner index represents entropy. It is a diversity index taking into account the number of individuals as well as the number of taxa. It varies from 0 for communities with only single taxa to high values for community with many taxa each with few individuals. This index can also determine the pollution status of a water body. Normal values range from 0 to 4. This index is a combination of species present and the evenness of the species. Examining the diversity in the range of polluted and unpolluted ecosystems, Wilham and Dorris (1968) concluded that the values of the index greater than 3 indicate clean water, values in the range of 1 to 3 are characterized by moderate pollution and values less than 1 are characterized as heavily polluted

10.2 RESULTS:

CHLOROPHYLL-a:

Water Samples for the chlorophyll estimation were collected from sub surface layer during high tide and low tide period of the tidal cycle for each sampling

locations and analysed for Chlorophyll - a and after acidification for Pheophytin – a. Chlorophyll - a value was used as algal biomass indicator (APHA,1998). Algal biomass was estimated by converting Chlorophyll value.

In the sub surface water chlorophyll-a was varying from 0.884 - 1.356 mg/m^3 with an average value 1.038 mg/m^3 of in harbour region of DPT in Kandla Creek during sampling done in spring tide period of March 2022. In the nearby creeks chlorophyll-a was varying from 0.662- 1.104mg/m^3 with an average value 0.853 mg/m^3. Pheophytin – a level was below detectable limit- the all the sampling stations during spring tide.

In the sub surface water chlorophyll-a was varying from 0.308 - 0.866mg/m^3 with an average value 0.516mg/m^3. In harbour region of DPT in Kandla Creek during sampling done in neap tide period of March 2022. In the nearby creeks chlorophyll-a was varying from 0.271 - 0.661mg/m^3 with an average value 0.482mg/m^3.· Pheophytin –a level was below detectable limit- the all the sampling stations.

In the sub surface water chlorophyll-a was varying from 0.662 - 1.104mg/m^3 with an average value 0.852mg/m^3. In harbour region of DPT OOT in path finder Creek during sampling done in spring tide period of March 2022. In the sub surface water chlorophyll-a was varying from 0.101 - 0.307 mg/m^{3}with an average value 0.237 mg/m^3. In harbour region of DPT OOT in path finder Creek during sampling done in Neap Tide period of March 2022.

TABLE 40 VARIATIONS IN CHLOROPHYLL –a PHEOPHYTIN- a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPT HARBOUR AREA IN KANDLA CREEK ,NEAR BY CREEKS AND DPT OOT JETTY IN PATH FINDER CREEK AND SPM NEAR VADINARDURING SPRING TIDE IN MARCH 2022

Sr.No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPT HARBOUR AREA KANDLA CREEK					
1	KPT1	High tide	1.356	BDL	90.85
		Low tide	0.898	BDL	60.16
2	KPT 2	High tide	0.984	BDL	65.93
		Low tide	1.207	BDL	80.87
3	KPT 3	High tide	0.884	BDL	59.23
		Low tide	0.899	BDL	60.23
CREEKS					
4	KPT-4 Khori-I	High tide	1.104	BDL	73.96
		Low tide	0.748	BDL	50.12
5	KPT-5 Nakti-I	High tide	0.748	BDL	50.12
		Low tide	1.000	BDL	67.0
6	KPT-6 Nakti-II	High tide	0.662	BDL	44.35
PATHFINDER CREEK VADINAR					
7	VADINAR-I jetty	High tide	0.409	BDL	27.40
8		Low tide	0.203	BDL	13.60
9	SPM	High tide	0.458	BDL	30.69
10	SPM	Low tide	0.406	BDL	27.20

BDL: Below Detectable Limit.

TABLE 41 VARIATIONS IN CHLOROPHYLL –a PHEOPHYTIN- a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPT HARBOUR AREA, NEAR BY CREEKS AND DPT OOT JETTY IN PATH FINDER CREEK AND SPM NEAR VADINARDURING NEAP TIDE IN MARCH 2022

Sr.No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPT HARBOUR AREA KANDLA CREEK					
1	KPT1	High tide	0.425	BDL	28.47
		Low tide	0.424	BDL	28.41
2	KPT 2	High tide	0.747	BDL	50.05
		Low tide	0.308	BDL	20.64
3	KPT 3	High tide	0.866	BDL	58.02
		Low tide	0.322	BDL	21.57
CREEKS					
4	KPT-4 Khori-I	High tide	0.660	BDL	44.22
		Low tide	0.425	BDL	28.47
5	KPT-5 Nakti-I	High tide	0.527	BDL	35.31
		Low tide	0.527	BDL	35.31
6	KPT-6 Nakti-II	High tide	0.271	BDL	18.16
PATHFINDER CREEK VADINAR					
7	VADINAR-I Jetty	High tide	0.306	BDL	20.50
8		Low tide	0.306	BDL	20.50
9	SPM	High tide	0.236	BDL	15.81
10	SPM	Low tide	0.101	BDL	6.76

BDL: Below Detectable Limit.

PHYTOPLANKTON POPULATION:

For the evaluation of the Phytoplankton population in DPT harbour area and within the immediate surroundings of the port, sampling was conducted from 5 sampling locations (3 in harbour area and two in Nakti creek) during high tide period and low tide period of spring tide and neap tide.

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by Diatoms, blue green algae and dinoflagellates during spring tide period. Diatoms were represented by 25 genera. Blue green were represented by 3 genera and dinoflagellates were represented by 4 genera

during the sampling conducted in spring tide in March, 2022. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 74-267 units/ L during high tide period and 169-233 units/ L during low tide of Spring Tide.

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by Diatoms, Blue green algae and Dinoflagellates during Neap tide period. Diatoms were represented by 28 genera Blue green algae were represented 4 genera and dinoflagellates with 4 genera during the sampling conducted in Neap tide in March, 2022. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from251-326 units/ L during high tide period and 214-246 units/ L during low tide of Neap Tide.

For the evaluation of the Phytoplankton population in DPT OOT jetty area in Path Finder creek sampling was conducted from two sampling locations ;jetty area during high tide period and low tide of spring tide and Neap tide period.

The phytoplankton community of the sub surface water in the path finder creeks was represented by Diatoms, Blue green anlage and Dinoflagellates during spring tide period.Diatoms were represented by 24 genera, Blue Green algae by 2 genera and Dinoflagellates 4 genera each during the sampling conducted in spring tide in March, 2022. Phytoplankton of the sampling stations at sub surface layer in the harbour area was varying from 188 units/ L during high tide period and 106units/ L during low tide of Spring Tide. Phytoplankton of the sampling stations at sub surface layer in the SPM area was varying from 192 units/ L during high tide period and 158 units/ L during low tide of Spring Tide.

The phytoplankton community of the sub surface water in the path finder creeks was represented by Diatoms, Blue green and Dinoflagellates during Neap tide period. Diatoms were represented by 28 genera and Blue green algae 4 genera and dinoflagellates by 4 genera each during the sampling conducted in Neap tide in March, 2022. Phytoplankton of the sampling stations at sub surface path finder creek near OOT Jetty was varying from 224- units/ L during high tide period and 219units/ L during low tide of Neap Tide. Phytoplankton of the sampling stations at sub surface path finder creek near SPM area was varying from 167 units/ L during high tide period and 127 units/ L during low tide of Neap Tide.

Species Richness Indices and Diversity Indices: Margalef's diversity index (Species Richness)S

At the organism level, the most widely used biodiversity measures are those based on the number of species present, perhaps adjusted for the number of individuals sampled, Here Margalef's Species richness index (d), or indices that describe the evenness of the distribution of the numbers of individuals among species, are derived.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek and nearby creeks sampling stations was varying from 3.02-5.018 with an average of 4.216 during the sampling conducted in High tide period of spring tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek region and nearby creeks was varying from 3.884 - 4.801 with an average of 4.474 during the consecutive low tide period.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations in Kandla creek and nearby creeks was varying from 3.979 - 5.791 with an average of 4.772 during the sampling conducted in High tide period of Neap tide. While Margalef's diversityindex (Species Richness) S of phytoplankton communities in the Kandla creek region and nearby creeks was varying from3.996 - 5.495 with an average of 4.795 during consecutive low tide.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations was 4.583 at OOT jetty area and 4.375 at SPM area during the sampling conducted in High tide period of spring tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the path finder creek near OOT jetty was 4.718 and 3.753 at SPM during the consecutive low tide period.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations was 3.935 at OOT jetty area and 3.411at SPM area during the sampling conducted in High tide period of Neap tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the path finder creek near OOT jetty was 4.014 and SPM area was 3.823 during the consecutive low tide period.

Shannon-Wiener's index:

Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.978- 1.084 (H'(log10)) between selected sampling stations with an average value of 1.032 during high tide period of spring tide at Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.979-1.148 (H'(log10)) between selected sampling stations with an average value of 1.040 during consecutive low tide at Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.818-1.146 (H'(log10)) between selected sampling stations with an average value of 0.958 during high tide period of neap tide at Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.918-1.054(H'(log10)) between selected sampling stations with an average value of 1.009 during consecutive low tide at Kandla creek and nearby creeks.

Shannon-Wiener's Index (H) of phytoplankton communities in the stations was 1.012at OOT jetty area and 0.9759at SPM area during the sampling conducted in High tide period of spring tide. While Shannon-Wiener's Index (H) of phytoplankton communities in the path finder creek near OOT jetty was 1.058 and 0.898 at SPM during the consecutive low tide period.

Shannon-Wiener's Index (H) of phytoplankton communities in the stations was 0.9852 at OOT jetty area and 1.183 at SPM area during the sampling conducted in High tide period of Neap tide. While Shannon-Wiener's Index (H) of phytoplankton communities in the path finder creek near OOT jetty was 1.009and at SPM area was1.154 during the consecutive low tide period.

Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon-Wiener's index increases as both the richness and the evenness of the community increase. This result indicates that diversity of phytoplankton of Kandla Harbour region and nearby creeks is less but with abundant population of few, with relatively few ecological niches and only very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson's diversity index:

Simpson's index (D) is a measure of diversity, which takes into account both species richness, and an evenness of abundance among the species present. The Simson index is one of the meaningful and robust biodiversity measures available. (Magurran,2004).

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stationsin the Kandla Harbour region and nearby creeks, which was varying from 0.840- 0.886 between selected sampling stations with an average of 0.855 during high tide period of spring tide. Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stationsin the Kandla Harbour region and nearby creeks except few, which was varying from 0.823-0.883 between selected sampling stations with an average of 0.846 during consecutive low tide.

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations except few in Kandla Harbour region and nearby creeks, during high tide period and low tide period during neap tide also, which was varying from 0.732-0.874 with an average value of 0.806 between selected sampling stations during high tide period and 0.7982-0.8571varying from with an average value of 0.836 between selected sampling stations during consecutive low tide period Low species diversity suggests a relatively few successful species in this habitat.

Simpson diversity index (1-D) of phytoplankton communities in the stations was 0.822 at OOT jetty area and0.826 at SPM area during the sampling conducted in High tide period of spring tide at Path finder creek. While Simpson diversity index (1-D) of phytoplankton

communities in the path finder creek near OOT jetty was 0.842and 0.803at SPM during the consecutive low tide period in the path finder creek.

Simpson diversity index (1-D) of phytoplankton communities in the stations was 0.763 at OOT jetty area and 0.882 at SPM area during the sampling conducted in High tide period of Neap tide at Path finder Creek. While Simpson diversity index (1-D) of phytoplankton communities in the path finder creek near OOT jetty was 0.760and at SPM area was 0.869during the consecutive low tide period.

Low species diversity suggests a relatively few successful species in this habitat. The environment is quite stressful with relatively few ecological niches and only

a few organisms are really well adapted to that environment. Any change in the environment would probably have quite serious effects.

Table 42 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND, NEAR BY CREEKS DURING SPRING TIDE IN MARCH 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	265	29/32	90.62	5.018	1.062	0.8468
	2	226	25/32	78.12	4.428	1.076	0.8713
	3	207	26/32	81.25	4.688	1.084	0.844
	4	238	25/32	78.12	4.386	1.006	0.8407
	5	267	22/32	68.75	3.759	0.988	0.8427
	6	74	14/32	43.75	3.02	0.9788	0.8863
LOW TIDE	1	228	27/32	84.38	4.789	1.047	0.8534
	2	225	27/32	84.38	4.801	0.9924	0.8235
	3	233	24/32	75	4.219	1.037	0.8381
	4	169	25/32	78.12	4.678	1.148	0.8838
	5	223	22/32	68.75	3.884	0.9797	0.8331

Table 43 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND, NEAR BY CREEKS DURING NEAP TIDE IN MARCH 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	251	33/35	94.28	5.791	1.146	0.8749
	2	289	29/35	82.85	4.941	1.019	0.8467
	3	326	27/35	77.14	4.493	0.8189	0.7327
	4	266	27/35	77.14	4.657	0.9452	0.7852
	5	252	23/35	65.71	3.979	0.8657	0.7944
	6	86	14/35	40	2.918	0.7864	0.7674
LOW TIDE	1	246	28/35	80	4.904	1.007	0.8276
	2	214	27/35	77.14	4.845	1.045	0.8571
	3	235	31/35	88.57	5.495	1.054	0.8493
	4	243	27/35	77.14	4.733	1.024	0.8495
	5	246	23/35	65.71	3.996	0.9186	0.7982

Table 44 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND, NEAR BY CREEKS DURING SPRING TIDE IN MARCH 2022

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	DIATOMS	71-251	25/32	78.15
			BLUE GREEN	2-9	3/32	9.35
			DINOFLAGELLATES	1-11	4/32	12.5
			TOTAL PHYTO PLANKTON	74-267	32	-
LOW TIDE	Sub surface	5	DIATOMS	148-221	25/32	78.15
			BLUE GREEN	3-8	3/32	9.35
			DINOFLAGELLATES	1-11	4/32	12.5
			TOTAL PHYTO PLANKTON	169-233	32	-

Table 45 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND, NEAR BY CREEKS DURING NEAP TIDE IN MARCH 2022

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	DIATOMS	86-317	28/35	80
			BLUE GREEN	0-7	3/35	8.57
			DINOFLAGELLATES	0-9	4/35	11.43
			TOTAL PHYTO PLANKTON	86-323	35	-
LOW TIDE	Sub surface	5	DIATOMS	207-232	28/35	28/35
			BLUE GREEN	2-11	3/35	3/35
			DINOFLAGELLATES	1-4	4/35	4/35
			TOTAL PHYTO PLANKTON	212-243	35	35

Table 46 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT OOT AT PATH FINDER CREEK , VADINAR &NEAR BY SPM, DURING SPRING TIDE IN MARCH 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	jetty	188	25/30	83.33	4.583	1.012	0.8229
	SPM	192	24/30	80	4.375	0.9759	0.826
LOW TIDE	jetty	106	23/30	76.66	4.718	1.058	0.8429
	SPM	158	20/30	66.66	3.753	0.898	0.8039

Table 47 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING NEAP TIDE IN MARCH 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	224	36/36	100	6.468	0.9852	0.763
	SPM	167	31/36	86.11	5.862	1.183	0.8816
LOW TIDE	Jetty	219	33/36	91.66	5.938	1.009	0.7601
	SPM	127	28/36	77.77	5.574	1.154	0.8699

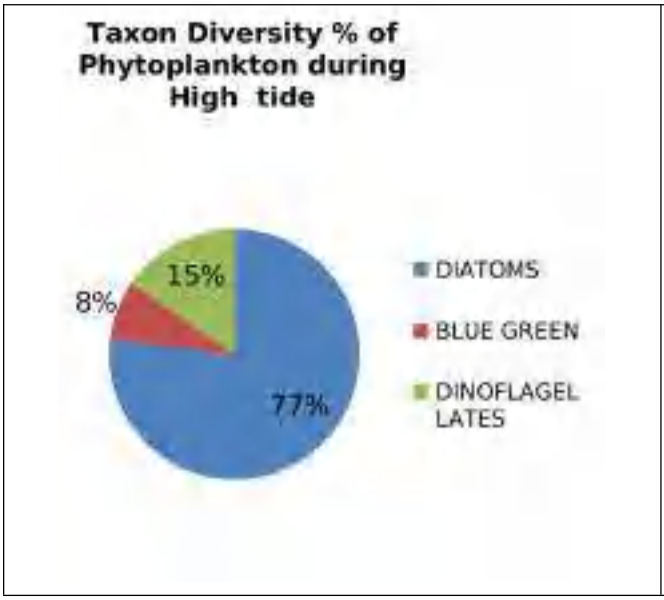
Table 48 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPTDPT OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING SPRING TIDE IN MARCH 2022

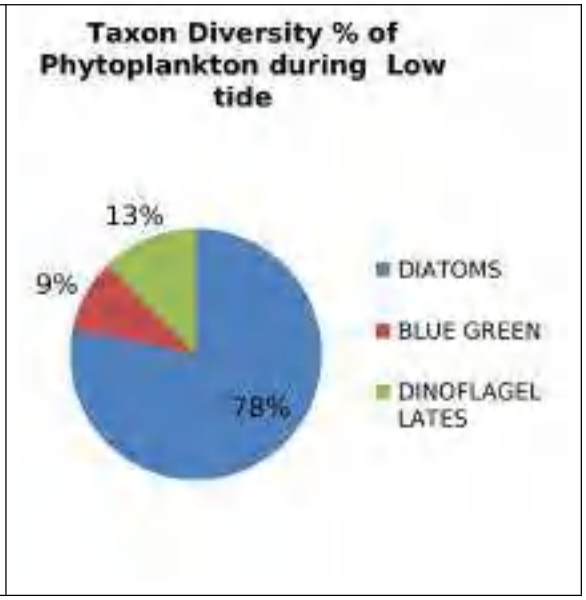
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	BLUE GREEN	0-6	2/30	6.67
			DIATOMS	176-185	24/30	80
			DINOFLAGELLATES	6-7	4/30	13.33
			TOTAL PHYTO PLANKTON	188-192	30	
LOW TIDE	Sub surface	2	BLUE GREEN	1-2	2/30	6.67
			DIATOMS	100-155	24/30	80
			DINOFLAGELLATES	1-5	4/30	13.33
			TOTAL PHYTO PLANKTON	106-158	30	

Table 49 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPTDPT OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING NEAP TIDE IN MARCH 2022

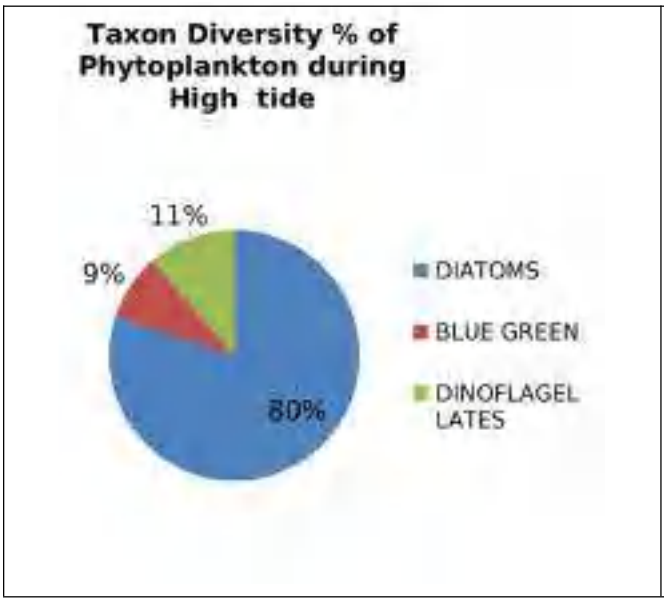
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	BLUE GREEN	8-12	4/36	11.11
			DIATOMS	147-210	28/36	77.78
			DINOFLAGELLATES	6-8	4/36	11.11
			TOTAL PHYTO PLANKTON	167-224	36	
LOW TIDE	Sub surface	2	BLUE GREEN	7-9	4/36	11.11
			DIATOMS	109-203	28/36	77.78
			DINOFLAGELLATES	7-11	4/36	11.11
			TOTAL PHYTO PLANKTON	127-219	36	

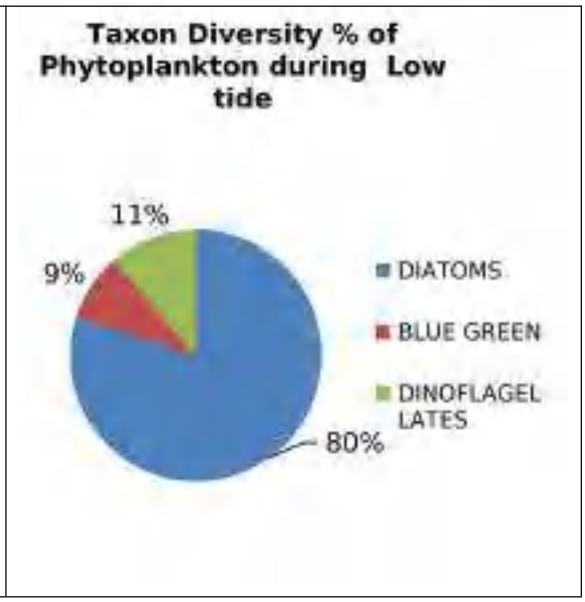
Taxon Diversity % of Phytoplankton during High tide and Low tide period during spring tide in Kandala creek and nearby creeks



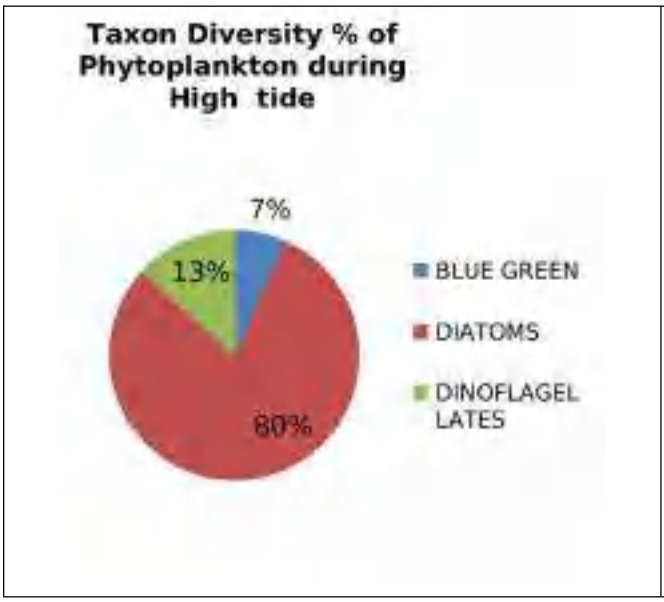


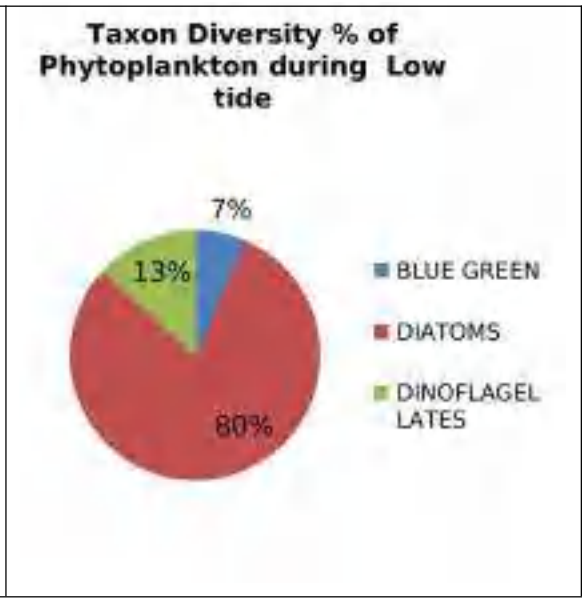
Taxon Diversity % of Phytoplankton during High tide and Low tide period during Neap tide in Kandala creek and nearby creeks



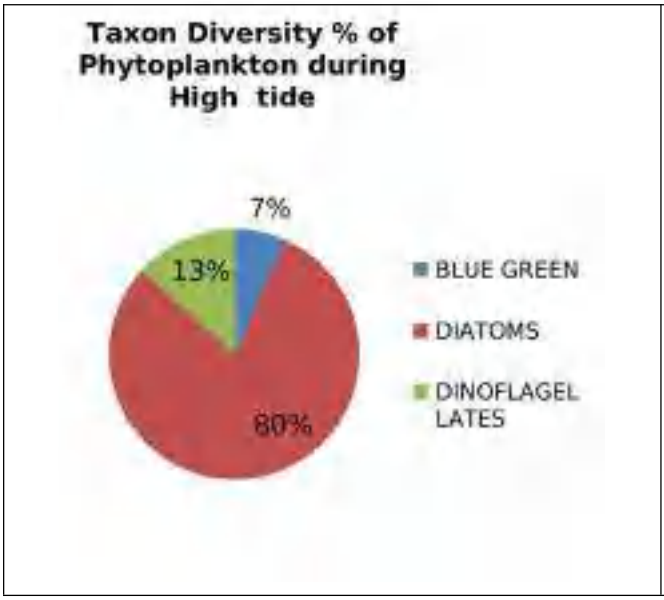


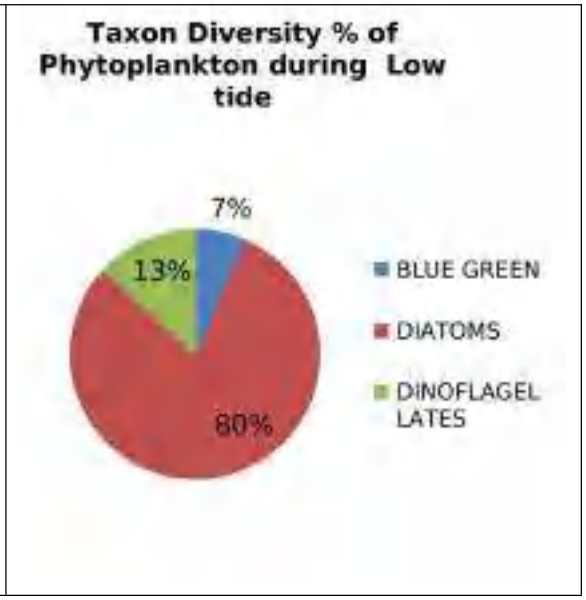
Taxon Diversity % of Phytoplankton during High tide and Low tide period during spring tide in Path Finder Creek, Vadinar





Taxon Diversity % of Phytoplankton during High tide and Low tide period during Neap tide in Path Finder Creek, Vadinar





ZOOPLANKTON POPULATION:

For the evaluation of the Zooplankton population in DPT harbour area and within the immediate surroundings of the port sampling was conducted from 6 sampling locations (3 in harbour area and two in Nakti creek and one in Khori creek) during high tide period and low tide period of spring tide and Neap tide in March, 2022. The Zooplankton community of the sub surface water in the harbour and nearby creeks during spring tide was represented by mainly 6 groups, and 8 larval forms; Tintinids, Copepods, Arrow worms, Mysids Urochordata, Foraminiferans, and 8 larval forms; The Zooplankton community of the sub surface water in the harbour and nearby creeks during neap tide was represented by mainly 7 groups, Tintinids, Copepods, Arrow worms, Mysids Urochordata, Hydroid Medusa and Foraminiferans and 8 larval forms

Zooplankton of the sampling stations at sub surface layer in the DPT harbour area and nearby creek was varying from 119-193 x10^3 N/ m^3 during high tide and 102-149 x10^3 N/ m^3 during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPT harbour area and nearby creek was varying from 159-233 x10^3 N/ m^3 during high tide and 132-183 x10^3 N/ m^3 during low tide of Neap Tide period.

For the evaluation of the Zooplankton population in DPT OOT jetty area in Path Finder creek and SPM in Vadinar selected 2 sampling locations (1 in jetty area and one near SPM) During spring tide sampling plankton sample were collected at Jetty area and near SPM during consecutive high tide period and low tide period. During Neap tide sampling Plankton samples were collected from jetty area and SPM during consecutive high tide period and low tide period.

The Zooplankton community of the sub surface water in the path finder creek creeks during spring tide was represented by mainly Titinids, Copepods, Arrow worms, Urochordata, Foraminiferans and 9 larval forms. The Zooplankton community of the sub surface water in the path Finder creeks at Jetty region and SPM during neap tide was represented by mainly four groups, Titinids, Copepods, Arrow worms, Urochordata, Foraminiferans and 8 larval forms, Zooplankton of the sampling stations at sub surface layer in the DPT OOTJetty area of path finder creek was 158 x10^3 N/ m^3 during high tide and 200 x10^3 N/ m^3 during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPT SPM area of path finder creek was 169 x10^3 N/ m^3 during high tide and 184x10^3 N/ m^3 during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPT OOT jetty area in path finder creek was recorded 129 x10^3 N/ m^3during high tide and 173 x10^3 N/ m^3 during consecutive low tide period of Neap. Zooplankton of the sampling stations at sub surface layer in the DPT SPM area in path finder creek was recorded 110 x10^3 N/ m^3 during high tide and 116 x10^3 N/ m^3 during consecutive low tide period of Neap Tide .

Species Richness Indices and Diversity Indices:

Margalef's diversity index (Species Richness)S

At the organismal level, the most widely used biodiversity measures are those based on the number of species present, perhaps adjusted for the number of individuals sampled, Here Margalef's Species richness index (d), or indices that describe the evenness of the distribution of the numbers of individuals among species, are derived.

Margalef's diversity index (Species Richness) S of Zooplankton communities in the stations Kandla creek region and nearby creeks was varying from 3.976-6.093 with an average of 4.924 during the sampling conducted in High tide period. Margalef's diversity index (Species Richness) S of Zooplankton communities varying from 3.459-5.112 with an average of 4.384 during the sampling conducted in low tide period during Spring tide.

Margalef's diversity index (Species Richness) S of Zooplankton communities in the Kandla creek region and nearby creeks sampling stations was varying from 4.735-5.948 with an average of 5.208 during the sampling conducted in high tide and varying from 4.255-6.043 with an average of 5.407 during the sampling conducted in low tide during Neap tide period.

Margalef's diversity index (Species Richness) S of Zooplankton communities in the sampling stationnear jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 5.728 and 4.718 respectively. Margalef's diversity index (Species Richness) S of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 4.873 and 4.219 respectively.

Margalef's diversity index (Species Richness) S of Zooplankton communities near Jetty at Path finder creek was varying from 4.115-4.269respectively during the sampling conducted in consecutive High tide period and Low tide period of Neap tide. While Margalef's diversity index (Species Richness) S of Zooplankton communities near SPM at Path finder creek was varying from 4.68-4.418 respectively during the consecutive High tide and low tide period.

Shannon-Wiener's index:

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.9715-1.209 (H'(log10)) between selected sampling stations with an average value of 1.0897 (H'(log10)) during high tide period of spring tide. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.9645-1.25 (H'(log10)) between selected sampling stations with an average value of 1.097 (H'(log10)) during consecutive low tide period.

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 1.101-1.17 (H'(log10)) between selected sampling stations with an average value of 1.1404 (H'(log10)) during high tide period of Neap tide. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range 1.06- 1.286 of (H'(log10)) between selected sampling stations with an average value of 1.1894 (H'(log10)) during consecutive low tide period.

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 1.168 and 1.045 respectively.Shannon-Wiener's Index (H) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 1.143 and 0.9398 respectively.

Shannon-Wiener's Index (H)of Zooplankton communities near jetty at Path finder creek was varying from 0.9748-1.089 during the sampling conducted consecutive High tide period and Low tide period of Neap tide. While Shannon-Wiener's Index (H) of Zooplankton communities near SPM at Path finder creek was varying from 0.9864-0.9746 during the consecutive High tide and low tide period.

Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon-Wiener's index increases as both the richness and the evenness of the community increase. This result indicates that diversity of Zooplankton of Kandla Harbour region and nearby creeks stations is slightly high with very minimum diverse population but very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson's diversity index:

Simpson's index (D) is a measure of diversity, which takes into account both species richness, and an evenness of abundance among the species present. The Simson index is one of the meaningful and robust biodiversity measures available. (Magurran, 2004).

Simpson diversity index (1-D) of Zooplankton communities was below 0.9 most of sampling stations in the Kandla Harbour region and nearby creeks during high tide and low tide of spring tide period except few stations, which was varying from 0.818-0.905 between selected sampling stations with an average of 0.871 during high tide period and was varying from 0.845-0.923 with an average value of 0.882 between selected sampling stations during low tide.

Simpson diversity index (1-D) of Zooplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks during high tide and low tide period of neap tide except few, which was varying from 0.864-0.884 between selected sampling stations with an average of 0.875 during high tide period and was varying from 0.831-0.928 with an average value of 0.894

between selected sampling stations during consecutive low tide. This species diversity suggests a relatively few successful species in this habitat during March 2022 sampling.

Simpson diversity index (1-D) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.898 and 0.868 respectively. Simpson diversity index (1-D) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.884 and 0.798respectively.

Simpson diversity index (1-D) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of Neap tide was recorded as 0.832-0.882 respectively. Simpson diversity index (1-D) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.797 and 0.837 respectively.

Table 50 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND NEAR BY CREEKS DURING SPRING TIDE IN MARCH 2022

Tide	Sampling Station	Abundance In Nx103/ m3	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log10)	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	162	32/37	86.48	6.093	1.209	0.9055
	2	119	20/37	54.05	3.976	0.9715	0.8187
	3	193	28/37	75.67	5.13	1.109	0.8749
	4	168	26/37	70.27	4.879	1.1	0.883
	5	158	24/37	64.86	4.543	1.059	0.8736
	6	96	17/37	45.95	3.505	1.004	0.8658
LOW TIDE	1	124	20/37	54.05	3.942	1.047	0.8754
	2	147	26/37	70.27	5.01	1.16	0.8984
	3	133	26/37	70.27	5.112	1.25	0.9236
	4	149	23/37	85.19	4.397	1.067	0.8676
	5	102	17/37	45.94	3.459	0.9645	0.8455

Table 51 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREAAT KANDLA CREEK AND NEAR BY CREEKS DURING NEAP TIDE IN MARCH 2022

Tide	Sampling Station	Abundance In No x103/ m3	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log10)	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	217	33/35	94.28	5.948	1.17	0.8812
	2	187	30/35	85.71	5.544	1.157	0.8748
	3	211	28/35	80	5.045	1.119	0.8649
	4	233	27/35	77.14	4.77	1.155	0.8847
	5	159	25/35	71.43	4.735	1.101	0.8716
	6	94	17/35	48.57	3.522	1.004	0.8566
LOW TIDE	1	176	23/35	65.71	4.255	1.092	0.8753
	2	132	29/35	82.85	5.734	1.258	0.9286
	3	147	31/35	88.57	6.012	1.251	0.9125
	4	169	32/35	91.43	6.043	1.286	0.9221
	5	183	27/35	77.14	4.991	1.06	0.8316

Table 52 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREAATKANDLA CREEK AND ,NEAR BY CREEKS DURING SPRING TIDE IN MARCH 2022

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton x103 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinids	18-30	6/37	16.21
			Copepods	38-84	15/37	40.54
			Rotifers	0-4	1/37	2.7
			Arrow worms	0-4	1/37	2.7
			Mysids	1-6	2/37	5.41
			Urochordata	0-2	2/37	5.41
			Foraminferans	0-1	2/37	5.41
			Larval forms	30-77	8/37	21.62
			Total Zooplankton N/ M3	96-193	37	
LOW TIDE	Sub surface	5	Tintinids	10-31	6/37	16.21
			Copepods	39-61	15/37	40.54
			Rotifers	0-4	1/37	2.7
			Arrow worms	0-4	1/37	2.7
			Mysids	0-4	2/37	5.41
			Urochordata	0-1	2/37	5.41
			Foraminferans	0-4	2/37	5.41
			Larval forms	35-61	8/37	21.62
			Total ZooplanktonN N/M3	102-149	37	

Table 53 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA IN KANDLA CREEK AND , NEAR BY CREEKS DURING NEAP TIDE IN MARCH 2022

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton x103 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinids	3-22	6/35	17.14
			Copepods	33-91	13/35	37.15
			Arrow worms	0-3	1/35	2.86
			Mysids	1-19	2/35	5.71
			Urochordata	0-6	2/35	5.71
			Medusa	0-2	1/35	2.86
			Foraminiferans	0-9	2/35	5.71
			Larval forms	44-96	8/35	22.86
			Total Zooplankton N/M3	94-233	35	
LOW TIDE	Sub surface	5	Tintinids	8-18	6/35	17.14
			Copepods	51-65	13/35	37.15
			Arrow worms	0-4	1/35	2.86
			Mysids	5-14	2/35	5.71
			Urochordata	0-6	2/35	5.71
			Medusa	0-2	1/35	2.86
			Foraminiferans	0-2	2/35	5.71
			Larval forms	45-93	8/35	22.86
			Total Zooplankton N/M3	132-183	35	

Table 54 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING SPRING TIDE IN MARCH 2022

Tide	Sampling Station	Abundance In x103N / m3	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log10)	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	158	30/32	93.75	5.728	1.168	0.898
	SPM	169	26/32	81.25	4.873	1.143	0.8842
LOW TIDE	Jetty	200	26/32	81.25	4.718	1.045	0.8686
	SPM	184	23/32	71.87	4.219	0.9398	0.798

Table 55 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING NEAP TIDE IN MARCH 2022

TOTAL Tide	Sampling Station	Abundance In Nx103/ m3	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log10)	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	129	21/27	77.77	4.115	0.9748	0.8327
	SPM	110	23/27	85.18	4.68	0.9864	0.7977
LOW TIDE	Jetty	173	23/27	85.18	4.269	1.089	0.8824
	SPM	116	22/27	81.48	4.418	0.9746	0.8375

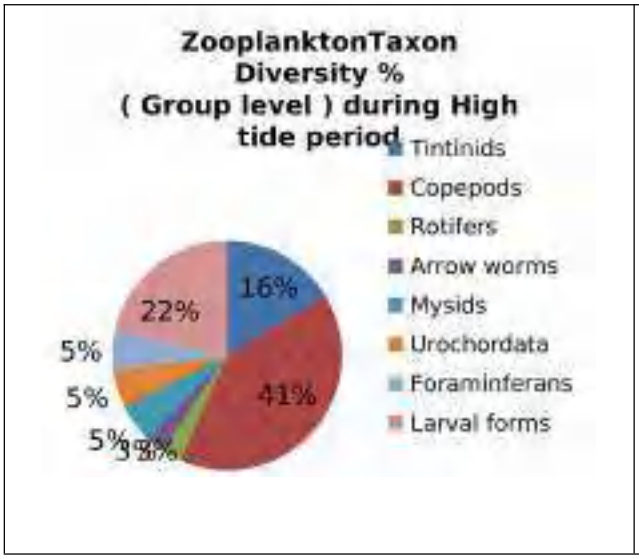
Table 56 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT OOT AREAAT PATH FINDER CREEK AND NEAR BY SPM DURING SPRING TIDE IN MARCH 2022

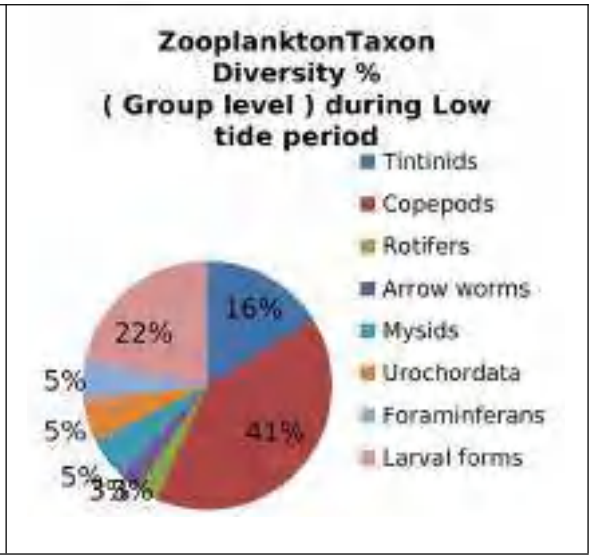
Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton x10³ Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	Tintinids	8-16	3/32	9.36
			Copepods	70-85	14/32	43.75
			Arrow worms	3-6	1/32	3.13
			Urochortata	6-8	2/32	6.25
			Medusa	0-1	1/32	3.13
			Foraminferans	2-9	2/32	6.25
			Larval forms	53-60	9/32	28.13
			Total Zooplankton NO/M3	158-169	32	
LOW TIDE	Sub surface	2	Tintinids	5-6	3/32	9.36
			Copepods	74-109	14/32	43.75
			Arrow worms	0-1	1/32	3.13
			Urochortata	10-11	2/32	6.25
			Medusa	0-1	1/32	3.13
			Foraminferans	2-3	2/32	6.25
			Larval forms	72-90	9/32	28.13
			Total Zooplankton NO/M3	184-200	32	

Table 57 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT OOT AREAAT PATH FINDER CREEK AND NEAR BY SPM DURING NEAP TIDE IN MARCH 2022

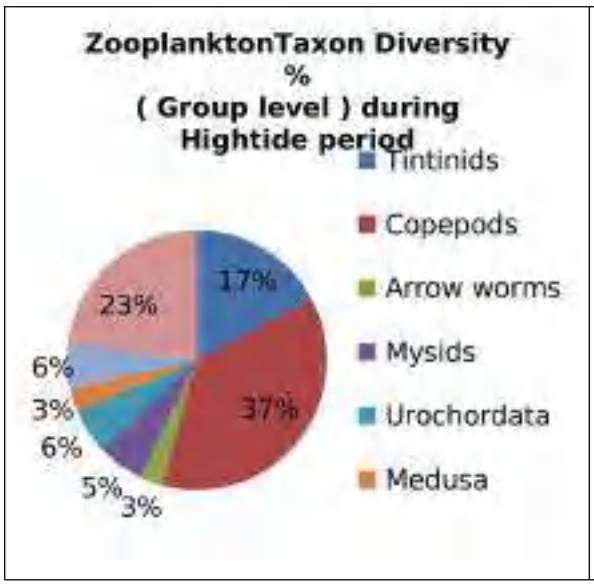
Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton x10^3 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	Tintinids	1-8	4/27	14.82
			Copepods	38-39	12/27	44.45
			Arrow worms	0-1	1/27	3.7
			Urochordata	0-1	1/27	3.7
			Foraminferans	1-3	1/27	3.7
			Larval forms	66-78	8/27	29.63
			Total Zooplankton NO/M3	110-125	27	-
LOW TIDE	Sub surface	2	Tintinids	4-12	4/27	14.82
			Copepods	43-51	12/27	44.45
			Arrow worms	0-1	1/27	3.7
			Urochordata	0-1	1/27	3.7
			Foraminferans	1-5	1/27	3.7
			Larval forms	65-100	8/27	29.63
			Total Zooplankton NO/M3	115-169	27	-

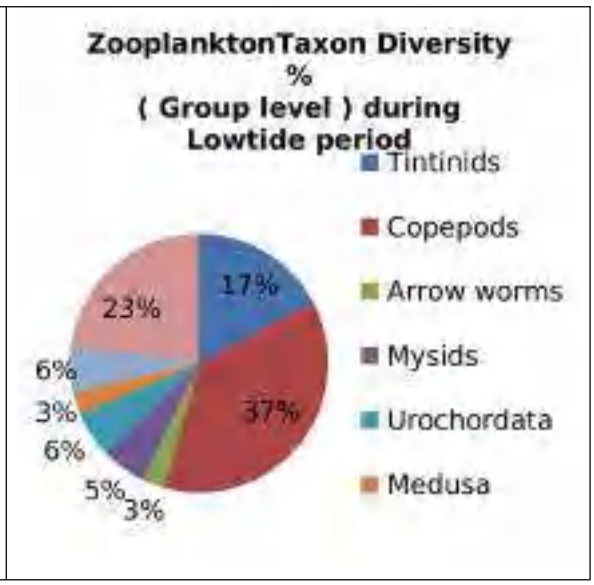
Taxon Diversity % of Zooplankton during High tide and Low tide period of Spring tide In Kandla Creek and nearby Creeks



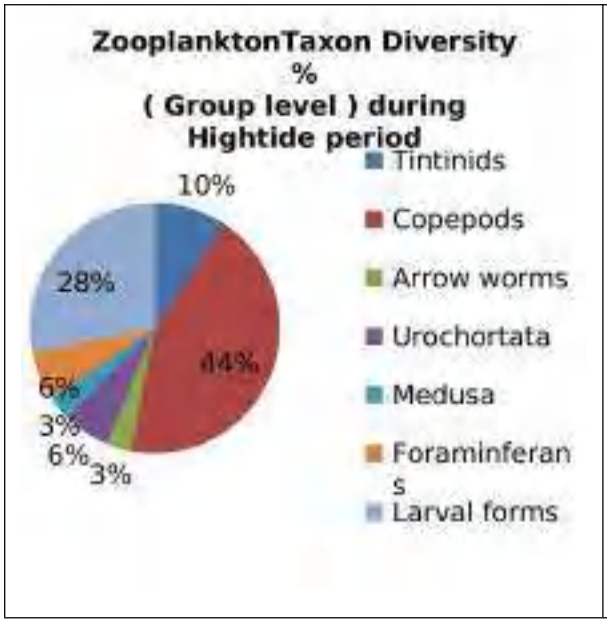


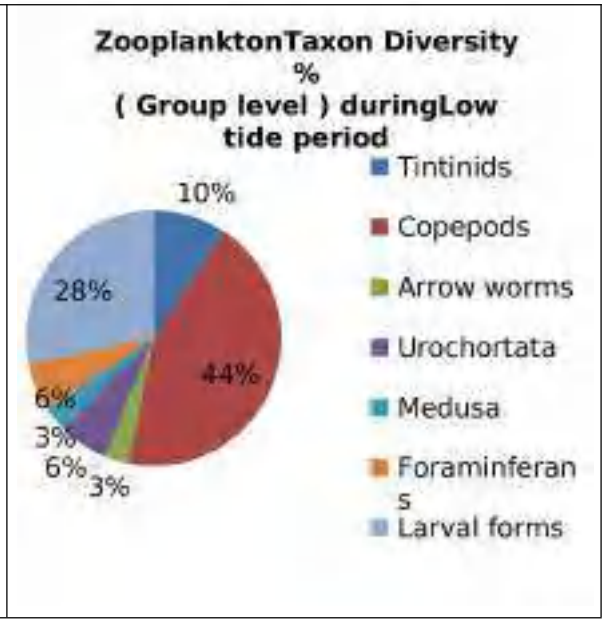
Taxon Diversity % of Zooplankton during High tide and Low tide period of Neap tide In Kandla Creek and nearby Creeks



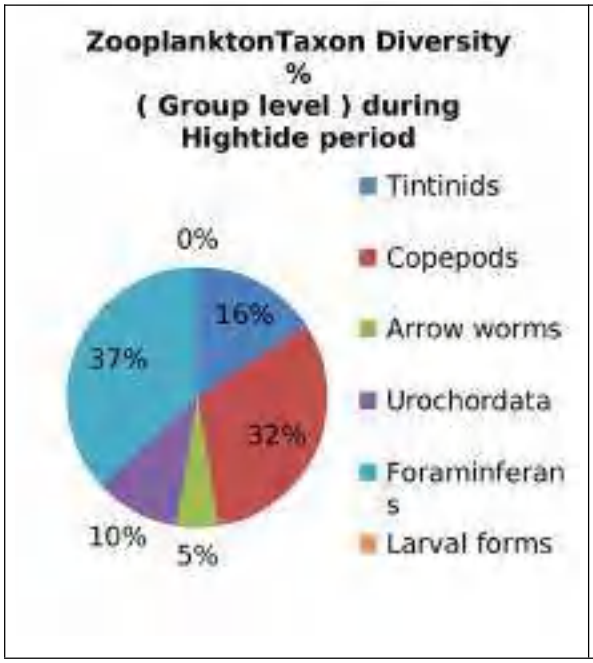


Taxon Diversity % of Zooplankton during High tide and Low tide period of Spring tide In Path Finder Creek and near Jetty





Taxon Diversity % of Zooplankton during High tide and Low tide period of Neap tide In Path Finder Creek near jetty and nearby SPM



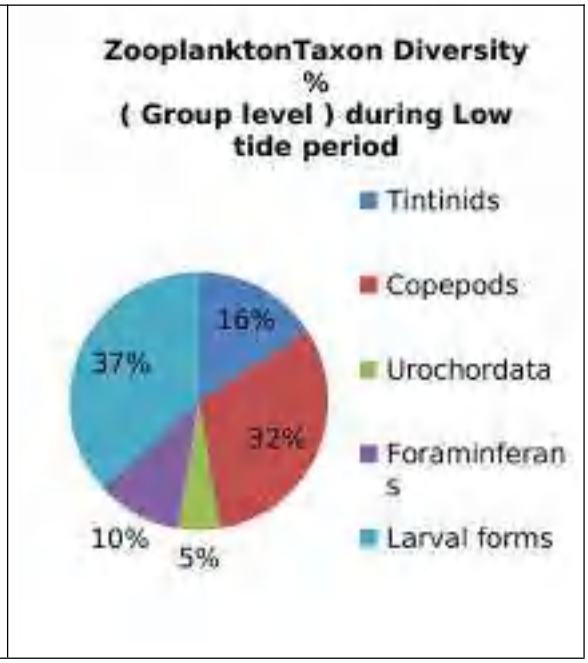


TABLE 58 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS OF DPT HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURINGSPRING TIDE OF MARCH 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAE	Cyanophyta	Cyanophyceae	Nostocales	Oscillatoriaceae	Lyngbya sp.	B1	Very sparse
					Oscillatoria sp.	B2	Very sparse
			Oscillatoriales	Phormidiaceae	Planktothrix sp.	B3	Very sparse
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Coscinodiscales	Coscinodiscaceae	Coscinodiscus sp.	D1	Dominant
			Thalassiosirales	Thalassiosiraceae	Planktoniellasp	D2	Very sparse
					Thalassiosira sp	D3	Very sparse
			Triceratiales	Triceratiaceae	Odontella sp.	D4	Very sparse
					Triceratium sp.	D5	Sparse
			Biddulphiales	Biddulphiaceae	Biddulphiasp	D6	Abundant
			Hemiaulales	Bellerocheaceae	Bellerochea sp	D7	Sparse
				Hemiaulaceae	Cerataulina sp.	D8	Abundant
					Eucampia sp	D9	Sparse
			Rhizosoleniales	Rhizosoleniaceae	Rhizosolenia sp.	D10	Scattered
			Chaetocerotales	Chaetocerotaceae	Chaetoceros sp	D11	Scattered
			Lithodesmiales	Lithodesmiaceae	Ditylum sp	D12	Sparse
		Bacillariophyceae	Naviculales	Naviculaceae	Navicula sp	D13	Very sparse
				Pleurosigmataceae	Gyrosigma sp	D14	Very sparse

					Pleurosigma sp	D15	Sparse
				Pinnulariaceae	Pinnularia sp	D16	Very sparse
			Bacillariales	Bacillariaceae	Bacillaria sp.	D17	Sparse
					Nitzschia sp	D18	Very sparse
					Pseudo-nitzschia sp	D19	Very sparse
			Surirellales	Surirellaceae	Surirella sp	D20	Very sparse
		Fragilariophyceae	Thalassionematales	Thalassionemataceae	Thalassiothrix sp.	D21	Scattered
					Thalassionema sp.	D22	Very sparse
			Fragilariales	Fragilariaceae	Fragilaria sp	D23	Very sparse
					Synedrasp	D24	Sparse
			Tabellariales	Tabellariaceae	Tabellaria sp	D25	Very sparse
DINO FLAGELLATES	Dinoflagellata / Dinozoa	Noctilucea / Noctiluciphyceae (Dinokaryota)	Noctilucales	Noctilucaceae	Noctiluca sp.	DF1	Very sparse
		Dinophyceae	Peridiniales	Protoperidiniaceae	Protoperidinium sp.	DF2	Sparse
			Gonyaulacales	Ceratiaceae	Ceratium furca	DF3	Very sparse
					Ceratium tripos	DF4	Very sparse

TABLE 59 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPT HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING AND NEAP TIDE OF MARCH 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative
BLUE GREEN ALGAE	Cyanophyta	Cyanophyceae	Nostocales	Oscillatoriaceae	Oscillatoria sp.	B1	Very sparse
			Oscillatoriales	Phormidiaceae	Planktothrix sp.	B2	Very sparse
			Stigonematales	Stigonemataceae	Stigonema sp.	B3	Very sparse
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Coscinodiscales	Coscinodiscaceae	Coscinodiscus sp.	D1	Dominant
			Thalassiosirales	Thalassiosiraceae	Planktoniellasp	D2	Very sparse
					Thalassiosira sp	D3	Very sparse
			Triceratiales	Triceratiaceae	Odontella sp.	D4	Very sparse
					Triceratium sp.	D5	Very sparse
			Biddulphiales	Biddulphiaceae	Biddulphiasp	D6	Dominant
			Hemiaulales	Bellerocheaceae	Bellerochea sp	D7	Sparse
				Hemiaulaceae	Cerataulina sp.	D8	Very sparse
					Eucampia sp	D9	Sparse
			Rhizosoleniales	Rhizosoleniaceae	Rhizosolenia sp.	D10	Scattered
			Chaetocerotales	Chaetocerotaceae	Chaetoceros sp.	D11	Sparse
			Lithodesmiales	Lithodesmiaceae	Ditylum sp	D12	Scattered
			Melosirales	Melosiraceae	Melosira sp	D13	Very sparse
		Bacillariophyceae	Bacillariales	Bacillariaceae	Bacillaria sp.	D14	Sparse
					Nitzschia sp	D15	Very sparse
					Pseudo-nitzschia	D16	Sparse
			Surirellales	Surirellaceae	Campylodiscus sp	D17	Very sparse
					Surirella sp	D18	Very sparse
			Naviculales	Naviculaceae	Navicula sp	D19	Very sparse
				Pleurosigmataceae	Gyrosigma sp.	D20	Very sparse
					Pleurosigma sp.	D21	Sparse
				Pinnulariaceae	Pinnularia sp	D22	Very sparse
		Fragilariophyceae	Thalassionematales	Thalassionemataceae	Thalassiothrix sp.	D23	Abundant
					Thalassionema sp.	D24	Very sparse
			Fragilariales	Fragilariaceae	Asterionellopsis sp	D25	Very sparse
					Fragilaria sp	D26	Very sparse
					Synedrasp	D27	Sparse
			Tabellariales	Tabellariaceae	Tabellaria sp	D28	Very sparse
DINO FLAGELLATES	Dinoflagellata / Dinozoa	Noctilucea /	Noctilucales	Noctilucaceae	Noctiluca sp.	DF1	Sparse
		Dinophyceae	Peridiniales	Protoperidiniaceae	Protoperidinium sp.	DF2	Very sparse
			Gonyaulacales	Ceratiaceae	Ceratium furca	DF3	Very sparse
					Ceratium tripos	DF4	Very sparse

TABLE 60 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPT OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING SPRING TIDE OF MARCH 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAE	Cyanophyta	Cyanophyceae	Nostocales	Oscillatoriaceae	*Lyngbya sp.*	B1	Very sparse
					Oscillatoria sp.	B2	Very sparse
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D1	Dominant
					Palmeria sp.	D2	Very sparse
			Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D3	Scattered
			Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D4	Sparse
				Hemiaulaceae	*Cerataulina sp.*	D5	Sparse
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D6	Sparse
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp	D7	Sparse
			Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D8	Very sparse
			Corethrales	Corethraceae	*Corethron sp.*	D9	Very sparse
			Thalassiosirales	Thalassiosiraceae	*Planktoniella*sp	D10	Very sparse
					Thalassiosira sp	D11	Abundant
			Triceratiales	Triceratiaceae	*Odontella* sp.	D12	Very sparse
					Triceratium sp.	D13	Very sparse
		Bacillariophyceae	Naviculales	Pleurosigmataceae	*Pleurosigma* sp	D14	Very sparse
				Pinnulariaceae	*Pinnularia sp*	D15	Very sparse
			Bacillariales	Bacillariaceae	*Bacillaria* sp.	D16	Sparse
					Nitzschia sp	D17	Sparse
					Pseudo-nitzschia sp	D18	Very sparse
			Surirellales	Entomoneidaceae	*Entomoneis sp.*	D19	Very sparse
		Fragilariophyceae	Fragilariales	Fragilariaceae	*Asterionellopsis sp*	D20	Very sparse
					Synedra sp.	D21	Scattered
			Climacospheniales	Climacospheniaceae	*Climacosphenia sp.*	D22	Very sparse
			Licmophorales	Licmophoraceae	*Licmophora sp.*	D23	Sparse
			Thalassionematales	Thalassionematacea e	*Thalassiothrix sp.*	D24	Sparse
DINOFLAGELL ATES	Dinoflagellata / Dinozoa	Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Very sparse
			Gonyaulacales	Ceratiaceae	*Ceratium furca*	DF2	Very sparse
					Ceratium macroceros	DF3	Very sparse
					Ceratium tripos	DF4	Very sparse

TABLE 61 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPT OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING AND NEAP TIDE OF MARCH 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAE	Cyanophyta	Cyanophyceae	Chlorococcales	Chroococcaceae	Merismopedia sp.	B1	Very sparse
			Nostocales	Oscillatoriaceae	Lyngbya sp.	B2	Very sparse
					Oscillatoria sp.	B3	Very sparse
			Stigonematales	Stigonemataceae	Stigonema sp.	B4	Very sparse
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Coscinodiscales	Coscinodiscaceae	Coscinodiscus sp.	D1	Dominant
					Palmeria sp.	D2	Very sparse
			Biddulphiales	Biddulphiaceae	Biddulphiasp	D3	Sparse
			Hemiaulales	Bellerocheaceae	Bellerochea sp	D4	Sparse
				Hemiaulaceae	Cerataulina sp.	D5	Very sparse
			Rhizosoleniales	Rhizosoleniaceae	Rhizosolenia sp.	D6	Sparse
			Chaetocerotales	Chaetocerotaceae	Chaetoceros sp	D7	Very sparse
			Lithodesmiales	Lithodesmiaceae	Ditylum sp	D8	Sparse
			Corethrales	Corethraceae	Corethron sp.	D9	Very sparse
			Melosirales	Melosiraceae	Melosira sp	D10	Very sparse
			Thalassiosirales	Thalassiosiraceae	Planktoniellasp	D11	Very sparse
			Triceratiales	Triceratiaceae	Odontella sp	D12	Sparse
					Triceratium sp	D13	Very sparse
		Bacillariophyceae	Naviculales	Naviculaceae	Navicula sp	D14	Very sparse
				Pleurosigmataceae	Gyrosigma sp.	D15	Very sparse
					Pleurosigma sp	D16	Very sparse
				Plagiotropidaceae	Plagiotropis sp.	D17	Very sparse
			Bacillariales	Bacillariaceae	Bacillaria sp.	D18	Sparse
					Nitzschia sp	D19	Scattered
					Pseudo-nitzschia sp	D20	Very sparse
			Surirellales	Surirellaceae	Campylodiscus sp	D21	Very sparse
			Achnanthales	Achnanthaceae	Achnanthes sp	D22	Very sparse
		Fragilariophyceae	Fragilariales	Fragilariaceae	Fragilaria sp	D23	Very sparse
					Synedra sp.	D24	Abundant
			Striatellales	Striatellaceae	Striatellasp	D25	Very sparse
			Thalassionematales	Thalassionemataceae	Thalassiothrix sp.	D26	Very sparse
			Climacospheniales	Climacospheniaceae	Climacosphenia sp.	D27	Very sparse

			Licmophorales	Licmophoraceae	Licmophora sp.	D28	Sparse
DINO FLAGELLATES	Dinoflagellata / Dinozoa	Noctilucea / Noctiluciphyceae (Dinokaryota)	Noctilucales	Noctilucaceae	Noctiluca sp.	DF1	Very sparse
		Dinophyceae	Peridiniales	Protoperidiniaceae	Protoperidinium sp.	DF2	Very sparse
			Gonyaulacales	Ceratiaceae	Ceratium furca	DF3	Sparse
					Ceratium tripos	DF4	Very sparse

TABLE 62 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPT HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKSDURING SPRING TIDE OF MARCH 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	Leprotintinnus sp.	T1	Very sparse
				Codonellidae	Tintinnopsis accuminata	T2	Very sparse
					Tintinnopsis failakkaensis	T3	Scattered
					Tintinnopsis gracilis	T4	Very sparse
					Tintinnopsis mortensenii	T5	Very sparse
					Tintinnopsis radix	T6	Very sparse
COPEPODS	ATHROPODA	Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	Acrocalanus sp.	C1	Scattered
					Parvocalanus sp.	C2	Very sparse
				Eucalanidae	Pareucalanus sp.	C3	Very sparse
					Subeucalanus sp.	C4	Very sparse
				Clausocalanidae	Clausocalanus sp.	C5	Very sparse
				Centropagidae	Centropages sp.	C6	Very sparse
				Acartiidae	Acartia sp.	C7	Very sparse
				Temoridae	Temora sp.	C8	Very sparse
				Tortanidae	Tortanus sp.	C9	Very sparse
			Cyclopoida	Oithonidae	Oithona sp.	C10	Abundant
			Harpacticoida	Ectinosomatidae	Microsetella sp.	C11	Abundant
				Euterpinidae	Euterpina sp.	C12	Sparse
				Canthocamptidae	Canthocamptus sp	C13	Very sparse
			Poicilostomatatoida	Corycaeidae	Corycaeus sp.	C14	Very sparse
				Oncaeidae	Oncaea sp.	C15	Very sparse

ROTIFERS	ROTIFERA	Rotifera Subclass: Eurotatoria	Superorder: Monogononta Order:Ploimida	Brachionidae	Brachionus plicatilis	R1	Very sparse
ARROW WORMS	CHAETOGNATHA	Sagittoidea	Aphragmophora	Sagittidae	Sagitta sp.	A1	Very sparse
MYSIDS	ATHROPODA CRUSTACEA	Malacostraca	Mysida, Decapoda	Penaeidae	Metapenaeus sp.	M1	Very sparse
				Solenoceridae	Solenocera sp.	M2	Very sparse
UROCHORDATA	CHORDATA SUB PHYLUM UROCHORDATA	Appendicularia		Oikopleuridae	Oikopleura sp.	U1	Very sparse
				Fritillariidae	Fritillaria sp.	U2	Very sparse
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of copepods	L1	Dominant
BRACHYURA LARVAE	ARTHROPODA (CRUSTACEA)	Malacostraca Decapoda			Brachyuran zoea larvae	L2	Sparse
BARNACLE LARVAE	ATHROPODA CRUSTACEA	Maxillopoda Thecostraca			Cirripede larvae	L3	Sparse
CYPHONAUTES LARVAE	BRYOZOA				Cyphonautes larvae	L4	Very sparse
ECHINODERMATA LARVAE	ECHINODERMATA				Ophipluutes larvae/ Echinoplutes larvae	L5	Very sparse
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L6	Sparse
POLYCHAETE LARVAE	ANNELIDA	Polychaeta			Trochophore larvae	L7	Very sparse
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of bivalves	L8	Very sparse
FORAMINIFERA	FORAMINIFERA	Globothalamea	Rotaliida	Globigerinidae	Globigerina sp.	F1	Very sparse
				Rotalliidae	Rotalia sp.	F2	Very sparse

TABLE 63 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING OF DPT HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING NEAP TIDE OF MARCH 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	Leprotintinnus sp.	T1	Sparse
				Codonellidae	Tintinnopsis accuminata	T2	Very sparse
					Tintinnopsis failakkaensis	T3	Sparse
					Tintinnopsis gracilis	T4	Very sparse
					Tintinnopsis mortensenii	T5	Very sparse
					Tintinnopsis radix	T6	Sparse
COPEPODS	ATHROPODA	Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	Acrocalanus sp.	C1	Scattered
					Parvocalanus sp.	C2	Very sparse
				Eucalanidae	Pareucalanus sp	C3	Very sparse
					Subeucalanus sp.	C4	Sparse
				Clausocalanidae	Clausocalanus sp.	C5	Very sparse
				Centropagidae	Centropages sp.	C6	Very sparse
				Acartiidae	Acartia sp.	C7	Very sparse
				Temoridae	Temora sp.	C8	Very sparse
			Cyclopoida	Oithonidae	Oithona sp.	C9	Abundant
			Harpacticoida	Ectinosomatidae	Microsetella sp.	C10	Abundant
				Euterpinidae	Euterpina sp.	C11	Sparse
			Poicilostomatatoida	Oncaeidae	Oncaea sp.	C12	Sparse
				Corycaeidae	Corycaeus sp.	C13	Very sparse
ARROW WORMS	CHAETOGNATHA	Sagittoidea	Aphragmophora	Sagittidae	Sagitta sp.	A1	Sparse
MYSIDS	ATHROPODA CRUSTACEA	Malacostraca	Mysida, Decapoda	Penaeidae	Penaeus sp.	M1	Scattered
				Solenoceridae	Solenocera sp.	M2	Scattered
UROCHORDATA	CHORDATA SUB PHYLUM UROCHORDATA	Appendicularia		Oikopleuridae	Oikopleura sp.	U1	Very sparse
				Fritillariidae	Fritillaria sp.	U2	Very sparse
MEDUSA	PHYLUM CNIDARIA	Hydrozoa			Unidentified medusa	ME 1	Very sparse
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of copepods	L1	Dominant
BRACHYURA	ARTHROPODA	Malacostraca			Brachyuran zoea larvae	L2	Very sparse

LARVAE	(CRUSTACEA)	Decapoda					
BARNACLE LARVAE	ATHROPODA CRUSTACEA	Maxillopoda Thecostraca			Cirripede larvae	L3	Scattered
CYPHONAUTES LARVAE	BRYOZOA				Cyphonautes larvae	L4	Very sparse
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L5	Sparse
ECHINODERMATA LARVAE	ECHINODERMATA				Ophipluutes larvae/ Echinoplutes larvae	L6	Sparse
POLYCHAETE LARVAE	ANNELIDA	Polychaeta			Trochophore larvae	L7	Sparse
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of bivalves	L8	Very sparse
FORAMINIFERA	FORAMINIFERA	Globothalamea	Rotaliida	Globigerinidae	Globigerina sp.	F1	Very sparse
				Rotalliidae	Rotalia sp.	F2	Very sparse

TABLE 64 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPT OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINARDURING SPRING TIDE OF MARCH 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	Leprotintinnus sp.	T1	Sparse
				Codonellidae	Tintinnopsis failakkaensis	T2	Very sparse
					Tintinnopsis radix	T3	Very sparse
COPEPODS	ATHROPODA	Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	Acrocalanus sp.	C1	Dominant
					Bestiolina sp.	C2	Very sparse
					Parvocalanus sp.	C3	Sparse
				Acartiidae	Acartia sp.	C4	Very sparse
				Centropagidae	Centropages sp.	C5	Sparse
				Clausocalanidae	Clausocalanus sp.	C6	Very sparse
				Temoridae	Temora sp.	C7	Very sparse
			Cyclopoida	Oithonidae	Oithona sp.	C8	Abundant
			Harpacticoida	Canthocamptidae	Canthocamptus sp	C9	Very sparse
				Ectinosomatidae	Microsetella sp.	C10	Sparse
				Euterpinidae	Euterpina sp.	C11	Abundant
			Poicilostomatatoida	Oncaeidae	Oncaea sp.	C12	Very sparse
				Corycaeidae	Corycaeus sp.	C13	Very sparse
					Farranula sp.	C14	Very sparse
ARROW WORMS	CHAETOGNATHA	Sagittoidea	Aphragmophora	Sagittidae	Sagitta sp.	A1	Sparse
UROCHORDATA	CHORDATA SUB PHYLUM UROCHORDATA	Appendicularia		Oikopleuridae	Oikopleura sp.	U1	Sparse
				Fritillariidae	Fritillaria sp.	U2	Very sparse
MEDUSA	PHYLUM CNIDARIA	Hydrozoa			Unidentified medusa	ME 1	Very sparse
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of copepods	L1	Dominant
ASCIDIAN LARVAE	CHORDATA SUBPHYLUM: TUNICATA	Ascidiacea			Ascidian tadpole larvae	L2	Very sparse
BRACHYURA LARVAE	ARTHROPODA (CRUSTACEA)	Malacostraca	Decapoda		Brachyuran zoea larvae	L3	Very sparse
BARNACLE LARVAE	ATHROPODA CRUSTACEA	Maxillopoda Thecostraca			Cirripede larvae	L4	Scattered
CYPHONAUTES LARVAE	BRYOZOA				Cyphonautes larvae	L5	Very sparse

ECHINODERMATA LARVAE	ECHINODERMATA				Ophipluutes larvae/ Echinoplutes larvae	L6	Very sparse
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L7	Sparse
POLYCHAETE LARVAE	ANNELIDA	Polychaeta			Trochophore larvae	L8	Sparse
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of bivalves	L9	Very sparse
FORAMINIFERA	FORAMINIFERA	Globothalamea	Rotaliida	Globigerinidae	Globigerina sp.	F1	Very sparse
				Rotalliidae	Rotalia sp.	F2	Very sparse

TABLE 65 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPT OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING NEAP TIDE OF MARCH 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	Leprotintinnus sp.	T1	Very sparse
				Codonellidae	Tintinnopsis failakkaensis	T2	Sparse
					Tintinnopsis gracilis	T3	Very sparse
					Tintinnopsis radix	T4	Sparse
COPEPODS	ATHROPODA	Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	Acrocalanus sp.	C1	Scattered
					Parvocalanus sp.	C2	Sparse
				Eucalanidae	Pareucalanus sp.	C3	Very sparse
				Centropagidae	Centropages sp.	C4	Very sparse
				Clausocalanidae	Clausocalanus sp.	C5	Very sparse
				Acartiidae	Acartia sp.	C6	Very sparse
			Cyclopoida	Oithonidae	Oithona sp.	C7	Abundant
			Harpacticoida	Canthocamptidae	Canthocamptus sp	C8	Very sparse
				Euterpinidae	Euterpina sp.	C9	Very sparse

				Ectinosomatidae	Microsetella sp.	C10	Very sparse
			Poicilostomatatoida	Oncaeidae	Oncaea sp.	C11	Very sparse
				Corycaeidae	Corycaeus sp.	C12	Very sparse
ARROW WORMS	CHAETOGNATHA	Sagittoidea	Aphragmophora	Sagittidae	Sagitta sp.	A1	Very sparse
UROCHORDATA	CHORDATA SUB PHYLUM: UROCHORDATA	Appendicularia		Fritillariidae	Fritillaria sp.	U1	Very sparse
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of copepods	L1	Dominant
ASCIDIAN LARVAE	CHORDATA SUBPHYLUM: TUNICATA	Ascidiacea			Ascidian tadpole larvae	L2	Very sparse
BARNACLE LARVAE	ATHROPODA CRUSTACEA	Maxillopoda Thecostraca			Cirripede larvae	L3	Sparse
CYPHONAUTES LARVAE	BRYOZOA				Cyphonautes larvae	L4	Very sparse
ECHINODERMATA LARVAE	ECHINODERMATA				Ophipluutes larvae/ Echinoplutes larvae	L5	Very sparse
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L6	Abundant
POLYCHAETE LARVAE	ANNELIDA	Polychaeta			Trochophore larvae	L7	Sparse
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of bivalves	L8	Sparse
FORAMINIFERA	FORAMINIFERA	Globothalamea	Rotaliida	Rotalliidae	Rotalia sp.	F1	Sparse

BENTHIC ORGANISMS:

Few Benthic organisms were observed in the collected sediments by using the Van-veen grabs during the sampling conducted during spring tide period and Neap tide period from DPT harbour region and nearby creek. The meiobenthic organisms during spring tide were represented by Polychaetes *Dasybranchus* sp., *Notomastus* sp, During neap tide Polychaetes Nereis sp., *Dasybranchus* sp and Few amphipods were detected.

Table 66 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPT HARBOUR AREA CREEKS DURING SPRING TIDE IN MARCH 2022

BENTHIC FAUNA	ABUNDANCE IN NO/M 2 DIFFERENT SAMPLING STATIONS					
	REPRESENTATION BY GROUP					
	DPT HARBOUR			CREEKS		
POLYCHAETES	KPT-1	KPT-2	KPT-3	KPT-4	KPT-5	KPT-6
Family : Capit*ellidaeDasybranchus sp.*	10	140	40	20	10	0
Family : Capit*ellidae Notomastussp*	10	20	10	40	20	0
Total Polychates N/M²	20	160	50	60	30	0
TOTAL Benthic Fauna NUMBER/ M²	20	160	50	60	30	0

NS : No sample

Table 67 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPT HARBOUR AREA CREEKS DURING NEAP TIDE IN MARCH 2022

BENTHIC FAUNA	ABUNDANCE IN NO/M 2 DIFFERENT SAMPLING STATIONS					
	REPRESENTATION BY GROUP					
	DPT HARBOUR			CREEKS		
POLYCHAETES	**KPT-1**	**KPT-2**	**KPT-3**	**KPT-4**	**KPT-5**	**KPT-6**
Family : Neridae Nereis sp.	0	0	0	0	10	0
Family : Capitellidae Dasybranchus sp	10	30	20	10	30	0
Total Polychaetes	10	30	20	10	40	0
Un identified Amphipods	10	20	10	20	30	0
TOTAL Benthic Fauna NUMBER/ M^2	20	50	30	40	110	0

11.1 Meteorological Data

Temperature

Temperature records indicate that the area experiences tropical coastal climate. The moderating effects of the nearby sea and the fairly high amount of relative humidity in the atmosphere have restricted the variability The seasonal variations of temperature follow closely the course of the sun. January is invariably the coldest month and May and June the warmest. With the onset of monsoon in fourthnight of June there is a reversal of the temperature curve and the temperature during the period of monsoon remains very nearly uniform at about 27°C The slight rise in temperature in October falls gradually till it reaches the coldest month in January. The temperatures vary from 11.7°C to 44.0°C. The mean daily air temperatures along with the extremes for each days.

Automatic Weather station (**ID KAZPHOEN424**) have been installed in Seva Sadan - 3 at the Deendayal Port which records the data on Temperature (°C), Humidity (%),Wind (mph), Dew Point (°C), Wind Direction (°), Pressure, Solar radiation, heat Index and UVI.

Temperature

The mean day time temperature for Deendayal Port was 19.8 °C. The day-time maximum temperature was 32.8°C. The minimum mean night time temperature recorded was 25.8 °C.

Air Pressure

The mean absolute air pressure for the month of March was 1013.21 hpa, whereas the mean relative pressure was 1013.31 hpa. The maximum absolute air pressure recorded for the month of March was 1021.9 hpa.

Heat Index

The mean day-time heat index for the month of March was 30.03^{o}C. The maximum heat index recorded was 42°C.

Solar Radiation

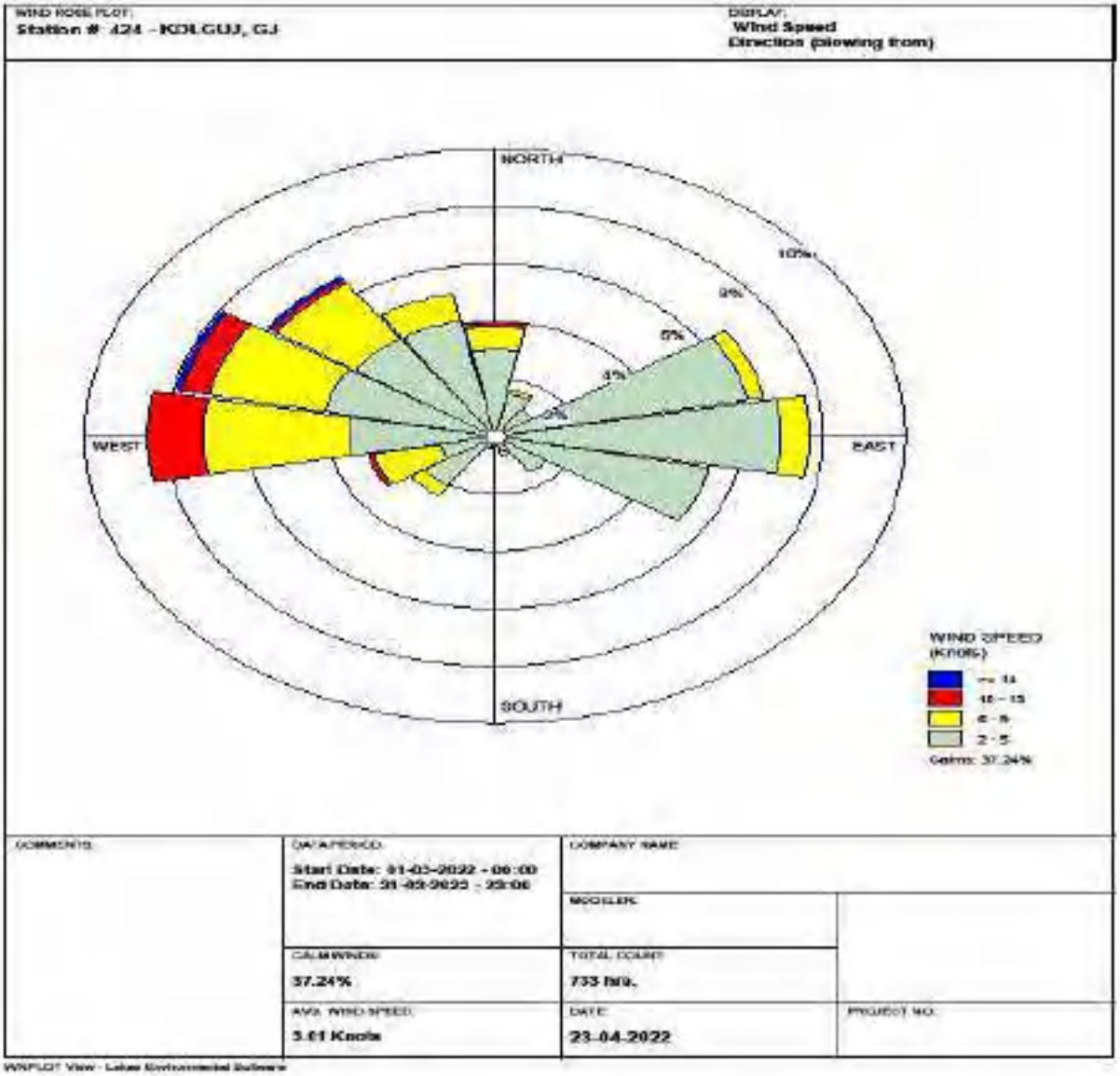
The mean Solar Radiation in March was 118.58 w/m^2. The maximum solar radiation recorded in the month of March was 530.7 w/m^2.

Humidity

The mean day-time humidity was 44.54 % for the month of March and mean night time humidity was 58.77 %. Maximum humidity recorded during day-time was 98.0 % and maximum humidity recorded during night-time was 69.0%.

Wind Velocity and Wind Direction

The mean wind velocity for the entire month of March was 5.20 km/hour. Maximum wind velocity recorded was 34.6 Km/hr . The wind direction was mostly SouthEast.


WIND ROSE PLOT:
Station # 424 - KDLGUJ, GJ
DISPLAY:
Wind Speed
Direction (blowing from)
NORTH
SOUTH
WEST
EAST
10%
8%
6%
4%
2%
WIND SPEED (KNOTS)
Calms: 37.24%
COMMENTS:
DATA PERIOD:
Start Date: 01-03-2022 - 00:00
End Date: 31-03-2022 - 23:00
COMPANY NAME:
MODELER:
CALM WINDS:
37.24%
TOTAL COUNT:
733 hrs.
AVG. WIND SPEED:
3.61 Knots
DATE:
23-04-2022
PROJECT NO.:
WRPLOT View - Lakes Environmental Software

12.0 Conclusive Summary and Remedial measures Suggested

The AAQ monitoring at six locations of Deendayal Port Kandla indicates that the mean PM_{10} values at all locations viz. Coal storage area, Marine Bhavan, Gopalpuri Hospital, Tuna Port, Kandla Colony and Oil Jetty area were found above the permissible standards (100 µg/m^3) and $PM_{2.5}$ was above permissible limits at Coal storage, Marine Bhavan, Oil Jetty, Gopalpuri Hospital, Kandala colony, Tuna port (Limit 60 µg/m^3).

The AAQ monitoring Vadinar at Admin building found above the permissible standards for both PM_{10} (Limit 100 µg/m^3) & $PM_{2.5}$ (Limit 60 µg/m^3)

Drinking water at all the twenty locations was found potable and was within permissible limits of BIS standards (IS 10500).

Noise quality was also within the set permissible standards of an Industrial Area. The noise level observed during day time was >75 dB (A) and at night time was >70 dB (A) during the entire monitoring period.

The sewage treated water of Deendayal Port Colony (Gopalpuri) was in line with the standards set by the Gujarat Pollution Control Board.

Reasons for higher Values of PM_{10}

Large amount of coal is handled at Berth No. 6, 7, 8 and 9. The unloading of coal directly in the truck, using grabs cause coal to spread in air as well as coal dust to fall on ground. This settled coal dust again mixes with the air while trucks travel through it.

Also, the coal laden trucks are not always covered with tarpaulin sheets and these results in spillage of coal from trucks/dumpers during its transit from vessel to yard or storage site. This also increased PM values around marine Bhavan & Coal storage area.

Remedial Measures

The values of PM_{10} & $PM_{2.5}$ during the month of March, 2022 were observed beyond the permissible limit at all locations mentioned above Except Vadinar Signal building for PM_{10} . Given below are the remedial measures suggest to minimize the Air pollution at Deendayal Port.

Except for the higher values of PM_{10} & $PM_{2.5}$ at Coal storage site, Oil Jetty, Tuna Port and Marine Bhavan locations, the monitoring results for the present month suggest that the overall Environment Quality of Deendayal Port is satisfactory.

During March, 2022 overall ambient air quality of the DPA is within GPCB permissible limits except TSPM, PM_{10}, $PM_{2.5}$ at Coal storage area, and Marine Bhavan. To improve air quality the port is using number of precautionary measures, such as maintained a wide expanse of Green zone, initiated Inter-Terminal Transfer (ITT) of tractor-trailers, Centralized Parking Plaza, providing shore power supply to tugs and port crafts, the use of LED lights at DPA area helps in lower energy consumption and decreases the carbon foot prints in the environment, time to time cleaning of paved and unpaved roads, use of tarpaulin sheets to cover dumpers at project sites etc. are helping to achieve the cleaner and green future at port.

Installed Mist Cannons system to suppresses dust generated in crushing and demolition sites, in material storage, cross-docking of Coal.

Solution towards the Green port:

Practice should be initiated for using mask as preventative measure, to avoid inhalation of dust particle- Mask advised in sensitive areas.

Use of renewable energy like solar energy should be optimal and ensure to work continuously.

Display of Environmental Initiative Boards and create awareness towards public. Stay sanitized of public transport and all basic items at public interaction places as much as possible.

Technology like Electric cart, Inter-Terminal Transfer (ITT) are worthy selection to reduce Port operation efficiency and fuel cost.

Limit the Activity and time of Exposure in Sensitive Area Prior planning.

Conventional RTGCs should be altered as E-RTGCs counting inside the portcompletely.

New scanning technology and new high power Tugs are reducing operation timing and CO2 Emission are good creativity.

Initiate Natural Gas (CNG) as fuel by all buses and trucks.

Guidelines for Coal Handling by GPCB should be strictly followed. (http://gpcb.gov.in/pdf/coal-handling-guidelines.pdf)

ENVIRONMENTAL MONITORING REPORT FOR DEENDAYAL PORT AUTHORITY

REPORT	**:**	**DCPL/DPA/21-22/24**
Mont	**:**	**April**
Issue	**:**	**01**
Revision	**:**	**00**
Prepare	**:**	**DETOX CORPORATION PVT. LTD., SURAT**

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ENVIRONMENTAL MONITORING PLAN FOR DEENDAYAL PORT ENVIRONMENTAL MONITORING REPORT- APRIL 2022

1. EXECUTIVE SUMMARY

Monitoring of various environmental aspects of the Deendayal port by M/s Detox Corporation Pvt. Ltd. has been carried out through collection of samples, analysis of the same, comparing results with respect to the national standards and any other relevant standards by GBCB/CPCB/MoEF & CC to identify non conformity in the Environment of the Deendayal Port. The results shall address the identified impacts and suggest measures to minimize the environmental impact due to various operations at Deendayal Port.

A) Ambient Air

The monitoring of Ambient Air quality at 6 locations at Deen Dayal Port Authority Kandla and 2 at Vadinar Port on 24 hourly basis for TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2, NH_3 in twice a Weak at Gopalpuri, Tuna Port, Marine Bhavan building, Coal storage area, Estate building, Oil jetty and at Vadinar port, Vadinar Jetty and vadinar colony area using respirable dust sampler,Fine particulate sampler and gaseous sampler.

The TSPM values in month of April 2022 were found 1295 µg/m^3 maximum at Coal Storage area on 14.04.2022 and minimum 73 µg/m^3 at Oil Jetty on 4th April 2022. The PM_{10} values were found from 1198 µg/m^3 maximum at Coal Storage area on 14.04.2022 and minimum 51 µg/m^3 at Tuna Port on 7th April 2022, The $PM_{2.5}$ values were found from 109 µg/m^3 maximum at Coal Storage area on 21st April 2022 and minimum 21 µg/m^3 at Oil Jetty on 25th April 2022. The PM_{10} values are found for five locations (Gopalpuri, Marine Bhavan building, Coal storage area, Estate building, Oil jetty) to above the permissible limit.The $PM_{2.5}$ values are found for four locations (Marine Bhavan building, Oil jetty, Gopalpuri & Estate building) within permissible limit Except Coal Storage area. The PM_{10} & $PM_{2.5}$ values are found for three locations (Tuna Port, Vadinar Signal building & Admin building) within permissible limit.

The overall values of April for SO_2 were found maximum of 7.57 µg/m^3 and minimum of 1.29 µg/m^3 , NOx were found maximum 25.67 µg/m^3 and minimum 8.63 µg/m^3, NH3 were found maximum 13.66 µg/m^3 and minimum 5.17µg/m^3, C6H6 were found maximum 1.25µg/m^3 and minimum 1.00 µg/m^3, CO were found

maximum 2.26 mg/m^3 and minimum of 1.41 mg/m^3 , CO2 were found maximum 809 ppm and minimum of 320 ppm and there is reported result for NMHC were BQL (Below Quantification Limit).

B) Marine Ecology (Flora and Fauna) / Marine Water / Sediments:

The results obtained from the study for the month of April, 2022. Physic-chemical parameters were observed for Flora and Fauna of ecological parameters for Arabian Sea at Kachchh Creek. Net Primary Productivity and Chlorophyll-a were well for ecological parameters for Arabian Sea. However, considering the activities in DPA Harbour, it is seen that the marine ecosystem is not adversely affected by Port activities.

C) Drinking Water Quality

Drinking water is water intended for human consumption for drinking and cooking purposes from any source. The drinking water being supplied to Deendayal Port is safe for drinking purpose. At all drinking water monitoring stations around port area are found to be as per the drinking water specifications given in IS 10500:2012 and also on the basis of analysis parameter.

The average results for 20 locations as per below.pH were found Min 7.23 to 7.61, TDS were found min 340 mg/l to Max found 910 mg/l, Chloride were found Min 210.0 mg/l to Max 611 mg/l, Total Hardness were found Min 410 mg/l to Max 480 mg/l and Calcium were found Min 48.09 mg/l to Max 72.14 mg/l. colour found colourless and odour were odourless. All water sample found for BOD, Heavy metal like manganese, Hexavalent chromium, Copper, Cadmium, Arsenic, Mercury, Lead, zinc all are found BQL (Below Quantification Limit). The bacterial count is absent in all drinking water samples.

D) Monitoring Performance of Sewage Treatment Plant

It is seen that the performance of STP at Deendayal Township, DPA STP Plant and Vadinar STP plant is satisfactory by overall. The treatment plant was well maintained during [April 2022] with considerable removal efficiency achieving the standards prescribed for final disposal. The average results for 3 locations as per below.Two locations (Gopalpuri & DPA STP) and one location at Vadinar. The pH were found 7.23 to Max 7.51,Total Suspended Solids were found 40.3 to 97.1 ,Residual Chlorine were below Detection Limit (Less Than 0.5) , COD were found 10 to 80 and BOD @ 27 °C were found 4 to 20 mg/l.

E) Weather

The data collected from Automatic weather station have been installed and other secondary sources to represent the metrological conditions of the project area has been reviewed and presented below for various attributes such as Temperature, Wind, Cloud cover, Relative Humidity, Rainfall, and Visibility. The predominant wind direction (blowing from) was the North West in the port area. Average values of wind speed was 8.19 m/s.

The Day maximum Temperature of 8th April 2022 was 41.6^{0}C and min 26.0^{0}C on 26th April 2022. Relative Humidity was recorded Mean at day 16.0 % on 8th April 2022 and on 16th & 29th April found the max 95.0%. Solar Radiation was recorded maximum 331.7 w/m^2 on 16th April 2022 The mean wind velocity for the entire month was 0.70 m/s. Maximum wind velocity recorded was 34.2 m/s on 26th April 2022 . The wind direction was mostly North West.

F) Noise

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. The Day Time Noise Level (SPL)in all 13 locations at Deendayal Port ranged from minimum of 55.4 dB(A) at Tuna port and entrance gate Vadinar port and maximum of 73.5 dB(A) at Main road, all results was within the permissible limits of 75 dB(A) for the industrial area for the daytime. The Night Time Average Noise Level (SPL) in all 13 locations of Deendayal Port ranged from minimum 45.5 dB at Port & custom office and maximum of 69.1 dB(A) at Main road, all results was within the permissible limits of 70 dB(A) for the industrial area for the night time.

2.0 Introduction

About Deendayal Port

The Deendayal Port is situated in the Kandla Creek and is 90 kms. From the mouth of Gulf of Kachchh. **Latitude: 23° 01" N Longitude: 70° 13"E**. Deendayal Port's journey began in 1931 with construction of RCC Jetty by Maharao Khengarji. After partition, Deendayal Port's success story has continued and it rise to the No. 1 Port in India in the year 2007-08 and since then retained the position for the 15 consecutive year. On 31.03.2016, Deendayal Port created history by handling 100 MMT cargoes in a year, the first Major Port to achieve the milestone. Kandla, also known as the Deendayal Port Authority is a seaport in Kutch District of Gujarat state in western India, near the city of Gandhidham. Located on the Gulf of Kutch, it is one of major ports on west coast. Kandla was constructed in the 1950s as the chief seaport serving western India, after the partition of India from Pakistan left the port of Karachi in Pakistan. The Port of Deendayal is located on the Gulf of Kutch on the northwestern coast of India some 256 nautical miles North West of the Port of Karachi in Pakistan and over 430 nautical miles north-northwest of the Port of Mumbai (Bombay). It is the largest port of India by volume of cargo handled. Kandla history Deendayal Port Authority, India's busiest major port in recent years, is gearing to add substantial cargo handling capacity with private sector participation. The west coast port handled 72,225 million tonnes of cargo in 2008-09, over 11% more than 64,920 million tonnes handled in2007-08. Even as much of this growth has come from handling of crude oil imports, mainly for Essar Oil's Vadinar refinery in Gujarat, the port is also taking measures to boost non-POL cargo. Last fiscal, POL traffic accounted for 63 per cent of the total cargo handled at Deendayal Port, as against 59% in 2007-08. Although Deendayal Port Authority officials declined to elaborate given the ongoing election code of conduct, it is reliably learnt that the port will soon initiate the process of selecting developers for four clean cargo berths that together aim to handle 8 million tonnes of cargo. The four berths will be supported by a 14 m draft capable of handling 75,000 dwt vessels.

The Deendayal Port Authority had commissioned the Off-shore Oil Terminal facilities at Vadinar in the year 1978, for which M/s. Indian Oil Corporation Limited (IOCL) provided Single Bouy Mooring (SBM) system, having a capacity of 54 MMTPA, which was first of its kind in India. Further, significant. Quantum of infrastructural upgradation has been affected & excellent maritime infrastructure been created at Vadinar for the 32MMTPA Essar Oil Refinery in Jamnagar District.

Monitoring of various environmental aspects of the Deendayal port by M/s Detox Corporation Pvt. Ltd. has been carried out through collection of samples, analysis of the

same, comparing results with respect to the prescribed standards by GBCB/CPCB/MoEF & CC. The results shall address the identified impacts and suggest measures to minimize the environmental impact due to various operations at Deendayal Port.

The environmental monitoring is carried out as per the Environment Management and Monitoring Plan submitted by Detox Corporation Pvt. Ltd

3. Introduction

Air pollutants are added in the atmosphere from variety of sources that change the composition of atmosphere and affect the biotic environment. The concentration of air pollutants depend not only on the quantities that are emitted from air pollution sources but also on the ability of the atmosphere to either absorb or disperse these emissions. The air pollution concentration vary spatially and temporarily causing the air pollution pattern to change with different locations and time due to changes in meteorological and topographical condition. The sources of air pollutants include

vehicles, industries, domestic sources and natural sources. Because of the presence of high amount of air pollutants in the ambient air, the health of the population and property is getting adversely affected. In order to arrest the deterioration in air quality, Govt. of India has enacted Air (Prevention and Control of Pollution) Act in 1981. The responsibility has been further emphasized under Environment (Protection) Act, 1986. It is necessary to assess the present and anticipated air pollution through continuous air quality survey/monitoring programs. Therefore, Central Pollution

Control Board had started National Ambient Air Quality Monitoring (NAAQM) Network during 1984 - 85 at national level. The programme was later renamed as National Air Quality Monitoring Programme (NAMP).

3.1 Ambient Air Quality Monitoring

As per the Environmental Monitoring Plan of Deendayal Port Authority, Air monitoring was carried out at six identified locations at Deendayal Port and two locations at Vadinar Port.

Air Quality Monitoring Methodology

Air quality is measured in all the stations, for 24 hour for Total Suspended Particulate Matter (TSPM), PM_{10}, $PM_{2.5}$, SO_2, NO_X, NH_3, NMHC & Benzene, and Grab-sampling for CO & CO_2 measurements. The Air samplers are operated for a period of 24 hours and after a continuous operation of 8 hours of the sampler. The reagents for SO_2 :- Mercuric Chloride, Potassium Chloride and EDTA used. For NO_X :- Sodium Hydroxide and Sodium Arsenite. For NH_3 need Coc. Sulphuric Acid and Distilled water was used. By replacing 3 times the reagents per day for each parameter namely, SO_2, NOx . The EPM 2000 filter paper and PTFE Membrane bound filter paper are used for a period of 24 hours to obtain one sample each of TSPM, PM10 & $PM_{2.5}$. The AAQ samples are collected twice a week from all the eight locations as per the EMP.

3.2 Results

The ambient air quality monitoring data for six stations, viz. Marine Bhavan, Oil Jetty, Port Colony, Gopalpuri Hospital, Tuna Port and Nr. Coal Storage Area for the month of April 2022 are given in Tables 1 to 6. The ambient air quality monitoring data for two stations at Vadinar (Nr. Admin Building & Nr. Signal Building) are given in Tables 7 to 8.

Note:AL1 To AL8 are Air Monitoring Location 1 to 8. Where AL1 Marine Bhavan, AL2 Oil Jetty, AL3 Estate Office, AL4 Gopalpuri Hospital, AL5 Coal Storage, AL6 Tuna Port, AL7 Signal Building (Vadinar) and AL8 Admin Building (Vadinar).

Location 1: Marine Bhavan (AL1)

Table 1 : Results of Air Pollutant Concentration at Marine Bhavan

Parameter	Date	TSPM [µg/m3]	PM_{10} [µg/m3]	$PM_{2.5}$ [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit			100 µg/m3	60 µg/m3		80 µg/m3		80 µg/m3		400 µg/m3
AL1 – 1	04.04.2022	149	77	67	2.14	2.00	20.30	19.13	8.06	9.09
					1.29		19.60		9.21	
					2.57		17.50		10.01	
AL1 – 2	07.04.2022	189	149	23	4.72	5.15	14.00	15.17	9.90	10.48
					5.57		12.60		8.98	
					5.15		18.90		12.55	
AL1 – 3	11.04.2022	333	257	58	7.29	5.86	27.31	25.67	13.01	13.09
					5.57		30.81		14.16	
					4.72		18.90		12.09	
AL1 – 4	14.04.2022	322	225	74	2.57	1.86	17.50	15.40	14.27	12.55
					1.72		12.60		10.82	
					1.29		16.10		12.55	
AL1 – 5	18.04.2022	338	234	78	3.00	4.00	21.00	21.24	6.68	7.83
					3.86		19.60		9.78	
					5.15		23.11		7.02	
AL1 - 6	21.04.2022	324	238	79	3.43	4.29	14.00	17.97	9.78	7.90
					5.15		22.40		8.86	
					4.29		17.50		5.06	
AL1 - 7	25.04.2022	268	225	43	2.14	2.29	14.00	17.27	11.28	11.55
					3.43		17.50		14.39	
					1.29		20.30		8.98	
AL1 – 8	28.04.2022	231	172	49	4.29	4.43	16.10	21.47	10.01	7.60
					5.15		29.41		7.02	
					3.86		18.90		5.76	
Monthly Average		269	197	59		3.74		19.16		10.01
Standard Deviation		73	60	20		1.51		3.53		2.22

Table 1 : Results of Air Pollutant Concentration at Marine Bhavan					
Parameter	Date	C6H6 [µg/m3]	*NMHC	CO [mg/m3]	CO2 [ppm]
Sampling Period		8 hr		Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m3	ppm	4.0 mg/m3	-
AL1 – 1	04.04.2022	1.1	BQL	2.12	474
AL1 – 2	07.04.2022	1.03	BQL	1.61	678
AL1 – 3	11.04.2022	1.2	BQL	1.41	647
AL1 – 4	14.04.2022	1.14	BQL	2.08	724
AL1 – 5	18.04.2022	1.08	BQL	1.94	643
AL1 - 6	21.04.2022	1.15	BQL	1.96	734
AL1 - 7	25.04.2022	1.2	BQL	1.64	578
AL1 - 8	28.04.2022	1.13	BQL	1.65	809
Monthly Average		1.13	-	1.80	661
Standard Deviation		0.06	-	0.26	103

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

At Marine Bhavan, the overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_X and NH_3 is attributed mainly by motor vehicle emission produced from various types of automobiles (both diesel and petrol driven). Moreover, the loading and unloading of Food Grains and Timber at Jetty no. 1 and 2 also contributes to the high levels of TSPM and PM_{10}. The mean TSPM value at Marine Bhavan was 269 µg/m^3,The mean PM_{10} values were 197 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were 99 µg/m^3. The average values of SO_2, NO_x and NH_3 were within the permissible limit. The average values of SO_2, NO_x and NH3 were 3.74 µg/ m^3, 19.16 µg/ m^3 & 10.01 µg/ m^3 respectively. These were within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Marine Bhavan. The mean Benzene concentration was 1.13 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.80 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 2: Oil Jetty (AL2)

Table 2 : Results of Air Pollutant Concentration at Oil Jetty

	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit			100 µg/m3	60 µg/m3		80 µg/m3		80 µg/m3		400 µg/m3
AL2 -1	04.04.2022	110	52	27	3.00	3.80	14.00	12.13	12.20	11.47
					2.80		10.50		11.40	
					5.60		11.90		10.82	
AL2 -2	07.04.2022	160	100	22	1.40	2.80	9.80	9.57	6.33	7.75
					3.50		10.50		7.71	
					3.50		8.40		9.21	
AL2 -3	11.04.2022	348	260	54	6.00	5.86	27.31	22.87	7.37	9.02
					7.29		21.70		10.01	
					4.29		19.60		9.67	
AL2 -4	14.04.2022	269	207	61	3.00	2.29	15.40	14.23	10.47	10.32
					1.72		16.10		11.40	
					2.14		11.20		9.09	
AL2 – 5	18.04.2022	203	122	44	3.86	2.43	12.60	16.34	8.98	8.67
					1.29		23.11		7.71	
					2.14		13.30		9.32	
AL2 – 6	21.04.2022	234	140	61	4.29	4.43	20.30	16.80	6.91	8.94
					5.15		16.10		9.90	
					3.86		14.00		10.01	
AL2 – 7	25.08.2021	134	100	21	0.86	1.29	23.11	19.60	8.29	10.25
					1.72		18.20		10.82	
					1.29		17.50		11.63	
AL2 -8	28.04.2022	180	142	36	2.14	2.14	16.80	13.77	6.79	8.30
					1.29		11.90		9.32	
					3.00		12.60		8.78	
Monthly Average		205	140	41		3.13		15.66		9.34
Standard Deviation		78	66	17		1.48		4.22		1.23

Table 2 : Results of Air Pollutant Concentration at Oil Jetty					
		C6H6 [µg/m3]		CO [mg/m3]	CO2 [ppm]
Sampling Period		8 hr		Grab Sampling	Grab Sampling
NAAQMS limit	Date	5.0 µg/m3	*NMHC	4.0 mg/m3	-
AL2 -1	04.04.2022	1.24	BQL	2.1	704
AL2 -2	07.04.2022	1.04	BQL	2.03	634
AL2 -3	11.04.2022	1.07	BQL	1.79	534
AL2 -4	14.04.2022	1.07	BQL	2.09	489
AL2 – 5	18.04.2022	1.17	BQL	2.07	734
AL2 – 6	21.04.2022	1.13	BQL	2.06	579
AL2 -7	25.04.2022	1.07	BQL	1.77	564
AL2 -8	28.04.2022	1.06	BQL	1.91	671
Monthly Average		1.11	-	1.98	615
Standard Deviation		0.07	-	0.14	85

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Oil Jetty area was mainly by motor vehicle emission produced from various types of vehicles Oil Jetty Area. The mean TSPM values at Oil Jetty were 205 µg/m^3. The mean PM_{10} values were 140 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were 41 µg/m^3. The average values of SO_2, NO_x and NH_3 were within the permissible limit, The mean concentration of SO_2, NO_x and NH3 were 3.13 µg/m^3, 15.66 µg/m^3 and 9.34 µg/m^3 respectively.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Oil Jetty. The mean Benzene concentration was 1.11 µg/m^3. Well below the permissible limit of 5.0 µg/m^3. , NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.98 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 3: Kandla Colony – Estate Office (AL-3)

Table 3 : Results of Air Pollutant Concentration at Estate Office

Parameter	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit			100 µg/m3	60 µg/m3		80 µg/m3		80 µg/m3		400 µg/m3
AL3 – 1	04.04.2022	167	129	34	0.86	1.72	16.80	14.70	13.01	12.28
					1.72		13.30		12.43	
					2.57		14.00		11.40	
AL3 – 2	07.04.2022	334	272	33	3.86	3.57	11.90	12.13	7.83	7.29
					2.57		10.50		6.91	
					4.29		14.00		7.14	
AL3 – 3	11.04.2022	271	159	92	3.00	3.43	15.40	15.87	9.32	7.83
					5.15		11.90		7.83	
					2.14		20.30		6.33	
AL3 – 4	14.04.2022	232	139	93	4.29	5.00	9.80	9.33	12.20	9.63
					6.00		8.40		9.09	
					4.72		9.80		7.60	
AL3 – 5	18.04.2022	288	175	90	3.43	3.43	23.11	20.07	10.24	11.28
					4.29		22.40		9.78	
					2.57		14.70		13.81	
AL3 – 6	21.04.2022	253	192	50	2.14	3.72	19.60	17.03	10.01	9.05
					3.86		16.80		11.05	
					5.15		14.70		6.10	
AL3 – 7	25.04.2022	388	337	42	5.15	3.43	21.70	20.07	12.20	11.51
					3.43		18.90		11.63	
					1.72		19.60		10.70	
AL3 – 8	28.04.2022	416	369	43	2.57	2.86	12.60	16.33	12.09	9.44
					4.29		16.80		9.21	
					1.72		19.60		7.02	
Monthly Average		294	221	60		3.40		15.69		9.79
Standard Deviation		82	92	27		0.91		3.68		1.78

Table 3 : Results of Air Pollutant Concentration at Estate Office					
		C6H6 [µg/m3]		CO [mg/m3]	CO2 [ppm]
Sampling Period	Date	8 hr	*MNHC	Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m3		4.0 mg/m3	-
AL3 -1	04.04.2022	1.21	BQL	1.89	564
AL3 -2	07.04.2022	1.01	BQL	2.01	786
AL3 -3	11.04.2022	1.01	BQL	2	544
AL3 -4	14.04.2022	1.01	BQL	1.96	679
AL3 – 5	18.04.2022	1.16	BQL	2.07	498
AL3 – 6	21.04.2022	1.06	BQL	1.94	653
AL3 – 7	25.04.2022	1.14	BQL	1.93	675
AL3 – 8	28.04.2022	1.1	BQL	1.83	756
Monthly Average		1.09	-	1.95	644
Standard Deviation		0.08	-	0.07	102

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Kandla Port Colony was attributed by vehicle emission produced from trucks and heavy duty vehicles that pass through the road outside Kandla Port Colony. The mean TSPM values at Kandla port Colony were 294 µg/m^3, The mean PM_{10} values were 221 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were 60 µg/m^3. The average values of SO_2, NO_x and NH_3 were 3.40 µg/m^3, 15.69 µg/m^3 and 9.79 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Kandla Port Colony. The mean Benzene concentration was 1.09 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.95 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 4: Gopalpuri Hospital (AL-4)

Table 4 : Results of Air Pollutant Concentration at Gopalpuri Hospital

Parameter	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit			100 µg/m3	60 µg/m3		80 µg/m3		80 µg/m3		400 µg/m3
AL4 -1	04.04.2022	192	95	49	1.72	2.00	8.40	10.50	9.67	9.05
					2.14		15.40		8.86	
					2.14		7.70		8.63	
AL4 -2	07.04.2022	201	136	56	3.00	1.72	6.30	10.73	7.71	8.71
					0.86		12.60		9.32	
					1.29		13.30		9.09	
AL4 -3	11.04.2022	214	135	78	2.57	3.00	11.20	9.80	5.41	6.33
					3.43		5.60		6.56	
					3.00		12.60		7.02	
AL4 -4	14.04.2022	196	126	52	2.57	3.57	10.50	9.57	8.06	8.33
					4.29		8.40		9.44	
					3.86		9.80		7.48	
AL4 – 5	18.04.2022	254	191	56	2.57	3.00	16.80	12.37	10.82	9.67
					3.43		9.80		9.32	
					3.00		10.50		8.86	
AL4 – 6	21.04.2022	182	134	43	3.86	4.58	13.30	11.67	5.64	6.48
					4.72		10.50		6.33	
					5.15		11.20		7.48	
AL4 – 7	25.04.2022	187	132	51	3.00	3.57	19.60	18.67	8.83	7.82
					5.15		20.30		6.56	
					2.57		16.10		8.06	
AL4 – 8	28.04.2022	190	128	61	1.72	2.29	13.30	12.83	7.25	6.94
					3.00		11.20		6.56	
					2.14		14.00		7.02	
Monthly Average		202	135	56		2.97		12.02		7.92
Standard Deviation		23	26	10		0.95		2.93		1.23

Table 4 : Results of Air Pollutant Concentration at Gopalpuri Hospital					
	Date	C6H6 [µg/m3]	*NMHC	CO [mg/m3]	CO2 [ppm]
Sampling Period		8 hr		Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m3		4.0 mg/m3	-
AL4 -1	04.04.2022	1.09	BQL	1.9	457
AL4 -2	07.04.2022	1	BQL	2.02	754
AL4 -3	11.04.2022	1.08	BQL	1.79	562
AL4 -4	14.04.2022	1.19	BQL	2.11	490
AL4 – 5	18.04.2022	1.1	BQL	1.75	695
AL4 – 6	21.04.2022	1.13	BQL	2.1	675
AL4 – 7	25.04.2022	1.06	BQL	2.02	700
AL4 – 8	28.04.2022	1.04	BQL	2.05	689
Monthly Average		1.09	-	1.97	628
Standard Deviation		0.06	-	0.14	110

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Gopalpuri Hospital was attributed by vehicle emission produced from light motor vehicles of the colony residents. The mean TSPM values at Gopalpuri Hospital were 202 µg/m^3, The mean PM_{10} values were 135 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were 56 µg/m^3. The average values of SO_2, NO_x and NH_3 were 2.97 µg/m^3, 12.02 µg/m^3 and 7.92 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Gopalpuri Hospital. The mean Benzene concentration was 1.09 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.97 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 5: Coal Storage Area (AL-5)

Table 5 : Results of Air Pollutant Concentration at Coal Storage Area

Parameter	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit			100 µg/m3	60 µg/m3		80 µg/m3		80 µg/m3		400 µg/m3
AL5 – 1	04.04.2022	351	304	40	3.86 3.00 5.15	4.00	23.11 21.00 20.30	21.47	9.44 7.25 9.90	8.86
AL5 – 2	07.04.2022	1128	1031	122	8.15 6.86 7.29	7.43	17.50 18.90 17.50	17.97	10.59 14.73 13.93	13.08
AL5 – 3	11.04.2022	1231	1185	132	9.00 7.29 6.43	7.57	24.51 19.60 26.61	23.57	9.90 7.60 8.29	8.60
AL5 – 4	14.04.2022	1295	1199	135	1.72 2.57 3.00	2.43	16.80 17.50 19.60	17.97	11.17 10.70 9.78	10.55
AL5 – 5	18.04.2022	959	848	93	4.29 3.86 4.29	4.15	21.70 19.60 17.50	19.60	11.51 10.47 9.90	10.63
AL5 – 6	21.04.2022	892	773	109	3.86 3.00 2.57	3.14	16.10 15.40 20.30	17.27	14.27 13.70 13.01	13.66
AL5 – 7	25.04.2022	572	493	79	4.29 5.57 5.15	5.00	11.90 14.70 18.20	14.93	10.01 9.67 9.09	9.59
AL5 – 8	28.04.2022	444	378	66	5.15 3.43 3.00	3.86	21.00 23.11 28.01	24.04	11.40 10.70 11.05	11.05
Monthly Average		859	776	97		4.70		19.60		10.75
Standard Deviation		364	354	34		1.89		3.20		1.84

Table 5 : Results of Air Pollutant Concentration at Coal Storage Area					
	Date	C6H6 [µg/m3]	*NMHC	CO [mg/m3]	CO2 [ppm]
Sampling Period		8 hr		Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m3		4.0 mg/m3	-
AL5 – 1	04.04.2022	1	BQL	2.15	696
AL5 – 2	07.04.2022	1.09	BQL	2.07	567
AL5 – 3	11.04.2022	1.21	BQL	2.02	678
AL5 – 4	14.04.2022	1.2	BQL	1.95	490
AL5 – 5	18.04.2022	1.04	BQL	2.26	521
AL5 – 6	21.04.2022	1.11	BQL	2.03	603
AL5 – 7	25.04.2022	1.21	BQL	2.1	562
AL5 – 8	28.04.2022	1.06	BQL	1.85	648
Monthly Average		1.12	-	2.05	596
Standard Deviation		0.08	-	0.12	74

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Coal Storage Area was comparatively highest among all the locations of Air Quality monitoring in Kandla Port. High values of TSPM, $PM_{10,}$ $PM_{2.5}$, SO_2, NO_X at this location was due to lifting of coal with grab and other coal handling processes near Berth no. 6 & 7. Moreover, the traffic was also heavy around this place for transport of coal thus emissions produced from heavy vehicles. The mean TSPM values at Coal storage were 859 µg/m^3. The mean PM_{10} values were 776 µg/m^3, which is well above the permissible limit. The $PM_{2.5}$ values were 97 µg/m^3. The average values of SO_2, NO_x and NH_3 were 4.70 µg/m^3, 19.60 µg/m^3 and 10.75 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Coal Storage Area. The mean Benzene concentration was 1.12 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 2.05 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 6: Tuna Port (AL-6)

Table 6 : Results of Air Pollutant Concentration at Tuna Port

Parameters	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit			100 µg/m3	60 µg/m3		80 µg/m3		80 µg/m3		400 µg/m3
AL6 -1	04.04.2022	100	61	32	1.29	1.72	21.70	15.63	11.51	11.39
					2.14		14.00		12.66	
					1.72		11.20		10.01	
AL6 – 2	07.04.2022	80	51	27	2.14	2.57	9.10	9.80	6.79	6.98
					3.00		9.80		7.02	
					2.57		10.50		7.14	
AL6 – 3	11.04.2022	128	88	29	3.43	2.29	15.40	18.20	7.60	6.75
					1.29		18.90		5.64	
					2.14		20.30		7.02	
AL6 – 4	14.04.2022	141	89	36	3.00	3.43	8.40	8.63	10.01	9.44
					4.29		7.70		9.21	
					3.00		9.80		9.09	
AL6 – 5	18.04.2022	125	93	28	0.86	1.29	20.30	15.87	10.59	11.40
					1.29		14.00		12.20	
					1.72		13.30		11.40	
AL6 – 6	21.04.2022	108	67	38	4.29	4.00	28.01	23.34	9.78	11.01
					3.43		20.30		13.12	
					4.29		21.70		10.13	
AL6 – 7	25.04.2022	126	92	24	3.00	3.00	16.10	16.80	8.98	9.71
					2.57		17.50		9.78	
					3.43		16.80		10.36	
AL6 – 8	28.04.2022	118	71	36	2.57	3.00	16.10	15.63	10.70	10.13
					3.00		15.40		9.67	
					3.43		15.40		10.01	
Monthly Average		116	76	31		2.66		15.49		9.60
Standard Deviation		19	16	5		0.89		4.63		

Table 6 : Results of Air Pollutant Concentration at Tuna Port					
	Date	C6H6 [µg/m3]	*NMHC	CO [mg/m3]	CO2 [ppm]
Sampling Period		8 hr		Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m3		4.0 mg/m3	-
AL6 -1	04.04.2022	1.14	BQL	1.96	567
AL6 – 2	07.04.2022	1.13	BQL	2.14	653
AL6 – 3	11.04.2022	1.17	BQL	1.79	489
AL6 – 4	14.04.2022	1.17	BQL	2.09	610
AL6 – 5	18.04.2022	1.19	BQL	2.04	680
AL6 – 6	21.04.2022	1.25	BQL	2.03	632
AL6 – 7	25.04.2022	1.11	BQL	1.7	458
AL6 – 8	28.04.2022	1.13	BQL	1.82	497
Monthly Average		1.16	-	1.95	573
Standard Deviation		0.04	-	0.16	83

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The mean TSPM values at Tuna Port were 116 µg/m^3, The mean PM_{10} values were 76 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were 31 µg/m^3. The average values of SO_2, NO_x and NH_3 were 2.66 µg/m^3, 15.49 µg/m^3 and 9.60 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Tuna Port. The mean Benzene concentration was 1.16 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.95 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 7: Signal Building (Vadinar) (AL-7)

Table 7 : Results of Air Pollutant Concentration at Signal building Vadinar

Parameters	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit			100 µg/m3	60 µg/m3		80 µg/m3		80 µg/m3		400 µg/m3
AL7 -1	05.04.2022	147	95	45	1.29	2.00	7.70	9.80	5.87	7.67
					2.14		11.90		8.75	
					2.57		9.80		8.40	
AL7 -2	08.04.2022	165	110	41	3.86	3.72	18.20	14.70	6.56	8.09
					4.29		15.40		9.09	
					3.00		10.50		8.63	
AL7 -3	12.04.2022	119	80	36	2.57	2.14	9.80	17.97	5.06	6.41
					2.14		23.81		7.48	
					1.72		20.30		6.68	
AL7 -4	15.04.2022	161	101	58	2.57	3.00	19.60	14.47	8.52	8.52
					3.00		14.00		9.44	
					3.43		9.80		7.60	
AL7 -5	19.04.2022	133	85	46	4.29	3.86	15.40	16.33	8.29	8.75
					3.43		21.70		9.55	
					3.86		11.90		8.40	
AL7 -6	22.04.2022	160	96	55	3.86	3.00	9.10	10.27	4.83	5.18
					3.00		8.40		5.06	
					2.14		13.30		5.64	
AL7 -7	26.04.2022	154	98	48	2.57	1.86	14.70	15.88	11.97	10.13
					1.72		12.60		12.20	
					1.29		20.33		6.22	
AL7-8	29.04.2022	168	106	50	4.29	3.00	7.70	13.07	9.90	10.09
					3.43		17.50		10.13	
					1.29		14.00		10.24	
Monthly Average		151	96	48		2.82		14.06		8.10
Standard Deviation		17	10	7		1		3		2

Table 7 : Results of Air Pollutant Concentration at Signal building Vadinar					
		C6H6 [µg/m3]		CO [mg/m3]	CO2 [ppm]
Sampling Period		8 hr		Grab Sampling	Grab Sampling
NAAQMS limit	Date	5.0 µg/m3	*NMHC	4.0 mg/m3	-
AL7 -1	05.04.2022	1.24	BQL	1.69	521
AL7 -2	08.04.2022	1.09	BQL	2.17	575
AL7 -3	12.04.2022	1.11	BQL	1.75	540
AL7 -4	15.04.2022	1.15	BQL	1.66	448
AL7 -5	19.04.2022	1.04	BQL	2.01	456
AL7 -6	22.04.2022	1.11	BQL	1.8	389
AL7 -7	26.04.2022	1.11	BQL	1.75	320
AL7 -8	29.04.2022	1.16	BQL	1.82	438
Monthly Average		1.13	-	1.83	461
Standard Deviation		0.06	-	0.17	83

*NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The mean TSPM values at Vadinar Port were 149 µg/m^3. The mean PM_{10} values were 96 µg/m^3, which is below the permissible limit. $PM_{2.5}$ values were 48µg/m^3. The average values of SO_2, NO_x and NH_3 were 2.82 µg/m^3, 14.06 µg/m^3 and 8.10 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Vadinar Port. The mean Benzene concentration was 1.13 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.83 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 8: Admin Building (Vadinar) (AL-8)

Table 8 : Results of Air Pollutant Concentration at Admin Building Vadinar

Parameters	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit			100 µg/m3	60 µg/m3		80 µg/m3		80 µg/m3		400 µg/m3
AL8 -1	05.04.2022	159	93	51	1.29	2.43	11.20	11.67	9.09	8.63
					2.57		14.00		8.63	
					3.43		9.80		8.17	
AL8 -2	08.04.2022	150	105	44	4.29	1.86	14.70	14.70	7.48	7.83
					0.43		16.10		7.94	
					0.86		13.30		8.06	
AL8 -3	12.04.2022	142	99	37	1.72	1.72	15.40	13.77	5.06	5.75
					1.29		13.30		6.79	
					2.14		12.60		5.41	
AL8 -4	15.04.2022	154	97	40	3.43	3.86	11.20	10.03	8.86	9.02
					4.29		9.80		9.21	
					3.86		9.10		8.98	
AL8 -5	19.04.2022	146	89	39	2.57	3.00	7.70	8.63	7.83	7.98
					3.00		8.40		9.32	
					3.43		9.80		6.79	
AL8 -6	22.04.2022	136	87	45	2.14	2.57	12.60	11.43	8.52	8.56
					3.00		11.20		9.44	
					2.57		10.50		7.71	
AL8 -7	26.04.2022	128	80	43	3.86	4.29	7.00	8.63	10.36	8.82
					4.29		8.40		7.02	
					4.72		10.50		9.09	
AL8-8	29.04.2022	163	92	54	2.57	2.57	12.60	11.67	6.45	5.99
					2.14		11.90		5.99	
					3.00		10.50		5.53	
Monthly Average		147	93	44		2.79		11.32		7.82
Standard Deviation		12	8	6		1		2		1

Table 8 : Results of Air Pollutant Concentration at Admin Building Vadinar					
	Date	C6H6 [µg/m3]	*NMHC	CO [mg/m3]	CO2 [ppm]
Sampling Period		8 hr		Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m3		4.0 mg/m3	-
AL8 -1	05.04.2022	1.16	BQL	1.68	493
AL8 -2	08.04.2022	1.05	BQL	2.08	630
AL8 -3	12.04.2022	1	BQL	1.72	520
AL8 -4	15.04.2022	1.09	BQL	1.66	448
AL8 -5	19.04.2022	1.14	BQL	1.89	381
AL8 -6	22.04.2022	1.15	BQL	1.89	324
AL8 -7	26.04.2022	1.09	BQL	1.63	322
AL8 -8	29.04.2022	1.14	BQL	1.87	356
Monthly Average		1.10	-	1.80	434
Standard Deviation		0.06	-	0.16	109

* NMHC- Non- Methane Hydrocarbon
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Admin Building Vadinar was comparatively low among all the locations of Air Quality monitoring in Kandla Port and Vadinar Port. The mean TSPM values at Vadinar Port were 147 µg/m^3. The mean PM_{10} values were 93 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were 44 µg/m^3. The average values of SO_2, NO_x and NH_3 were 2.79 µg/m^3, 11.32 µg/m^3 and 7.82 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Admin Building, Vadinar Port. The mean Benzene concentration was 1.10 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and

Carbon Monoxide concentration was 1.80 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

3.3 Observations and Conclusion

During the monitoring period, the overall Ambient Air Quality of the port area was found within permissible levels for various gaseous pollutants. However, Total Suspended Particulate matter as TSPM, Particulate matter as PM_{10} was found to exceed the limits at locations like Near Coal storage area, Marine Bhavan, Estate Office, Tuna Port , Oil Jetty area, and Gopalpuri. The $PM_{2.5}$ values are found for four locations (Marine Bhavan building, Oil jetty, Gopalpuri & Estate building) within permissible limit Except Coal Storage area

4.0 Drinking Water Quality Monitoring

Drinking Water Quality Monitoring was carried out at twenty stations at Kandla, Vadinar & Township Area of Deendayal Port.

4.1 Drinking Water Monitoring Methodology

Drinking water samples were collected from 20 locations as prescribed in the tender document. Samples for physico-chemical analysis were collected in 1 liter carboys and samples for microbiological parameters were collected in sterilized bottles. These samples were then analyzed in laboratory for various drinking water parameters at Kandla Lab/Surat.

The Sampling was done as per IS 3025 Part-1 and Analysis was done as per standard methods - IS 10500:2012. The water samples were analyzed for various parameters, viz. Color , Odor, Turbidity , Conductivity , pH , Chlorides , TDS, Total Hardness, Iron , Sulphate , Salinity , DO, BOD, Na, K, Ca, Mg, F, NO_3, NO_2, Mn, Cr-6, Cu, Cd, As, Hg, Pb, Zn, Bacterial Count (cfu) .

4.2 Results

The Drinking Water Quality monitoring data for 20 stations are given in below from table No. 9 to Table No. 15

Table 9: Drinking Water Quality Monitoring Parameters for Nirman Building 1 (23° 0' 27"E, 70° 13' 21"N) P & C building (23° 0' 33"E 70° 13' 20"N) & Main Gate (North) at Kandla (23° 0' 26.97"E, 70° 13' 21.87"N)

Sr. No.	Parameter	Unit	Nirman Building 1	P & C building	Main Gate North	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.36	7.41	7.31	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	420.0	440.0	390.0	500	2000
3	Turbidity	NTU	1	1	0.5	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	S/m	686.0	700.0	718.0	NS*	NS*
7	BOD	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	310.69	315.70	305.68	250	1000
9	Total Hardness	mg/l	420.0	430.0	450.0	200	600
10	Calcium	mg/l	56.11	52.10	60.12	75	200
11	Salinity	%	0.56	0.57	0.55	NS*	NS*
12	Mg as Mg	mg/l	68.04	72.90	72.90	30	100
13	Fluorides as F	mg/l	0.42	0.49	0.35	1	1.5
14	Sulphate as SO_4	mg/l	265.2	273.6	277.2	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	6.90	8.52	8.87	45	No Relaxation
17	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
18	Sodium as Na	mg/l	201	219	249	NS*	NS*
19	Potassium as K	mg/l	3.04	4.38	5.14	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	NS*
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	NS*
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	NS*
27	Zinc	mg/l	<0.1	<0.1	<0.1	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe- 0.009 mg/l, Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu- 0.004 mg/l, Cd- 0.003 mg/l, As- 0.003mg/l, Hg- 0.001 mg/l, Pb- 0.006mg/l, Zinc- 0.021 mg/l).

Table 10: Drinking Water Quality Monitoring Parameters for Canteen, (23° 2' 17.2674"E, 70° 13' 18.2814"N) West Gate – I(23° 59' 40.48"E, 70° 12' 50.96"N) & Wharf Area (22° 59' 52.2"E,70° 13' 22.95"N) at Kandla

Sr. No.	Parameter	Unit	Canteen	West Gate – I	Wharf Area	Acceptable Limits as per	Permissible Limits in the absence of Alternate
1	pH	-	7.23	7.45	7.5	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	420.0	340.0	440.0	500	2000
3	Turbidity	NTU	1	0.3	0.4	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	S/m	745.0	620.0	779.0	NS*	NS*
7	BOD	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	310.69	295.66	320.71	250	1000
9	Total Hardness	mg/l	414.0	430.0	460.0	75	600
10	Calcium	mg/l	56.11	72.14	52.10	30	200
11	Salinity	%	0.56	0.53	0.58	200	NS*
12	Mg as Mg	mg/l	65.61	60.75	80.19	0.3	100
13	Fluorides as F	mg/l	0.28	0.34	0.56	1	1.5
14	Sulphate as SO_4	mg/l	222.0	235.2	252.0	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	9.50	10.28	8.73	45	No Relaxation
17	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
18	Sodium as Na	mg/l	228	255	242	NS*	NS*
19	Potassium as K	mg/l	4.83	5.03	4.46	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	NS*
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	NS*
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	NS*
27	Zinc	mg/l	<0.1	<0.1	<0.1	5	15
28	Bacterial Count	CFU/100 ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 11: Drinking Water Quality Monitoring Parameters for Sewa sadan – 3,(23° 0' 22.55"E, 70° 13' 15.34"N) Workshop I (23° 0' 33.74"E, 70° 13' 20.05"N)&Custom Building (23° 1' 8.70"E, 70° 12' 52.0"N) at Kandla

Sr. No.	Parameter	Unit	Sewa Sadan – 3	Workshop	Custom Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.55	7.53	7.41	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	400.0	460.0	370.0	500	2000
3	Turbidity	NTU	1	1	0.5	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	S/m	702.0	820.0	692.0	NS*	NS*
7	BOD	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	305.68	310.69	315.70	250	1000
9	Total Hardness	mg/l	450.0	420.0	470.0	200	600
10	Calcium	mg/l	56.11	64.13	72.14	75	200
11	Salinity	%	0.55	0.56	0.57	NS*	NS*
12	Mg as Mg	mg/l	75.33	63.18	70.47	30	100
13	Fluorides as F	mg/l	0.67	0.78	0.52	1	1.5
14	Sulphate as SO_4	mg/l	255.6	262.8	211.2	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	12.32	11.40	12.74	45	100
17	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	1.0
18	Sodium as Na	mg/l	302	298	209	NS*	NS*
19	Potassium as K	mg/l	6.18	5.96	3.68	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 12:Drinking Water Quality Monitoring Parameters for Port Colony Kandla(23° 11' 14.9"E, 70° 12' 48.4"N) Hospital Kandla 23° 1' 5.02"E, 70° 12' 44.38"N)& A.O. Building (23° 3' 42.89"E, 70° 8' 41.5"N) at Gandhidham

Sr. No.	Parameter	Unit	Port Colony Kandla	Hospital Kandla	A.O. Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.36	7.41	7.26	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	430.0	410.0	910.0	500	2000
3	Turbidity	NTU	1	0.3	1	1	5
4	Odour	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	S/m	775.0	720.0	1546.0	NS*	NS*
7	BOD	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	330.74	335.75	611.36	250	1000
9	Total Hardness	mg/l	430.0	440.0	480.0	200	600
10	Calcium	mg/l	56.11	68.14	60.12	75	200
11	Salinity	%	0.60	0.61	1.10	NS*	NS*
12	Mg as Mg	mg/l	70.47	65.61	80.19	30	100
13	Fluorides as F	mg/l	0.60	0.68	0.86	1	1.5
14	Sulphate as SO_4	mg/l	220.0	232.6	288.2	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	11.20	12.62	11.20	45	100
17	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	1.0
18	Sodium as Na	mg/l	221	246	233	NS*	NS*
19	Potassium as K	mg/l	4.15	4.70	4.98	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 13: Drinking Water Quality Monitoring Parameters for School Gopalpuri,(23° 5' 1.03"E, 70° 7' 55.42"N) Guest House (23° 4' 43.14"E, 70° 7' 51.92"N) & E - Type Quarter(23° 4' 59.90"E, 70° 7' 56.72"N) at Gopalpuri, Gandhidham

Sr. No.	Parameter	Unit	Gopalpuri School	Guest House	E - Type Quarter	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.36	7.4	7.51	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	450.0	600.0	360.0	500	2000
3	Turbidity	NTU	1	1	0.4	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	S/m	775.0	1048.0	642.0	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	210.47	275.61	305.68	250	1000
9	Total Hardness	mg/l	450.0	420.0	460.0	200	600
10	Calcium	mg/l	48.10	56.11	52.10	75	200
11	Salinity	%	0.38	0.50	0.55	NS*	NS*
12	Mg as Mg	mg/l	80.19	68.04	80.19	30	100
13	Fluorides as F	mg/l	0.72	0.66	0.70	1	1.5
14	Sulphate as SO_4	mg/l	272.0	296.0	198.0	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	9.80	12.40	9.60	45	100
17	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	1.0
18	Sodium as Na	mg/l	341	298	30	NS*	NS*
19	Potassium as K	mg/l	6.78	5.90	5.08	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 14:Drinking Water Quality Monitoring Parameters for F - Type Quarter, (23° 4' 38.45"E, 70° 8' 8.63"N) Hospital Gopalpuri (23° 4' 54.09"E, 70° 8' 7.5"N) & Tuna Port (23° 58' 23.06"E, 70° 5' 35.6"N)

Sr. No.	Parameter	Unit	F - Type Quarter	Hospital Gopalpuri	Tuna Port	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.61	7.45	7.33	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	440.0	420.0	640.0	500	2000
3	Turbidity	NTU	0.4	1	1	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	S/m	756.0	745.0	1154.0	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	310.69	325.72	340.76	250	1000
9	Total Hardness	mg/l	450.0	480.0	460.0	200	600
10	Calcium	mg/l	64.13	48.10	60.12	75	200
11	Salinity	%	0.56	0.59	0.62	NS*	NS*
12	Mg as Mg	mg/l	70.47	87.48	75.33	30	100
13	Fluorides as F	mg/l	0.60	0.82	0.88	1	1.5
14	Sulphate as SO_4	mg/l	232.0	210.0	266.0	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	10.22	9.60	11.56	45	100
17	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	1.0
18	Sodium as Na	mg/l	258	266	248	NS*	NS*
19	Potassium as K	mg/l	5.18	5.69	4.78	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 15: Drinking Water Quality Monitoring Parameters for Vadinar Jetty(22° 25' 51.73"E, 69° 41' 36.62"N) & Port Colony (22° 30' 26.25"E, 69° 39' 45.03"N) at Vadinar

Sr. No.	Parameter	Unit	Vadinar Jetty	Port Colony Vadinar	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.41	7.51	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	450	430	500	2000
3	Turbidity	NTU	0.3	1.00	1	5
4	Odor	-	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	5	15
6	Conductivity	S/m	850	800	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	290.00	210.00	250	1000
9	Total Hardness	mg/l	470	450	200	600
10	Calcium	mg/l	56.11	60.12	75	200
11	Salinity	%	0.50	0.54	NS*	NS*
12	Mg as Mg	mg/l	80.19	72.90	30	100
13	Fluorides as F	mg/l	0.72	0.86	1	1.5
14	Sulphate as SO_4	mg/l	27.00	28.20	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	8.66	9.82	45	100
17	Iron as Fe	mg/l	BQL	BQL	0.3	1.0
18	Sodium as Na	mg/l	49.7	47.2	NS*	NS*
19	Potassium as K	mg/l	5.7	5.2	NS*	NS*
20	Manganese	mg/l	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

4.3 Results & Discussion

The colour of all drinking water samples was Colourless unit and odour of the samples was also agreeable. All parameters are found to be within the specified limit of the Drinking water Standard.

pH

The limit of pH value for drinking water is specified as 7.23 to 7.61. All the sampling points showed pH values within the prescribed limit by Indian Standards.

Total Dissolved Solids (TDS)

TDS values in the studied area varied between 340 - 910 mg/l. None of the sampling points showed higher TDS values than the prescribed limit by Indian standards.

Conductivity

Electrical Conductivity is the ability of a solution to transfer (conduct) electric current. Conductivity is used to measure the concentration of dissolved solids which have been ionized in a polar solution such as water. The conductivity in the samples collected during the month of April ranged from 620-1546 S/m.

BOD

BOD value in the studied area was found Below Quantification Limit (2.0 mg/l). IS 10500 :2012 does not show any standard values for BOD in drinking water.

Chlorides

Excessive chloride concentration increase rates of corrosion of metals in the distribution system. This can lead to increased concentration of metals in the supply. Chloride value in the studied area varied between 210.0- 611.36 mg/l and is found to be within the Permissible limit of the Drinking Water Standard.

Calcium

Calcium value in the studied area varied between 48.10 - 72.14 mg/l and is found to be within the Permissible limit of the Drinking Water Standard. If calcium is present beyond the maximum acceptable limit, it causes incrustation of pipes.

Magnesium

Magnesium value in the studied area varied between 60.75 - 87.48 mg/l. All the locations had Magnesium within the prescribed limits of 30-100 mg/L.

Total Hardness

Hardness value in the studied area varied between 414 - 480 mg/l and is found to be within the Permissible limit of the Drinking Water Standard. The prescribed limit by Indian Standards is 200-600 mg/L.

Iron

Iron value in the studied area was found Below Quantification Limit (0.009 mg/l) and hence well below the permissible limit as per Indian Standards is 0.3 mg/L. The excess amount of iron causes slight toxicity; gives stringent taste to water.

Fluoride

Fluoride value in the studied area varied between 0.28 – 0.88 mg/l and hence well below the permissible limit as per Indian Standards is 1.0-1.5 mg/L. Moderate amounts lead to dental effects, but long-term ingestion of large amounts can lead to potentially severe skeletal problems.

Sulphates

Sulphate value in the studied area varied between 27.0 – 296.0 mg/l. All the sampling points showed sulphate values within the prescribed limits by Indian Standards (200-400 mg/L). Sulphate content in drinking water exceeding the 400 mg/L imparts bitter taste.

Nitrites (NO_2) and Nitrates (NO_3)

Nitrite values in all the water samples were found Below Quantification Limit (0.1 mg/l). There are no specified standard values for Nitrites in Drinking water. The minimum Nitrate value in drinking water of DPA was 6.90 To 12.74 mg/l which is well within the permissible limit of the Drinking water Standard.

Salinity

Salinity in drinking water in the present samples collected ranged from 0.38 to 1.10 %.There are no prescribed Indian standards for salinity in Drinking water**.**

Sodium and Potassium Salts

Sodium values in the samples collected ranged from 47.2 - 341.0 mg/l and Potassium salts ranged from 3.04 to 6.78 mg/l. There are no prescribed limits of Sodium and Potassium in Indian standards for Drinking water**.**

Heavy Metals in Drinking Water

In the present study period drinking water samples were analyzed for Mn, Cr, Cu, Cd, As, Hg, Pb and Zn. All these heavy metals were well Below the Quantification limits prescribed by the Indian Standards.

Bacteriological Study

Analysis of the bacteriological parameter at all location shows that Bacteria is not present and hence Bacterial count is in line with the permissible limit of drinking water. This shows that all the drinking water samples were safe from any bacteriological contamination.

4.4 Conclusions

These results are compared with acceptable limits as prescribed in IS 10500:2012 – Drinking Water Specification. It is seen from the analysis data that during the study period the water was safe for human consumption as per analyzed parameters only at all drinking water monitoring stations.

5.0 Noise Level Monitoring

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. Noise Monitoring was done at 13 stations at Kandla, Vadinar and Township area.

5.1 Method of Monitoring

Sampling was done at all stations for 24 hour period. Data was recorded using automated sound level meter. The intensity of sound was measured in sound pressure level (SPL) and common unit of measurement is decibel (dB).

5.2 Results

Table 16: Noise Monitoring data for ten locations of Deendayal Port and three locations of Vadinar Port

Sr. No.	Location	Day Time Average Noise Level (SPL) in dB(A)	Night Time Average Noise Level (SPL) in dB(A)
	Sampling Time	**6:00 am to 10:00 PM**	**10:00PM to 6:00 AM**
1	Marine Bhavan	58.8	55.2
2	Nirman Building 1	56.4	54.1
3	Tuna Port	55.4	52.9
4	Main Gate North	62.5	59.1
5	West Gate I	73.3	67.2
6	Canteen Area	59.0	57.5
7	Main Road	73.5	69.1
8	ATM Building	66.1	60.1
9	Wharf Area /Jetty Area	73.2	65.7
10	Port & Custom Office	59.4	45.5
Vadinar Port			
11	Entrance Gate of Vadinar Port	55.4	54.5
12	Nr. Port Colony, Vadinar	56.4	54.4
13	Nr. Vadinar Jetty	57.4	53.1

5.3 Conclusions

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. The Day Time Noise Level (SPL)in all 13 locations at Deendayal Port ranged from 56.4 dB(A) to 73.5 dB(A) and it was within the permissible limits of 75 dB(A) for the industrial area for the daytime. The Night Time Average Noise Level (SPL) in all 13 locations of Deendayal Port ranged from 45.5 dB to 69.1 dB(A) and it was within the permissible limits of 70 dB(A) for the industrial area for the night time.

6.0 Soil Monitoring

Sampling and analysis of soil samples were undertaken at six locations within the study area (Deendayal Port and Vadinar Port) as a part of EMP. The soil sampling locations are initially decided based on the locations as provided in the tender document of the Deendayal Port.

6.1 Methodology

The soil samples were collected in the month of April 2022. The samples collected from the all locations are homogeneous representative of each location. At random locations were identified at each location and soil was dug from 30 cm below the surface. It was uniformly mixed before homogenizing the soil samples. The samples were filled in polythene bags, labeled in the field with number and site name and sent to laboratory for analysis.

6.2 Results

Table-17: Chemical Characteristics of Soil in the Study Area for Tuna port, (22° 58' 10.18"E, 70° 6' 3.7"N) IFFCO plant (23° 26' 8.37"E, 70° 13' 4.4"N), Khori creek, (22° 58' 10.18"E, 70° 6' 3.7"N) Nakti Creek,(23° 2' 1.10"E, 70° 9' 33.6"N) DPA admin site,(22° 26' 30.9"E, 69° 40' 37.03"N) DPA colony(22° 23' 57.09"E, 69° 42' 49.42"N)

Sr. No.	Parameter	Unit	Station Name					
			SL1	SL2	SL3	SL4	SL5	SL6
			Tuna Port	IFFCO Plant	Khori Creek	Nakti Creek	DPA Admin Site	DPA Colony
			Near main gate of Port	10 m away from main	Sand from creek at low tide			Vadinar
1	Texture		Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	pH	-	8.03	7.96	8.36	8.60	7.82	7.96
3	Electrical Conductivity	S/m	21,900.00	12,800.00	28,020.00	24,090.0	678.0	490.0
4	Moisture	%	22.31	13.69	49.66	17.12	8.01	8.27
5	Total Organic Carbon	%	0.61	1.03	0.46	0.66	0.36	0.71
6	Alkalinity	mg/kg	18.02	28.03	30.03	18.02	20.02	28.03
7	Total Nitrogen	%	0.05	0.09	0.04	0.06	0.03	0.06
8	Chloride	mg/kg	5,636.6	5,494.8	10,812.3	4,608.5	283.6	212.7
9	Sulphate	mg/kg	780.13	837.61	2,997.73	713.45	128.52	24.2
10	Phosphorus	mg/kg	5.05	5.44	9.67	3.03	5.91	1.33
11	Potassium	mg/kg	187.31	158.40	198.77	140.88	19.47	34.54
12	Sodium	mg/kg	1,921.65	1,993.81	2,879.74	1,630.91	35.52	76.98
13	Calcium	mg/kg	232.46	212.42	1,683.36	228.46	941.88	777.55
14	Copper as Cu	mg/kg	BQL	26.80	17.50	BQL	93.40	72.40
15	Lead as Pb	mg/kg	BQL	5.80	BQL	BQL	BQL	BQL
16	Nickel as Ni	mg/kg	BQL	45.50	10.80	BQL	46.80	41.70
17	Zinc as Zn	mg/kg	BQL	67.20	21.50	BQL	58.20	59.60
18	Cadmium as Cd	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (TN: 0.001%, Cd: 1.0mg/kg).

6.3 Discussion

The data shows that value of pH ranges from 7.82 at DPA Colony (Vadinar) to 8.60 at Natki Creek indicating that all soil samples are neutral to slight basic. Khari Creek samples showed maximum conductivity of 28020.00 µmhos/cm, while DPA Colony (Vadinar) location showed minimum conductivity of 490. S/m. Conductivity at Vadinar Port was 678 S/m at Admin site and Vadinar Port colony respectively.

Total organic Carbon ranged from 0.46 % to 1.03 % at Deendayal Port. At Vadinar Port, organic Carbon range from 0.36 % to 0.71 %.

The concentration of Phosphorus and Potassium in the soil samples varies from 3.03 to 9.67 mg/kg and 140.88 to 198.77 mg/kg respectively at Deendayal Port. The mean concentration of Phosphorous at Vadinar site was 3.62 mg/kg and mean concentration of Potassium at Vadinar site was 27.00 mg/kg.

These differences in NPK in soil at different locations are due to the dissimilar nature of soil at each of the locations. Samples SL3 & SL4 (Khori Creek & Nakti Creek) are of saline nature as they are coastal soil; where as other locations are inland locations and have different chemical properties.

Heavy Metals in the Soil

Traces of Copper, Lead, Nickel and Zinc were observed in the soil samples collected from all the four locations of Deendayal Port and two locations of Vadinar Port. Cadmium metal was below detection limit in the Soil.

6.4 Conclusion

The soils of Deendayal Port and Vadinar Port appears to be neutral to basic with varying levels of Chloride, Sulphate, NPK and Calcium. As the nature of soil at different locations are different with respect to its proximity to the sea, the samples showed high degree of variations in their chemical properties.

7.0 Sewage Treatment Plant Monitoring

This involves safe collection of waste water (spent/used water) from wash areas, bathroom, industrial units, etc., waste from toilets of various buildings and its conveyance to the treatment plant and final disposal in conformity with the requirement and guide lines of State Pollution Control Board and other statutory bodies.

7.1 Methodology for STP Monitoring

To monitor the working efficiency of Sewage Treatment Plant (STP), STP Inlet and Outlet Samples were collected once a week. Locations selected are namely Gopalpuri Township, Deendayal Port and Vadinar. Samples were collected in 1 lit. Carboys and were analyzed in laboratory for various parameters.

7.2 Results

Kandla STP

Table 18: Sewage Water Monitoring at Kandla STP (1st Week)

Date of Sampling	06.04.22

Sr. No.	**Parameters**	**Unit**	**Results**		**GPCB Prescribed Limit**
			DPA STP I/L	**DPA STP O/L**	
1	pH	-	7.72	7.51	6.5 - 8.5
2	Total Suspended	mg/l	126.8	90.2	100
3	Residual Chlorine	mg/l	<0.5	<0.5	-
4	COD	mg/l	90	30	100
5	BOD @ 27 °C	mg/l	24	8	30
Aeration Tank					
7	MLSS	mg/l	11		
8	MLVSS	%	98		

Table 19: Sewage Water Monitoring at Kandla STP (2nd Week)

Date of Sampling	13.04.22

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.61	7.32	6.5 - 8.5
2	Total Suspended Solids	mg/l	109.4	61.5	100
3	Residual Chlorine	mg/l	<0.5	<0.5	-
4	COD	mg/l	80	20	100
5	BOD @ 27 °C	mg/l	22	8	30
Aeration Tank					
7	MLSS	mg/l	14		
8	MLVSS	%	96		

Table 20: Sewage Water Monitoring at Kandla STP (3rd Week)

Date of Sampling	20.04.22

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.65	7.41	6.5 - 8.5
2	Total Suspended Solids	mg/l	126.8	54.7	100
3	Residual Chlorine	mg/l	<0.5	<0.5	-
4	COD	mg/l	120	60	100
5	BOD @ 27 °C	mg/l	38	18	30
Aeration Tank					
7	MLSS	mg/l	10		
8	MLVSS	%	98		

Table 21: Sewage Water Monitoring at Kandla STP (4th Week)

Date of Sampling	27.04.22

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.46	7.23	6.5 - 8.5
2	Total Suspended Solids	mg/l	232	97.1	100
3	Residual Chlorine	mg/l	<0.5	<0.5	-
4	COD	mg/l	108	69	100
5	BOD @ 27 °C	mg/l	26.0	18.0	30
Aeration Tank					
7	MLSS	mg/l	20		
8	MLVSS	%	94.0		

Table 22: Sewage Water Monitoring at Gopalpuri STP (1st Week)

Date of Sampling	06.04.22

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Gopalpuri STP I/L	Gopalpuri STP O/L	
1	pH	-	7.65	7.41	6.5 - 8.5
2	Total Suspended Solids	mg/l	153.4	59.3	100
3	Residual Chlorine	mg/l	<0.5	<0.5	-
4	COD	mg/l	120	80	100
5	BOD @ 27 °C	mg/l	38	20	30
Aeration Tank					
7	MLSS	mg/l	39		
8	MLVSS	%	101		

Table 23: Sewage Water Monitoring at Gopalpuri STP (2nd Week)

Date of Sampling	13.04.22

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Gopalpuri STP I/L	Gopalpuri STP O/L	
1	pH	-	7.56	7.23	6.5 - 8.5
2	Total Suspended Solids	mg/l	170.6	75.5	100
3	Residual Chlorine	mg/l	<0.5	<0.5	-
4	COD	mg/l	110	60	100
5	BOD @ 27 °C	mg/l	30	18	30
Aeration Tank					
7	MLSS	mg/l	40.0		
8	MLVSS	%	84.0		

Table 24: Sewage Water Monitoring at Gopalpuri STP (3rd Week)

Date of Sampling	20.04.22

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Gopalpuri STP I/L	Gopalpuri STP O/L	
1	pH	-	7.53	7.32	6.5 - 8.5
2	Total Suspended Solids	mg/l	131.4	68.6	100
3	Residual Chlorine	mg/l	<0.5	<0.5	-
4	COD	mg/l	110.0	10.0	100
5	BOD @ 27 °C	mg/l	30.0	4.0	30
Aeration Tank					
7	MLSS	mg/l	32.0		
8	MLVSS	%	89.0		

Table 25: Sewage Water Monitoring at Gopalpuri STP (4th Week)

Date of Sampling	27.04.22

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Gopalpuri STP I/L	Gopalpuri STP O/L	
1	pH	-	7.56	7.37	6.5 - 8.5
2	Total Suspended Solids	mg/l	135.6	88.8	100
3	Residual Chlorine	mg/l	<0.5	<0.5	-
4	COD	mg/l	127.0	39.0	100
5	BOD @ 27 °C	mg/l	38.0	10.0	30
Aeration Tank					
7	MLSS	mg/l	18.0		
8	MLVSS	%	95.0		

Vadinar STP

Table 26: Sewage Water Monitoring at Vadinar STP (1st Week)

Date of Sampling	06.04.22

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar O/L	
1	pH	-	7.70	7.50	6.5 - 8.5
2	Total Suspended Solids	mg/l	101.8	43.0	100
3	Residual Chlorine	mg/l	<0.5	<0.5	-
4	COD	mg/l	80	40	100
5	BOD @ 27 °C	mg/l	18	12	30

Table 27: Sewage Water Monitoring at Vadinar STP (2nd Week)

Date of Sampling	13.04.22

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar O/L	
1	pH	-	7.41	7.23	6.5 - 8.5
2	Total Suspended Solids	mg/l	86.9	40.3	100
3	Residual Chlorine	mg/l	<0.5	<0.5	-
4	COD	mg/l	40.0	10.0	100
5	BOD @ 27 °C	mg/l	8.0	4.0	30

Table 28: Sewage Water Monitoring at Vadinar STP (3rd Week)

Date of Sampling	20.04.22

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar O/L	
1	pH	-	7.41	7.23	6.5 - 8.5
2	Total Suspended Solids	mg/l	86.9	40.3	100
3	Residual Chlorine	mg/l	<0.5	<0.5	-
4	COD	mg/l	78.0	39.0	100
5	BOD @ 27 °C	mg/l	21.0	10.0	30

Table 29: Sewage Water Monitoring at Vadinar STP (4th Week)

Date of Sampling	27.04.22

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar O/L	
1	pH	-	7.71	7.42	6.5 - 8.5
2	Total Suspended Solids	mg/l	101.8	43	100
3	Residual Chlorine	mg/l	<0.5	<0.5	-
4	COD	mg/l	69.0	29.0	100
5	BOD @ 27 °C	mg/l	16.0	7.0	30

7.3 Conclusions:

The GPCB specification for pH ,TSS, Residual Chlorine , COD and BOD for STP outlet are 6.5 to 8.5 , 100 mg/lit, 0.5 mg/l, 100 mg/lit and 30 mg/lit respectively. All parameters for STP outlet are within limit. It is suggested to do treatment on regular basis to avoid flow of contamination / Polluent water into the sea.

8.0 Marine Water Monitoring

Marine Water Quality

The Forty Second Amendment to the Constitution in 1976 underscored the importance of 'green thinking'. Article 48A enjoins the state to protect and improve the environment and safeguard the forests and wildlife in the country. Further, Article 51A(g) states that the "fundamental duty of every citizen is to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures".

Policy Statement for Abatement of Pollution (1992) has suggested developing relevant legislation and regulation, fiscal incentives, voluntary agreements and educational programs and information campaigns. It emphasizes the need for integration by incorporating environmental considerations into decision making at all levels by adopting frameworks namely, pollution prevention at source, application of best practicable solution, ensure polluter pays for control of pollution, focus on heavily polluted areas and river stretches and involve public in decision-making. The National Conservation Strategy and Policy Statement on Environment and Development, (1992) aimed at "integrating environmental concerns with developmental imperatives to meet the challenges by redirecting the thrust of our developmental process so that the basic needs of our people could be fulfilled by making judicious and sustainable use of natural resources." The priorities mentioned in this policy document include the sustainable use of land and water resources, prevention and control of pollution and preservation of biodiversity.

The National Water Policy, (2002) contains provisions for developing, conserving, sustainable utilizing and managing this important water resources and need to be governed by national perspectives.

Sampling Stations

The monitoring of marine environment for the study of biological and ecological parameters was carried out on 03rd & 04th April-2022 in harbor regions of DPA and on 03rd April-2022 at Vadinar during spring tide period of New moon phase of Lunar Cycle. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 10th& 11th April 2022 in harbor regions of DPA. 10th April -2022 in Vadinar during Neap tide period first quarter of Lunar Cycle..

Plankton samples from sub surface layer was collected both during high tide period and low tide period from 3 water quality monitoring stations of DPA harbour area and two stations in Nakti creek and one station in Khori creek. The same sampling schedule was repeated during consecutive spring tide and neap tide in same month. Plankton samples from sub surface layer was collected both during high tide period and low tide period from 1 water quality monitoring stations near Vadinar jetty area during spring tide and neap tide in this month. Collected water samples were processed for estimation of Chlorophyll- a, Pheophytin- a, qualitative & quantitative evaluation of phytoplankton, qualitative & quantitative evaluation zooplanktons (density and their population).

Sampling Locations

Offshore monitoring requirement	Number of locations
Offshore Installations	3 in Kandla creek 2 in Nakti creek 1 in Khori creek 1 near Vadinar Jetty 1 near 1st SBM
Total Number of locations	**8**

8.1 Marine Water Quality and Results

Marine water quality of marine waters of Deendayal Port Harbor waters, Khori & Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each month. The results of marine water quality from table no 30 to 37.

Table 30: Marine Water Quality Monitoring Parameters for location near DPA colony

Sr. No.	Parameters	Unit	Kandla Creek Near DPA colony (1)			
			23°0'58"N 70°13'22."E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.36	7.41	7.41	7.36
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31.2	31.8	31.7	32.2
5	Turbidity	NTU	33	34	34.0	35.0
6	Total Dissolved Solids	mg/l	40732	41282	41282.0	48372.0
7	Total Suspended Solids	mg/l	680.9	872.5	872.5	766.8
8	Total Solids	mg/l	46378	45280	42200.0	50100.0
9	DO	mg/l	4.4	4.5	4.5	4.3
10	COD	mg/l	80	76	78	82
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.68	0.7	0.72	0.70
13	Phosphate	mg/l	0.24	0.2	0.20	0.24
14	Sulphate	mg/l	2600	2480	2210	2190
15	Nitrate	mg/l	2.77	2.68	3.12	2.88
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	601.2	681.36	681.36	641.28
18	Magnesium	mg/l	1725.3	1701	1628.1	1676.7
19	Sodium	mg/l	9436	9150	9231.0	9118.0
20	Potassium	mg/l	367.8	327	340.0	336.9
21	Iron	mg/l	0.81	0.31	0.89	2.00
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 31: Marine Water Quality Monitoring Parameters for location near passenger Jetty One at Kandla

Sr. No.	Parameters	Unit	Near passenger Jetty One (2)			
			23° 0'18 "N 70°13'31"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.26	7.30	7.31	7.42
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	32	31.9	31.8	31.1
5	Turbidity	NTU	35	37	37.0	38.0
6	Total Dissolved Solids	mg/l	48372	40680	40680.0	34170.0
7	Total Suspended Solids	mg/l	766.8	751.9	751.9	659.5
8	Total Solids	mg/l	49660	42940	42300.0	35120.0
9	DO	mg/l	4.3	4.4	4.4	4.2
10	COD	mg/l	78	74	72.0	70.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.74	0.72	0.77	0.74
13	Phosphate	mg/l	0.20	0.22	0.30	0.28
14	Sulphate	mg/l	2555	2620	2410	2488
15	Nitrate	mg/l	2.89	2.9	3.07	3.42
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	641.28	561.12	561.12	601.2
18	Magnesium	mg/l	1676.7	1749.6	1773.9	1652.4
19	Sodium	mg/l	9638	9149	9524.0	9198.0
20	Potassium	mg/l	389.6	315.6	371.8	349.8
21	Iron	mg/l	0.69	0.45	1.58	2.19
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Nitrite: 0.05mg/lCu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 32: Marine Water Quality Monitoring Parameters for location Near Coal Berth

Sr. No.	Parameters	Unit	Near Coal Berth			
			22°59'12"N 70°13'40"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.40	7.50	7.51	7.46
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31.2	31.8	32.0	31.9
5	Turbidity	NTU	38	39	39.0	32.0
6	Total Dissolved Solids	mg/l	34170	51520	51520.0	37282.0
7	Total Suspended Solids	mg/l	659.5	811.7	811.7	711.6
8	Total Solids	mg/l	35020	52960	52400.0	38180.0
9	DO	mg/l	4.2	4.3	4.3	4.6
10	COD	mg/l	82	80	72.0	74.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.76	0.78	0.80	0.78
13	Phosphate	mg/l	0.32	0.30	0.18	0.20
14	Sulphate	mg/l	2700	2560	2160	2210
15	Nitrate	mg/l	3.01	2.98	3.96	4.00
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	521.04	601.2	521.04	601.2
18	Magnesium	mg/l	1798.2	1628.1	1725.3	1628.1
19	Sodium	mg/l	9076	8992	9248.0	9639.0
20	Potassium	mg/l	303.7	294.8	343.4	375.9
21	Iron	mg/l	0.13	1.66	0.31	1.77
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 33: Marine Water Quality Monitoring Parameters for location Khori creek at Kandla

Sr. No.	Parameters	Unit	DPA 4			
			Near 15/16 Berth			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.35	7.41	7.38	7.36
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	32	31.6	32.0	31.8
5	Turbidity	NTU	32	34	34.0	39.0
6	Total Dissolved Solids	mg/l	37282	43942	43942.0	36930.0
7	Total Suspended Solids	mg/l	711.6	816.9	816.9	763.6
8	Total Solids	mg/l	38520	54440	44850.0	37720.0
9	DO	mg/l	4.6	4.5	4.5	4.3
10	COD	mg/l	86	88	86.0	88.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.60	0.62	0.88	0.82
13	Phosphate	mg/l	0.19	0.18	0.26	0.28
14	Sulphate	mg/l	2700	2680	2744	2690
15	Nitrate	mg/l	2.66	2.72	3.92	4.20
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	641.28	681.36	561.12	681.36
18	Magnesium	mg/l	1676.7	1628.1	1773.9	1725.3
19	Sodium	mg/l	9130	8875	9710.0	9904.0
20	Potassium	mg/l	314	284	383.4	394.1
21	Iron	mg/l	0.17	1.17	2.82	0.65
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	0.25

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 34: Marine Water Quality Monitoring Parameters for location Nakti Creek near Tuna Port

Sr. No.	Parameters	Unit	Nakti Creek Near Tuna Port			
			22°57'49."N 70° 7'0.67"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.51	7.45	7.28	7.31
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31.7	31.8	31.0	32.2
5	Turbidity	NTU	39	40	40.0	41.0
6	Total Dissolved Solids	mg/l	36930	37440	37440.0	41330.0
7	Total Suspended Solids	mg/l	763.6	843.8	843.8	795.2
8	Total Solids	mg/l	37900	39540	38320.0	42200.0
9	DO	mg/l	4.3	4.4	4.4	4.7
10	COD	mg/l	90	92	92.0	96.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.80	0.82	0.92	0.90
13	Phosphate	mg/l	0.41	0.40	0.19	0.16
14	Sulphate	mg/l	2860	2900	2780	2710
15	Nitrate	mg/l	3.46	3.56	5.26	4.98
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	601.2	561.12	721.44	681.36
18	Magnesium	mg/l	1749.6	1749.6	1628.1	1628.1
19	Sodium	mg/l	10280	10418	9805.0	9669.0
20	Potassium	mg/l	392.3	404.1	393.8	380.3
21	Iron	mg/l	1.1	1.52	1.20	1.34
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 35: Marine Water Quality Monitoring Parameters for location Nakti Creek Near NH-8A at Kandla

Sr. No.	Parameters	Unit	Nakti Creek Near NH-8A			
			23° 02'01"N 70° 09'31"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.45	Sampling not possible during Low Tide	31.0	Sampling not possible during Low Tide
2	Color	-	Colorless		Colorless	
3	Odor	-	Odorless		Odorless	
4	Salinity	ppt	31.4		18.1	
5	Turbidity	NTU	41		40	
6	Total Dissolved Solids	mg/l	41330		21035	
7	Total Suspended Solids	mg/l	795.2		678.5	
8	Total Solids	mg/l	42240		21812	
9	DO	mg/l	4.7		4.5	
10	COD	mg/l	94		96	
11	BOD	mg/l	BQL		BQL	
12	Silica	mg/l	0.84		0.85	
13	Phosphate	mg/l	0.43		0.21	
14	Sulphate	mg/l	2820		2376	
15	Nitrate	mg/l	4.01		4.65	
16	Nitrite	mg/l	BQL		BQL	
17	Calcium	mg/l	641.28		641.28	
18	Magnesium	mg/l	1676.7		1725.3	
19	Sodium	mg/l	10446		9631	
20	Potassium	mg/l	405.7		375.6	
21	Iron	mg/l	1.39		1.07	
22	Chromium	mg/l	BQL		BQL	
23	Copper	mg/l	BQL		BQL	
24	Arsenic	mg/l	BQL		BQL	
25	Cadmium	mg/l	BQL		BQL	
26	Mercury	mg/l	BQL		BQL	
27	Lead	mg/l	BQL		BQL	
28	Zinc	mg/l	BQL		0.02	

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 36: Marine Water Quality Monitoring Parameters for locations Nr. Vadinar Jetty

Sr. No.	Parameters	Unit	Nr.Vadinar Jetty			
			22°26'25.26"N 69°40'20.41"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.41	7.36	7.38	7.41
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31.5	31.8	31.8	32.0
5	Turbidity	NTU	37	36	36.0	34.0
6	Total Dissolved Solids	mg/l	35495	41380	41380.0	34860.0
7	Total Suspended Solids	mg/l	725.9	666.8	666.8	689.7
8	Total Solids	mg/l	36340	43060	42120.0	36620.0
9	DO	mg/l	4.5	4.6	4.6	4.4
10	COD	mg/l	80	82	80.0	82.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.86	0.88	0.72	0.76
13	Phosphate	mg/l	0.32	0.30	0.18	0.20
14	Sulphate	mg/l	2610	2580	2468	2392
15	Nitrate	mg/l	4.88	4.92	3.52	2.98
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	681.36	601.2	561.12	601.2
18	Magnesium	mg/l	1603.8	1628.1	1701	1701
19	Sodium	mg/l	10551	10739	10346.0	10450.0
20	Potassium	mg/l	418	422.4	430.5	420.3
21	Iron	mg/l	0.56	0.79	0.56	0.79
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 37: Marine Water Quality Monitoring Parameters for locations Nr. Vadinar SPM

Sr. No.	Parameters	Unit	Nr.Vadinar SPM			
			22°30'56.15"N 69°42'12.07"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.28	7.25	7.44	7.4
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	32	32.1	32.2	32.4
5	Turbidity	NTU	34	35	42	43
6	Total Dissolved Solids	mg/l	34860	37750	34920	35216
7	Total Suspended Solids	mg/l	689.7	641.6	688	692
8	Total Solids	721.44	37940	38440	36210.0	36426
9	DO	mg/l	4.4	4.3	4.8	4.5
10	COD	mg/l	88	90	80.0	84
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.9	0.92	0.74	0.79
13	Phosphate	mg/l	0.32	0.28	0.30	0.32
14	Sulphate	mg/l	2789	2492	2770	2710
15	Nitrate	mg/l	5.96	6.22	4.93	5.01
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	561.12	521.04	641.28	681.36
18	Magnesium	mg/l	1628.1	1725.3	1676.7	1628.1
19	Sodium	mg/l	10682	10708	10538.0	10678
20	Potassium	mg/l	409.8	421.4	434.9	438.6
21	Iron	mg/l	0.7	0.83	0.7	0.83
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

8.2 Results & Discussion for Marine water samples

Marine water quality of marine waters of Deendayal Port Harbor waters, Khori and Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters

during spring and neap tide of each month. The Heavy metal analyzed and found below quantification limit .

pH

The limit of pH value for drinking water is specified as 7.25 to 7.51.

Total Dissolved Solids (TDS)

TDS values in the studied area varied between 34170 to 51520 mg/l.

Calcium

Calcium value in the studied area varied between 521.04 to 721.44 mg/l.

Magnesium

Magnesium value in the studied area varied between 1603.80 to 1798.20 mg/l.

Iron

Iron value in the studied area was found 0.13 to 2.82 mg/l).

Sulphates

Sulphate value in the studied area varied between 2160.0 – 2900.0 mg/l.

Salinity

Salinity in marine water in the present samples collected ranged from 31.0 to 32.4 %.

Sodium and Potassium Salts

Sodium values in the samples collected ranged from 8875.0 to 10739.0 mg/l and Potassium salts ranged from 284.0 to 438.6 mg/l.

Heavy Metals in Drinking Water

In the present study period marine water samples were analyzed for Cr, Cu, Cd, As, Hg, Pb and Zn. All these heavy metals were well Below the Quantification limits prescribed by the Indian Standards.

9.0 Marine Sediments

Sediment samples were collected with Van Veen Grab from the six locations in Kandla Port Waters and two locations in Vadinar Port. Samples were collected and preserved in silver foil in ice box to prevent the contamination/decaying of the samples.

9.1 Results

The Sediment Quality results are given in below from table no. 38 & 39.

Table 38: Results of Analysis of Sediment of Kandla & Vadinar Port (Spring Tide)

Sr. No.	Parameters	Unit	DPA - 1	DPA - 2	DPA - 3	DPA - 4	DPA - 5	Jetty	SPM
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	1.31	4.26	1.43	0.72	0.57	5.48	2.86
3	Organic Carbon	mg/kg	0.76	2.47	0.83	0.42	0.33	3.18	1.66
4	Inorganic Phosphate	mg/kg	110.00	112.00	122.00	132.00	144.00	142.00	156.00
5	Moisture	%	11.02	33.21	7.35	4.73	8.85	28.89	29.69
6	Aluminium	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
7	Silica	mg/kg	30.20	24.20	32.00	28.00	34.20	49.20	48.88
8	Phosphate	mg/kg	2.58	BQL	1.41	3.29	3.83	1.04	2.72
9	Sulphate	mg/kg	282.56	867.09	198.77	190.91	194.90	938.80	570.04
10	Nitrite	mg/kg	0.11	0.12	0.10	0.11	0.13	0.11	0.12
11	Nitrate	mg/kg	11.10	12.22	10.22	11.62	14.20	11.85	13.02
12	Calcium	mg/kg	164.33	236.41	220.44	172.34	112.22	244.49	252.50
13	Magnesium	mg/kg	51.03	116.64	34.02	51.03	48.60	182.25	128.79
14	Sodium	mg/kg	640.40	1315.14	385.49	405.60	405.65	1145.33	1194.03
15	Potassium	mg/kg	43.96	136.25	23.69	27.58	26.82	217.63	162.70
16	Chromium	mg/kg	18.10	48.70	8.00	5.00	8.00	44.90	13.50
17	Nickel	mg/kg	10.00	38.30	BQL	BQL	5.60	28.90	5.70
18	Copper	mg/kg	7.20	14.20	BQL	BQL	BQL	14.00	B
19	Zinc	mg/kg	16.90	59.30	BQL	BQL	25.70	38.40	5.70
20	Cadmium	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
21	Lead	mg/kg	BQL	5.20	BQL	BQL	BQL	BQL	BQL
22	Mercury	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
23	Arsenic	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL

*ND - Not Detected, BQL: Below Quantification Limit (NO3:10.0mg/kg, Cd: 1.0mg/kg, Hg: 1.0mg/kg, As: 1.0mg/kg).

Table 39 : Results of Analysis of Sediment of Kandla & Vadinar Port (Neap Tide)

Sr. No.	Parameters	Unit	DPA - 1	DPA - 2	DPA - 3	DPA - 4	DPA - 5	Jetty	SPM
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	2.33	5.14	2.00	1.38	1.67	8.57	14.15
3	Organic Carbon	mg/kg	1.35	2.98	1.16	0.80	0.97	4.97	8.21
4	Inorganic Phosphate	mg/kg	112.00	109.00	115.00	130.00	136.00	152.00	157.00
5	Moisture	%	9.22	24.86	11.12	7.93	17.60	28.11	36.89
6	Aluminium	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
7	Silica	mg/kg	28.88	22.60	30.00	24.00	30.20	52.60	56.20
8	Phosphate	mg/kg	3.90	1.38	1.16	1.23	BQL	BQL	0.93
9	Sulphate	mg/kg	241.00	433.27	296.55	402.90	285.38	864.14	1077.88
10	Nitrite	mg/kg	0.11	0.12	0.11	0.10	0.12	0.12	0.11
11	Nitrate	mg/kg	BQL	BQL	BQL	BQL	BQL	13.32	14.20
12	Calcium	mg/kg	180.36	200.40	176.35	192.38	160.32	260.52	212.42
13	Magnesium	mg/kg	60.75	75.33	63.18	53.46	94.77	114.21	167.67
14	Sodium	mg/kg	360.43	474.10	379.45	408.00	326.90	816.95	1335.31
15	Potassium	mg/kg	21.87	85.61	32.25	25.83	35.97	144.95	195.05
16	Chromium	mg/kg	42.90	40.70	8.60	67.30	14.80	53.00	59.50
17	Nickel	mg/kg	33.00	31.80	5.20	47.10	8.70	39.70	44.30
18	Copper	mg/kg	21.90	12.20	BQL	28.60	BQL	32.10	27.00
19	Zinc	mg/kg	53.80	47.60	14.30	67.60	14.60	70.30	62.50
20	Cadmium	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
21	Lead	mg/kg	5.30	BQL	BQL	5.40	BQL	31.10	5.50
22	Mercury	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
23	Arsenic	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL

*ND - Not Detected, BQL: Below Quantification Limit (NO3:10.0mg/kg,Cd: 1.0mg/kg,Hg: 1.0mg/kg, As: 1.0mg/kg)

9.2 Discussion of Marine Sediment samples

Marine Sediments of Deendayal Port Harbor waters, Khori and Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each month. The Heavy metal analyzed and found below quantification limit.

The soil types is majority Sandy loamy. Also many of the parameters found below Quantification limit wise NO3, Cd, Hg, AS etc.

10.1 INTRODUCTION:

Sampling Stations:

The monitoring of marine environment for the study of biological and ecological Parameters was carried out on 03rdApril 2022 in harbour region of DPA at Kandla Creek, and on 04thApril 2022 in creeks near by the port during spring tide. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 25thApril,2022 in harbour region of DPA at Kandla Creek and on 26th April, 2022 in creeks near by the port during neap tidal condition.

Plankton samples from sub surface layer was collected both during high tide period and low tide period from 3 water quality monitoring stations of DPA harbour area and two stations in Nakti creek and one station in Khori creek. Sampling at second sampling station of Nakti creek was possible only during high tide period. The same sampling schedule was repeated duringconsecutive Neap tide and spring tide in same month.

Plankton samples from sub surface layer were collected during high tide period and low tide period from monitoring station near Vadinar jetty at Path Finder Creek during spring tide on 03/03/2022 and Neap tide period on 10/03/2022. Collected water samples were processed for estimation of Chlorophyll- a, Pheophytin - a, qualitative & quantitative evaluation of phytoplankton, qualitative & quantitative evaluation zooplanktons(density and their population).

TABLE #1 SAMPLING LOCATIONS

monitoring requirement	Number of locations
Kandla creek Nakti creek Khori Creek Vadinar jetty SPM	3 in Kandla creek 2 in Nakti creek 1 in Khori creek 1 near Vadinar Jetty 1 near I stSPM
Total Number of locations	**8**

Sampling methodology adopted:

A marine sampling is an estimation of the body of information in the population. The theory of the sampling design is depending upon the underlying frequency distribution of the population of interest. The requirement for useful water

sampling is to collect a representative sample of suitable volume from the specified depth and retain it free from contamination during retrieval.

50 litres of the water sample were collected from Sub surface by using bucket. From the collected water sample 1 litres of water sample were taken in an opaque plastic bottle for chlorophyll estimation, thereafter plankton samples were collected by using filtration assembly with nilyobolt cloth of 20µm mesh size.

Samples Processing for chlorophyll estimation:

Samples for the chlorophyll estimation were preserved in ice box on board in darkness to avoid degradation in opaque container covered with aluminium foil. Immediately after reaching the shore after sampling, 1 litre of collected water sample was filtered through GF/F filters (pore size 0.45 µm) by using vacuum filtration assembly. After vacuum filtration the glass micro fiber filter paper was grunted in tissue grinder, macerating of glass fiber filter paper along with the filtrate was done in 90% aqueous Acetone in the glass tissue grinder with glass grinding tube. Glass fiber filter paper will assist breaking the cell during grinding and chlorophyll content was extracted with 10 ml of 90% Acetone, under cold dark conditions along with saturated magnesium carbonate solution in glass screw cap tubes. After an extraction period of 24 hours, the samples were transferred to calibrated centrifuge tubes and adjusted the volume to original volume with 90% aqueous acetone solution to make up the evaporation loss. The extract was clarified by using centrifuge in closed tubes. The clarified extracts were then decanted in clean cuvette and optical density was observed at wavelength 664, 665 nm. By using corrected optical density, Chlorophyll-a value was calculated as given in (APHA, 1998).

PLANKTON:

The entire area open water in the sea is the pelagic realm. Pelagic organisms live in the open sea. In contrast to the pelagic realm, the benthic realm comprises organisms and zone of the bottom of the sea. Vertically the pelagic realm can be dividing into two zones based on light penetration; upper photic or euphotic zone and lower dark water mass, aphotic zone below the photic zone.

The term plankton is general term for organisms have such limited powers of locomotion that they are at the mercy of the prevailing water movement. Plankton is subdivided to phytoplankton and zooplankton. Phytoplankton is free floating organisms that are capable of photosynthesis and zooplankton is the various free floating animals.

Pelagic zone, represents the entire ocean water column from the surface to the deepest depths, is home to a diverse community of organisms. Differences in their locomotive ability categorize the organisms in the pelagic realm into two, ***plankton*** and ***nekton*** (Lalli and Parsons, 1997). ***Plankton*** consists of all organisms drifting in the water and is unable to swim against water currents, whereas ***Nekton*** includes organisms having strong locomotive power. Ecological studies on the plankton community, which form the base of the aquatic food chain, help in the better understanding of the dynamics and functioning of the marine ecosystem. The term 'Plankton' first coined by Victor Hensen (1887), Plankton, (Greek word: *planktos* meaning "passively drifting or wandering") is defined as drifting or free-floating organisms that inhabit the pelagic zone of water. Based on their mode of nutrition planktonic organisms are categorised into phytoplankton (organisms having an autotrophic mode of nutrition) and zooplankton (organisms having a heterotrophic mode of nutrition).

Phytoplankton in the marine environment:

Phytoplankton is free floating unicellular, filamentous and colonial eutrophic organisms that grow in aquatic environments whose movement is more or less dependent upon water currents. These micro flora acts as primary producers as well as the basis of food chain, source of protein, bio purifier and bio indicators of the aquatic ecosystems of which diverse array of the life depends. They are considered as an important component of aquatic flora, play a key role in maintaining equilibrium between abiotic and biotic components of aquatic ecosystem.

The phytoplankton includes a wide range of photosynthetic and phototrophic organisms. Marine phytoplankton is mostly microscopic and unicellular floating flora, which are the primary producers that support the pelagic food-chain. The two most prominent groups of phytoplankton are diatoms (Bacillariophyceae) and dinoflagellates (Dinophyceae).The phytoplankton those normally captured in the net from the Gulf of Kutch is normally dominated by these two major groups; diatoms and dinoflagellates. Phytoplankton also include numerous and diverse collection of extremely small, motile algae which are termed micro flagellates (naked flagellates) as well as and Cyanophytes (blue-green algae).

Algae are an ecologically important group in most aquatic ecosystems and have been an important component of biological monitoring programs. Algae are ideally suited for water quality assessment because they have rapid reproduction

rates and very short life cycles, making them valuable indicators of short-term impacts.

Aquatic populations are impacted by anthropogenic stress, resulting in a variety of alterations in the biological integrity of aquatic systems. Algae can serve as an indicator of the degree of deterioration of water quality, and many algal indicators have been used to assess environmental status.

Zooplankton in the marine environment:

Zooplankton includes a taxonomically and morphologically diverse community of heterotrophic organisms that drift in the waters of the world's oceans. Qualitative and quantitative studies on zooplankton community are a prerequisite to delineate the ecological processes active in the marine ecosystem. Zooplankton community plays a pivotal role in the pelagic food web as the primary consumers of phytoplankton and act as the food source for organisms in the higher trophic levels, particularly the economically essential groups such as fish larvae and fishes. They also function in the cycling of elements in the marine ecosystem. The dynamics of the zooplankton community, their reproduction, and growth and survival rate are all significant factors determining the recruitment and abundance of fish stocks as they form an essential food for larval, juvenile and adult fishes (Beaugrand et al., 2004). Zooplankton grazing in the marine environment controls the primary Production and helps in determining the pelagic ecosystem (Banse, 1995). Through grazing in surface waters and following the production of sinking faecal matters and also by the active transportation of dissolved and particulate matter to deeper waters via vertical migration, they help in the transport of organic carbon to deep ocean layers and thus act as key drivers of biological pump in the marine ecosystem. Zooplankton grazing and metabolism also, transform particulate organic matter into dissolved forms, promoting primary producer community, microbial demineralization, and particle export to the ocean’s interior.

The categorisation of zooplankton into various ecological groups is based on several factors such as duration of planktonic life, size, food preferences and habitat. As they vary significantly in size from microscopic to metazoic forms, the classification of zooplankton based on size has paramount importance in the field of quantitative plankton research.

Based on the duration of planktonic life, zooplankton are categorised into Holoplankton (organisms which complete their entire lifecycle as plankton) and Meroplankton (organisms which are planktonic during the early part of their lives

such as the larval stages of benthic and nektonic organisms). Tychoplankton are organisms which live a brief planktonic life, such as the benthic crustaceans (Cumaceans, mysids, isopods) which ascend to the water column at night for feeding and certain ectoparasitic copepods, they leave the host and spend their life as plankton during their breeding cycle.

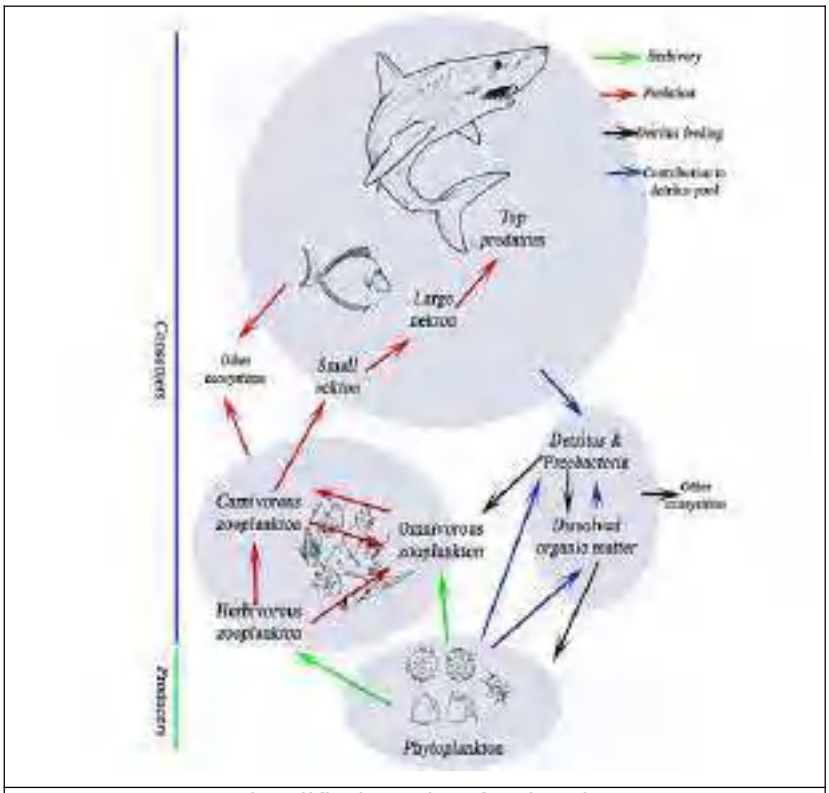
Zooplankton can be subdivided into holoplankton, i.e., permanent members of the plankton (e.g., Calanoid copepods), and meroplankton, i.e., temporary members in the plankton e.g., larvae of fish, shrimp, and crab). The meroplankton group consists of larval and young stages of animals that will adopt a different lifestyle once they mature. In contrast to phytoplankton which consist of a relatively smaller variety of organisms, Zooplankton are extremely divers, consist of a host of larval and adult forms representing many animal phylum.

Among the zooplankton one group always dominate than others; members of sub class copepods (Phylum Athropoda) and Tintinids (Phylum Protozoa) among the net planktons. These small animals are of vital importance in marine ecosystem as one of the primary herbivores animals in the sea, and it is they provide vital link between primary producer (autotrophs) and numerous small and large marine consumers.

As their community structure and function are highly susceptible to changes in the environmental conditions regular monitoring of their distribution as well as their interactions with various physicochemical parameters is inevitable for the sustainable management of the ecosystem (Kusum et al., 2014). Of all the marine zooplankton groups, copepods mainly Calanoid copepods are the dominant groups in marine subtropical and tropical waters and exhibit considerable diversity in morphology and habitats they occupy (Madhupratap, 1991;)

It has been well established that potential of pelagic fishes viz. finfishes, crustaceans, molluscs and marine mammals either directly or indirectly depend on zooplankton. The herbivorous zooplankton is efficient grazers of the phytoplankton and is referred to as living machines transforming plant material into animal tissue. Hence they play an essential role as the intermediaries for nutrients/energy transfer between primary and tertiary trophic levels. Due to their large density, shorter lifespan, drifting nature, high group/species diversity and different tolerance to the stress, they used as the indicator organisms for the

physical, chemical and biological processes in the aquatic ecosystem (Ghajbhiye, 2002).



Simplified marine food web

Spatial distribution of Plankton:

A characteristic of plankton population is that they tend to occur in patches, which are varying spatially on a scale of few meters to far as few kilometers in distance. They also vary in time scale, season as well as vertically in the water column. It is this patchiness and its constant changes in time and spot, that has made it so difficult for plankton biologist to learn about the ecology of plankton. The biological factors that causes this patchiness is due to the ability of zooplankton to migrate vertically and graze out the phytoplankton at a rapid rate that can create patchiness. Similarly the active swimming ability by certain zooplankton organisms can cause to aggregate in dense group.

At its most extreme, because the water in which plankton is suspended is constantly moving, each sample taken by the plankton biologists remain a different volume of water, so each sample is unique and replicate does not exist.

Plankton may also exhibit vertical patchiness. Physical factors contribute to this type of patchiness include light intensity, nutrients and density gradients in the water column.

Phytoplankton in particular tends to be unequally distributed vertically, which leads to the existence of different concentration of a chlorophyll value between photic zone and below the photic zone.

Methodology adopted for Plankton sampling:

Mixed plankton sample were obtained from the sub surface layer at each sampling locations by towing the net horizontally with the weight. After the tow of about 15-30minutes, plankton net was pulled up and washed down to the tail and collected the plankton adhered to plankton net in the collection bucket at the bottom by springing outer and inner surface of the net with sea water, while the net was hanging with the mouth upward. For quantitative evaluation 50 L water samples were collected from subsurface layer and filtered through 20µm mesh size net by using bucket and filtration assembly.

Preservation and storage:

Both filtered plankton and those collected from the plankton net were preserved with 5% buffered formalin and stored in 1L plastic container for further processing in the laboratory.

Sample concentration:

The collected plankton samples were concentrated by using centrifuge and made up to 50 ml with 5% formalin -Glycerine mixture.

Taxonomic evaluation:

Before processing, the sample was mixed carefully and a sub sample was taken with a calibrated Stempel-pipette. 1 ml of the concentrated plankton samples were transferred on a glass slide with automatic pipette. The plankton sample on the glass slides were stained by using Lugol's iodine and added glycerine to avoid drying while observation. The plankton samples were identified by using Labex triangular Research microscope with photographic attachment. Microphotographs of the plankton samples were taken for record as well as for confirming the identification. The bigger sized zooplankton was observed through dissecting stereomicroscope with magnification of 20-30 x. Plankton organisms in the whole slide were identified to the lowest axon possible. A thorough literature search was conducted for the identification of the different groups of zooplankton that were encountered

Cell counts by drop count method:

The common glass slide mounted with a 1ml of concentrated phytoplankton/zooplankton sample in glycerol and covered with cover slip 22 x 60mm was placed under the compound microscope provided with a mechanical

stage. The plankton was then counted from the microscopic field of the left top corner of the slide. Then slide is moved horizontally along the right side and plankton in each microscopic field was thus counted. When first microscopic field row was finished the next consecutive row was adjusted using the mechanical device of the stage. In this way all the plankton present in entire microscopic field are counted. From this total number in 1ml of the concentrated plankton, total number of plankton in the original volume of sample filtered was calculated as units/L.

BENTHIC ORGANISMS:

Benthos is those organisms that are associated with the sea bed or benthic habitats. Epi- benthic organisms live attached to a hard substratum or rooted to a shallow depth below the surface. In fauna organisms live below the sediment–water interface. Interstitial organisms live and move in pore water among sedimentary grains.

Because the benthic organisms are often collected and separated on sieves, a classification based on the overall size is used. Macro benthos include organisms whose shortest dimension is greater than or equal to 0.5 mm. Meio benthos are smaller than 0.5mm but larger than 42µ in size.

The terms such as macro fauna and Meio fauna generally have little relevance with taxonomic classification. The terms Meio fauna and macro fauna depend on the size. Meio fauna were considered as good bioassay of community health and rather sensitive indicators of environmental changes.

SAMPLING METHODOLOGY ADOPTED FOR SUB TIDAL REGION:

Van veen sampler ($0.09m^2$) was used for sampling bottom sediments. Two sets of sediments were sampled from each location, one for macro fauna and other for Meio fauna. The macro fauna in the sediments were sieved on board to separate out the organisms. The fixation of Meio fauna is normally done by bulk fixation of the sediment sample. The bulk fixation is done by using 10% formalin (Buffered with borate). The organisms were preserved with seawater as diluting agent.

Sample sieving:

Sediments samples were sieved to extract the organisms. Sieving was performed carefully as possible to avoid any damage to the animals. The large portion of the sediment was split in to smaller portions and mixed with sea water in a bucket. The cohesive lumps were broken down by continuous stirring. The dis-aggregated sediments were then passed through the sieves.

Sample staining:

Sorting of the Meio fauna from the sieve is difficult task especially in the preserved material, because organisms are not easily detectable. To facilitate the animal detection the entire sample retained on the sieve after sieving operation were stained by immersing the sieve in a flat bottom tub with 1% Rose Bangal stain; a protein stain. A staining period of 10-30 minutes is sufficient for sample detection.

DIVERSITY INDICES:

On the whole, diversity indices provide more information about community composition than simply species richness (number of species present); they also, take the relative abundances of different species into account. Based on this fact, diversity indices therefore depend not only on species richness but on the evenness, or equitability, with which individuals are distributed among the different species (Magurram, A.E. (1988).

A diversity index is a measure of species diversity within a community that consists of co-occurring populations of several (two or more) different species. It includes two components: richness and evenness. Richness is the measure of the number of different species within a sample showing that more the types of species in a community, the higher is the diversity or greater is the richness. Evenness is the measure of relative abundance of the different species within a community.

The basic idea of diversity index is to obtain a quantitative estimate of biological variability that can be used to compare biological entities composed of discrete components in space and time (Carol H.R. *etal*. 1998). Biodiversity is commonly expressed through indices based on species richness and species abundances (Whittaker 1972, Lande 1996, Purvis and Hector 2000). Biodiversity indices are a non-parametric tool used to describe the relationship between species number and abundance. The most widely used bio diversity indices are Shannon Weiner index and Simpson’s index.

A diversity Index is a single statistic that incorporates in formation on richness and evenness. The diversity measures that incorporate the two concepts may be termed heterogeneity measures (Magurran, 2004).

Any study intended to interpret causes and effect of adverse impact on Biodiversity of communities require suitable measures to evaluate specie richness and Diversity. The former is number of species in community, while latter is a function of relative frequency of different species. Species richness is

the iconic measure of biological diversity (Magurran, 2004). Several indices have been created to measure the diversity of species; however, the most widely used in the last decades are the Shannon (1948) and Simpson (1949) (Buzas and Hayek 1996; Gorelick 2006), with the components of diversity: richness (*S)* and evenness (*J)*

Simpson's diversity index

Simpson's index (**D**) is a measure of diversity, which takes into account both species richness, and evenness of abundance among the species present. The Simson index is one of the meaningful and robust biodiversity measures available.(Magurran ,2004).

Low species diversity suggests:

Relatively few successful species in the habitat

The environment is quite stressful with relatively few ecological niches and only a few organisms are really well adapted to that environment

Food webs which are relatively simple

Change in the environment would probably have quite serious effects

High species diversity suggests:

A greater number of successful species and a more stable ecosystem

More ecological niches are available and the environment is less likely to be hostile complex food webs

Environmental change is less likely to be damaging to the ecosystem as a whole

Species richness indices

The species richness***(S)*** is simply the number of species present in an ecosystem. Species richness Indices of species richness are widely used to quantify or monitor the effects of anthropogenic disturbance. A decline in species richness may be concomitant with severe or chronic human-induced perturbation (Fair Fair weather 1990,) Species richness measures have traditionally been the mainstay in assessing the effects of environmental degradation on the biodiversity of natural assemblages of organisms (Clarke &Warwick, 2001)

Species richness is the iconic measure of biological diversity (Magurran, 2004). The species richness ***(S)*** is simply the number of species present in an ecosystem. This index makes no use of relative abundances. The term species richness was coined by McIntosh (1967) and oldest and most intuitive measure of biological diversity (Magurran, 2004).

Margalef's diversity index is a species richness index. Margalef's Species richness index (d), or indices that describe the evenness of the distribution of the numbers of individuals among species, were derived.

The value of a diversity index increases both when the number of types increases and when evenness increases. For a given number of types, the value of diversity index is maximized when all types are equally abundant (Rosenzweig, M. L. (1995).

Shannon-Wiener's index:

An index of diversity commonly used in plankton community analyses is the Shannon-Wiener's index **(H),** which emphasizes not only the number of species (richness or variety), but also the apportionment of the numbers of individuals among the species (Odum 1971 and Reish 1984). Shannon-Wiener's index **(H**) reproduces community parameters to a single number by using an equation.

$$H' = -\sum_{j=1}^{s} \frac{n_j}{N} \ln\left(\frac{n_j}{N}\right)$$

Shannon and Weiner index represents entropy. It is a diversity index taking into account the number of individuals as well as the number of taxa. It varies from 0 for communities with only single taxa to high values for community with many taxa each with few individuals. This index can also determine the pollution status of a water body. Normal values range from 0 to 4. This index is a combination of species present and the evenness of the species. Examining the diversity in the range of polluted and unpolluted ecosystems, Wilham and Dorris (1968) concluded that the values of the index greater than 3 indicate clean water, values in the range of 1 to 3 are characterized by moderate pollution and values less than 1 are characterized as heavily polluted

10.2 RESULTS:

CHLOROPHYLL-a:

Water Samples for the chlorophyll estimation were collected from sub surface layer during high tide and low tide period of the tidal cycle for each sampling locations and analysed for Chlorophyll -a and after acidification for Pheophytin –a. Chlorophyll- a value was used as algal biomass indicator (APHA,1998) Algal biomass was estimated by converting Chlorophyll value.

In the sub surface water chlorophyll-a was varying from 0.409- 0.865 mg/m^3 with an average value 0.594 mg/m^{3}of in harbour region of DPA in Kandla Creek during sampling done in spring tide period of April 2022. In the nearby creeks chlorophyll-a was varying from 0.322- 1.103mg/m^3.with an average value 0.740 mg/m^{3}Pheophytin –a level was below detectable limit- the all the sampling stations during springtide.

In the sub surface water chlorophyll-a was varying from 0.307 -0.882mg/m^{3}with an average value 0.639 mg/m^3.in harbour region of DPA in Kandla Creek during sampling done in neap tide period of April 2022. In the nearby creeks chlorophyll-a was varying from 0.271 0.574 mg/m^3 with an average value 0.461 mg/m^3.·Pheophytin –a level was below detectable limit- the all the sampling stations.

In the sub surface water chlorophyll-a was varying from 0.731 – 0.835 mg/m^{3}with an average value 0.761 mg/m^3.in harbour region of DPA OOT in path finder Creek during sampling done in spring tide period of April 2022. In the sub surface water chlorophyll-a was varying from 0.630- 1.039 mg/m^3 ^{3} with an average value 0.809 mg/m^3.in harbour region of DPA OOT in path finder Creek during sampling done in Neap Tide period of April 2022.5.23

TABLE 40 VARIATIONS IN CHLOROPHYLL –a PHEOPHYTIN- a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPA HARBOUR AREA IN KANDLA CREEK ,NEAR BY CREEKS AND DPA OOT JETTY IN PATH FINDER CREEK AND SPM NEAR VADINARDURING SPRING TIDE IN APRIL 2022

Sr. No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPA HARBOUR AREA KANDLA CREEK					
1	DPA1 - Oil Jetty	High tide	0.645	BDL	43.21
		Low tide	0.409	BDL	27.40
2	DPA 2 - Passenger Jetty	High tide	0.865	BDL	57.95
		Low tide	0.544	BDL	36.45
3	DPA 3 - Coal Berth	High tide	0.542	BDL	36.31
		Low tide	0.558	BDL	37.39
CREEKS					
4	DPA-4 Khori-I	High tide	0.662	BDL	44.35
		Low tide	0.630	BDL	42.21
5	DPA-5 Nakti-I	High tide	1.103	BDL	73.90
		Low tide	0.985	BDL	65.99
6	DPA-6 Nakti-II	High tide	0.322	BDL	21.57
PATHFINDER CREEK VADINAR					
7	VADINAR-I jetty	High tide	0.731	BDL	48.97
8		Low tide	0.732	BDL	49.04
9	SPM	High tide	0.835	BDL	55.94
10	SPM	Low tide	0.748	BDL	50.11

BDL: Below Detectable Limit.

TABLE 41 VARIATIONS IN CHLOROPHYLL –a PHEOPHYTIN- a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPA HARBOUR AREA ,NEAR BY CREEKS AND DPA OOT JETTY IN PATH FINDER CREEK AND SPM NEAR VADINAR DURING NEAP TIDE IN APRIL 2022

Sr. No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPA HARBOUR AREA KANDLA CREEK					
1	DPA1 - Oil Jetty	High tide	0.882	BDL	59.09
		Low tide	0.307	BDL	20.57
2	DPA 2 - Passenger Jetty	High tide	0.678	BDL	45.42
		Low tide	0.543	BDL	36.38
3	DPA 3 - Coal Berth	High tide	0.559	BDL	37.45
		Low tide	0.866	BDL	58.02
CREEKS					
4	DPA-4 Khori-I	High tide	0.560	BDL	37.52
		Low tide	0.441	BDL	29.54
5	DPA-5 Nakti-I	High tide	0.458	BDL	30.69
		Low tide	0.272	BDL	18.22
6	DPA-6 Nakti-II	High tide	0.575	BDL	38.53
PATHFINDER CREEK VADINAR					
7	VADINAR-I jetty	High tide	1.039	BDL	69.61
8		Low tide	0.733	BDL	49.11
9	SPM	High tide	0.630	BDL	42.21
10	SPM	Low tide	0.834	BDL	55.88

BDL: Below Detectable Limit.

PHYTOPLANKTON POPULATION:

For the evaluation of the Phytoplankton population in DPA harbour area and within the immediate surroundings of the port, sampling was conducted from 5 sampling locations (3 in harbour area and two in Nakti creek) during high tide period and low tide period of spring tide and neap tide.

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by, Diatoms blue green algae and dinoflagellates during spring tide period. Diatoms were represented by 24 genera. Blue green were represented by 2 genera and dinoflagellates were represented by 3 genera during the sampling conducted in spring tide in April, 2022. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 82-225 units/ L during high tide period and 167-182 units/ L during low tide of Spring Tide.

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by Diatoms, Blue green algae and Dinoflagellates

during Neap tide period. Diatoms were represented by 23 genera, Blue green algae were represented 3 genera and dinoflagellates with 4 genera during the sampling conducted in Neap tide in April, 2022. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 59-240 units/ L during high tide period and 114-199units/ L during low tide of Neap Tide.

For the evaluation of the Phytoplankton population in DPA OOT jetty area in Path Finder creek sampling was conducted from two sampling locations ;jetty area during high tide period and low tide of spring tide and Neap tide period.

The phytoplankton community of the sub surface water in the path finder creeks was represented by Diatoms, Blue green algae and Dinoflagellates during spring tide period. Diatoms were represented by 27 genera, Blue Green algae by 5 genera and Dinoflagellates 5 genera each during the sampling conducted in spring tide in April, 2022. Phytoplankton of the sampling stations at sub surface layer in the harbour area was varying from 434 units/ L during high tide period and 437 units/ L during low tide of Spring Tide. Phytoplankton of the sampling stations at sub surface layer in the *SPM area* was varying from 414units/ L during high tide period and 410 units/ L during low tide of Spring Tide.

The phytoplankton community of the sub surface water in the path finder creeks was represented by Diatoms, Blue green and Dinoflagellates during Neap tide period. Diatoms were represented by 21 genera and Blue green algae 6 genera and dinoflagellates by 5 genera each during the sampling conducted in Neap tide in April, 2022. Phytoplankton of the sampling stations at sub surface path finder creek near OOT Jetty was varying from 197- units/ L during high tide period and 130 units/ L during low tide of Neap Tide. Phytoplankton of the sampling stations at sub surface path finder creek near SPM area was varying from 139 units/ L during high tide period and 157 units/ L during low tide of Neap Tide.

Species Richness Indices and Diversity Indices:

Margalef's diversity index (Species Richness)S

At the organismal level, the most widely used biodiversity measures are those based on the number of species present, perhaps adjusted for the number of individuals sampled, Here Margalef's Species richness index (d), or indices that describe the evenness of the distribution of the numbers of individuals among species, are derived.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek and nearby creeks sampling stations was varying from 4.312-

4.931with an average of 4.684during the sampling conducted in High tide period of spring tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek region and nearby creeks was varying from2.498- 4.652 with an average of 4.034during the consecutive low tide period.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations in Kandla creek and nearby creeks was varying from 3.105-4.744with an average of 3.919during the sampling conducted in High tide period of Neap tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek region and nearby creeks was varying from2.834- 4.434 with an average of3.371during consecutive low tide.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations was 5.599 at OOT jetty area and 4.979 at SPM area during the sampling conducted in High tide period of spring tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the path finder creek near OOT jetty was 4.605 and 4.654 at SPM during the consecutive low tide period.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations was 4.732 at OOT jetty area and 4.053 at SPM area during the sampling conducted in High tide period of Neap tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the path finder creek near OOT jetty was 2.671 and SPM area was 4.747 during the consecutive low tide period.

Shannon-Wiener's index:

Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.934- 1.231(H'(log10)) between selected sampling stations with an average value of 1.016during high tide period of spring tide at Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.663-1.019(H'(log10)) between selected sampling stations with an average value of 0.891during consecutive lowtide at Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.891- 1.01(H'(log10)) between selected sampling stations with an average value of 0.947during high tide period of neap tide at Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.755- 1.027(H'(log10)) between selected sampling

stations with an average value of 0.883during consecutive low tideat Kandla creek and nearby creeks.

Shannon-Wiener's Index (H) of phytoplankton communities in the stations was 1.062 at OOT jetty area and 1.08 at SPM area during the sampling conducted in High tide period of spring tide. While Shannon-Wiener's Index (H) of phytoplankton communities in the path finder creek near OOT jetty was 0.893 and 1.022 at SPM during the consecutive low tide period.

Shannon-Wiener's Index (H) of phytoplankton communities in the stations was 0.990 at OOT jetty area and 0.995 at SPM area during the sampling conducted in High tide period of Neap tide. While Shannon-Wiener's Index (H) of phytoplankton communities in the path finder creek near OOT jetty was 0.768 and at SPM area was 1.064 during the consecutive low tide period.

Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon-Wiener's index increases as both the richness and the evenness of the community increase. This result indicates that diversity of phytoplankton of Kandla Harbour region and nearby creeks is less but with abundant population of few, with relatively few ecological niches and only very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson's diversity index:

Simpson's index (D) is a measure of diversity, which takes into account both species richness, and an evenness of abundance among the species present. The Simson index is one of the meaningful and robust biodiversity measures available. (Magurran,2004).

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stationsin the Kandla Harbour region and nearby creeks, which was varying from 0.782- 0.946between selected sampling stations with an average of0.824during high tide period of spring tide. Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stationsin the Kandla Harbour region and nearby creeks except few, which was varying from 0.682-0.823between selected sampling stations with an average of 0.760during consecutive low tide .

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations except few in Kandla Harbour region and nearby creeks, during high tide period and low tide period during neap tide also, which was varying from 0.811- 0.874with an average value of 0.832between selected

sampling stations during high tide period and 0.753- 0.8601varying from with an average value of 0.803between selected sampling stations during consecutive low tide period Low species diversity suggests a relatively few successful species in this habitat.

Simpson diversity index (1-D) of phytoplankton communities in the stations was 0.843 at OOT jetty area and 0.874 at SPM area during the sampling conducted in High tide period of spring tide at Path finder creek. While Simpson diversity index (1-D) of phytoplankton communities in the path finder creek near OOT jetty was 0.796 and 0.853 at SPM during the consecutive low tide period in the path finder creek.

Simpson diversity index (1-D) of phytoplankton communities in the stations was 0.831 at OOT jetty area and 0.851 at SPM area during the sampling conducted in High tide period of Neap tide at Path finder Creek. While Simpson diversity index (1-D) of phytoplankton communities in the path finder creek near OOT jetty was 0.756 and at SPM area was 0.867 during the consecutive low tide period. Low species diversity suggests a relatively few successful species in this habitat. The environment is quite stressful with relatively few ecological niches and only a few organisms are really well adapted to that environment. Any change in the environment would probably have quite serious effects.

Table 42 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND ,NEAR BY CREEKS DURING SPRING TIDE IN APRIL 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	195	27/29	93.10	4.931	0.971	0.7877
	2	211	27/29	93.10	4.858	0.9547	0.7818
	3	153	24/29	82.76	4.572	0.9335	0.7897
	4	180	26/29	89.66	4.814	1.025	0.8241
	5	225	26/29	89.66	4.616	0.9789	0.8143
	6	82	20/29	68.97	4.312	1.231	0.9455
LOW TIDE	1	167	22/29	75.86	4.103	0.8892	0.7507
	2	174	25/29	86.21	4.652	1.019	0.8229
	3	174	24/29	82.76	4.458	0.9703	0.7921
	4	174	24/29	82.76	4.458	0.9141	0.7508
	5	182	14/29	48.28	2.498	0.6632	0.6824

Table 43 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND ,NEAR BY CREEKS DURING NEAP TIDE IN APRIL 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	240	27/30	90.00	4.744	0.9912	0.8236
	2	198	22/30	73.33	3.971	0.891	0.8105
	3	197	22/30	73.33	3.975	0.966	0.8304
	4	170	23/30	76.67	4.284	0.9299	0.8248
	5	173	17/30	56.67	3.105	0.8937	0.8297
	6	59	15/30	50.00	3.433	1.01	0.8738
LOW TIDE	1	114	22/30	73.33	4.434	1.027	0.8601
	2	170	19/30	63.33	3.505	0.8775	0.7967
	3	199	16/30	53.33	2.834	0.835	0.7672
	4	151	17/30	56.67	3.189	0.9182	0.8358
	5	179	16/30	53.33	2.892	0.755	0.753

Table 44 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND , NEAR BY CREEKS DURING SPRING TIDE IN APRIL 2022

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	DIATOMS	79-214	24/29	82.76
			BLUE GREEN	2-6	2/29	6.90
			DINOFLAGELLATES	0-12	3/29	10.34
			TOTAL PHYTO PLANKTON	82-225	29	-
LOW TIDE	Sub surface	5	DIATOMS	157-181	24/29	82.76
			BLUE GREEN	1-6	2/29	6.90
			DINOFLAGELLATES	0-8	3/29	10.34
			TOTAL PHYTO PLANKTON	167-182	29	-

Table 45 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND , NEAR BY CREEKS DURING NEAP TIDE IN APRIL 2022

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	DIATOMS	49-217	23/30	76.67
			BLUE GREEN	7-15	3/30	10.00
			DINOFLAGELLATES	1-8	4/30	13.33
			TOTAL PHYTO PLANKTON	59-240	30	-
LOW TIDE	Sub surface	5	DIATOMS	102-187	23/30	76.67
			BLUE GREEN	4-11	3/30	10.00
			DINOFLAGELLATES	2-7	4/30	13.33
			TOTAL PHYTO PLANKTON	114-199	30	-

Table 46 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA OOT AT PATH FINDER CREEK , VADINAR &NEAR BY SPM, DURING SPRING TIDE IN APRIL 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	JETTY	434	35/37	94.59	5.599	1.062	0.8433
	SPM	414	31/37	83.78	4.979	1.08	0.8743
LOW TIDE	JETTY	437	29/37	78.38	4.605	0.8933	0.7963
	SPM	410	29/37	78.38	4.654	1.022	0.8526

Table 47 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING NEAP TIDE IN APRIL 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	JETTY	197	26/32	81.25	4.732	0.9898	0.8318
	SPM	139	21/32	65.63	4.053	0.995	0.8507
LOW TIDE	JETTY	130	14/32	43.75	2.671	0.7682	0.7515
	SPM	157	25/32	78.13	4.747	1.064	0.8672

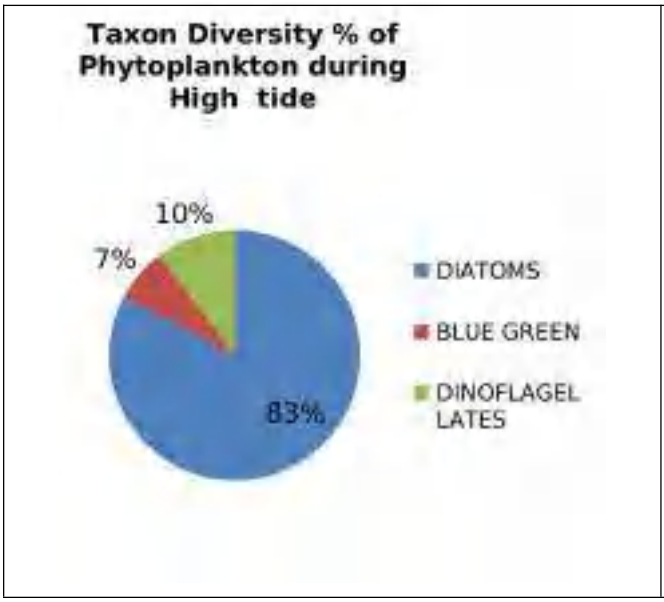
Table 48 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPADPA OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING SPRING TIDE IN APRIL 2022

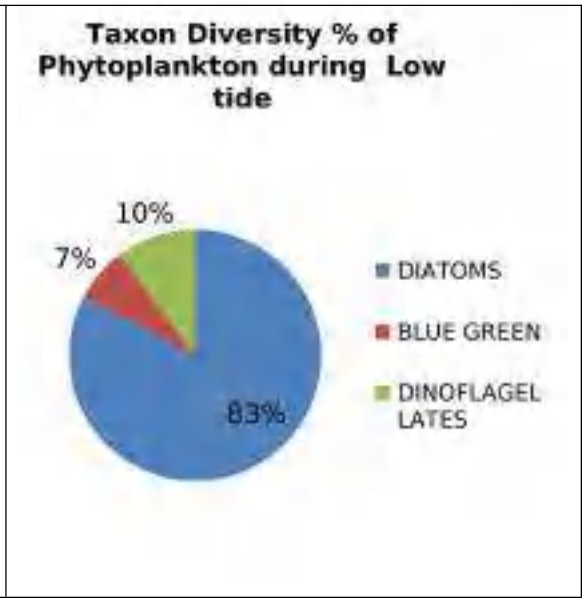
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	BLUE GREEN	18-22	5/37	13.51
			DIATOMS	384-401	27/37	72.98
			DINOFLAGELLATES	11-12	5/37	13.51
			TOTAL PHYTO PLANKTON	414-434	37	
LOW TIDE	Sub surface	2	BLUE GREEN	12-15	5/37	13.51
			DIATOMS	385-419	27/37	72.98
			DINOFLAGELLATES	3-13	5/37	13.51
			TOTAL PHYTO PLANKTON	410-437	37	

Table 49 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPADPA OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING NEAP TIDE IN APRIL 2022

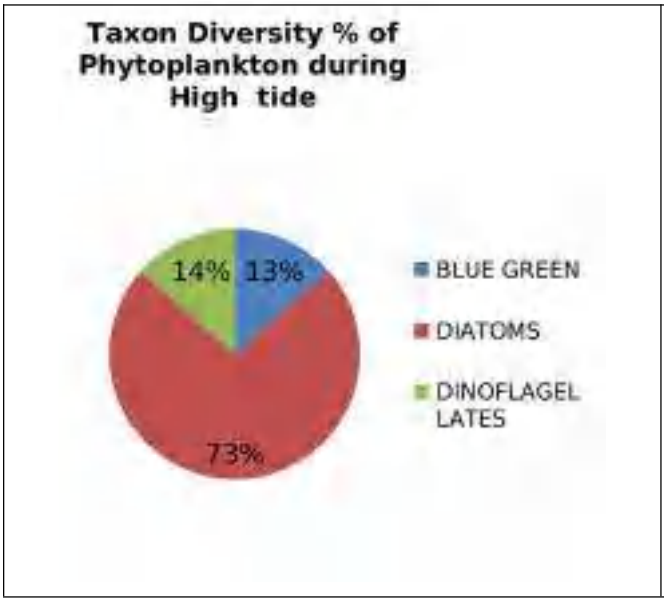
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	BLUE GREEN	9-10	6/32	18.75
			DIATOMS	119-182	21/32	65.62
			DINOFLAGELLATES	5-11	5/32	15.63
			TOTAL PHYTO PLANKTON	139-197	32	-
LOW TIDE	Sub surface	2	BLUE GREEN	5-8	6/32	18.75
			DIATOMS	120-137	21/32	65.62
			DINOFLAGELLATES	5-12	5/32	15.63
			TOTAL PHYTO PLANKTON	130-157	32	-

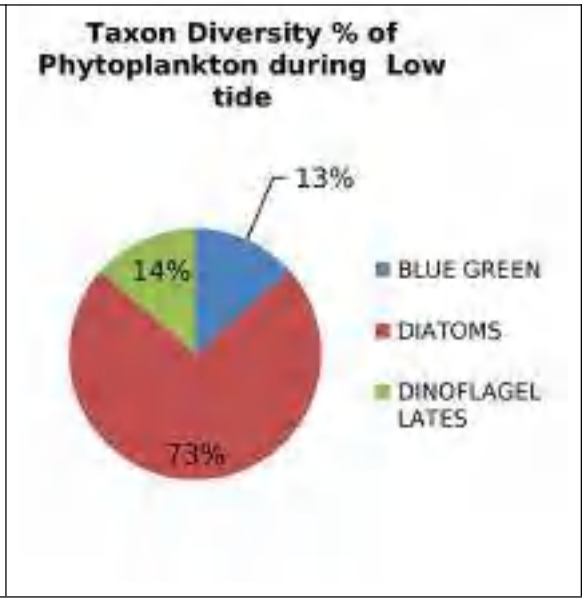
TAXON DIVERSITY % OF PHYTOPLANKTON DURING HIGH TIDE AND LOW TIDE PERIOD DURING SPRING TIDE IN KANDALA CREEK AND NEARBY CREEKS



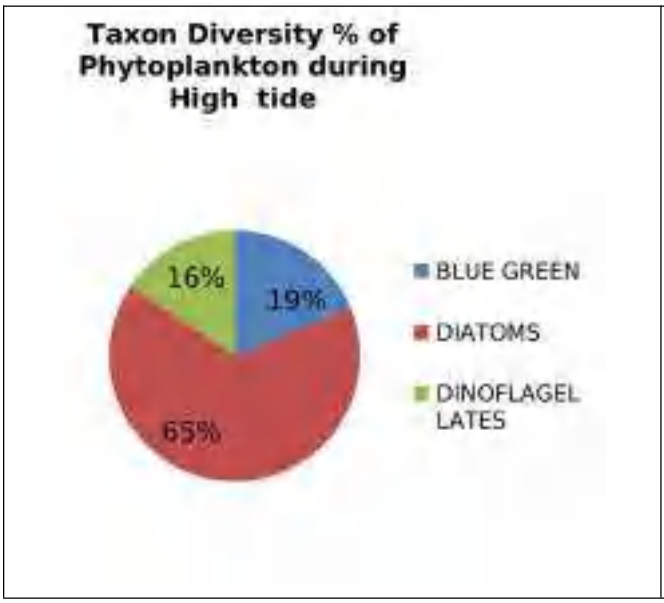


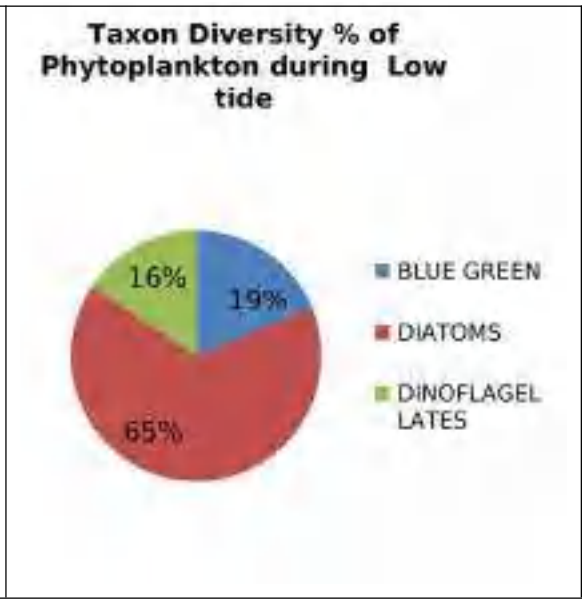
TAXON DIVERSITY % OF PHYTOPLANKTON DURING HIGH TIDE AND LOW TIDE PERIOD DURING NEAP TIDE IN KANDALA CREEK AND NEARBY CREEKS



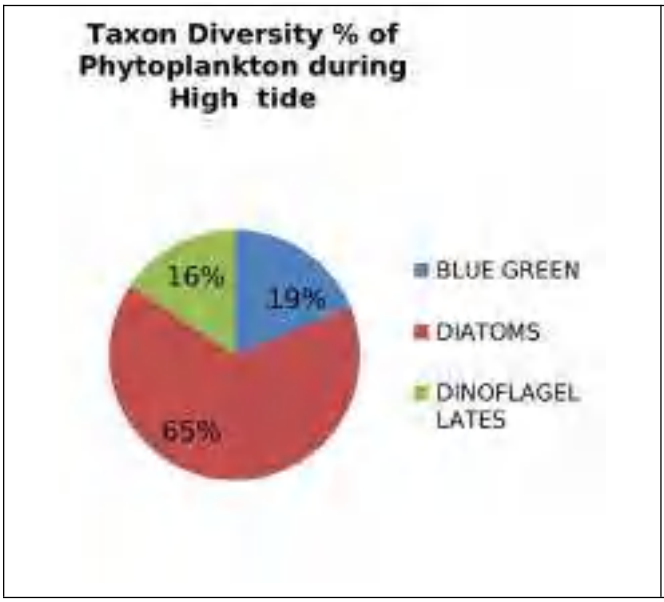


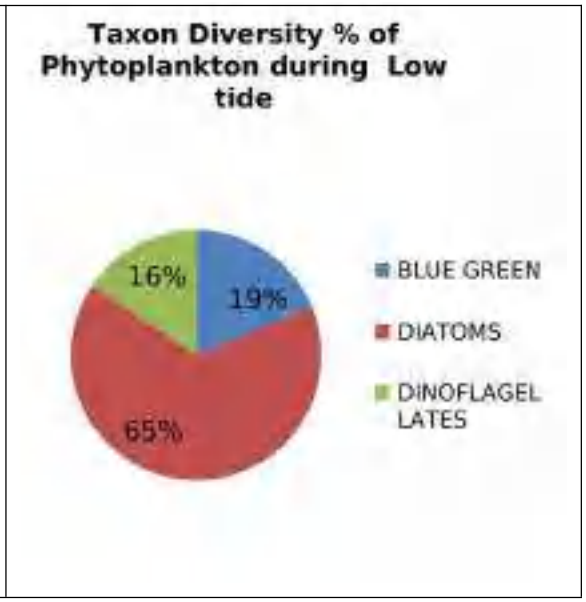
TAXON DIVERSITY % OF PHYTOPLANKTON DURING HIGH TIDE AND LOW TIDE PERIOD DURING SPRING TIDE IN PATH FINDER CREEK, VADINAR





TAXON DIVERSITY % OF PHYTOPLANKTON DURING HIGH TIDE AND LOW TIDE PERIOD DURING NEAP TIDE IN PATH FINDER CREEK, VADINAR





ZOOPLANKTON POPULATION:

For the evaluation of the Zooplankton population in DPA harbour area and within the immediate surroundings of the port sampling was conducted from 6 sampling locations (3 in harbour area and two in Nakti creek and one in Khori creek) during high tide period and low tide period of spring tide and Neap tide in April, 2022. The Zooplankton community of the sub surface water in the harbour and nearby creeks during spring tide was represented by mainly 8 groups, and 8 larval forms; Tintinids, Copepods, Arrow worms, Medusa, Mysids Urochordata, Foraminiferans , and 8 larval forms; The Zooplankton community of the sub surface water in the harbour and nearby creeks during neap tide was represented by mainly 9 groups, Tintinids, Copepods, Arrow worms ,Mysids, Urochordata, Ciliates, Medusa and , Foraminiferans and 9 larval forms

Zooplankton of the sampling stations at sub surface layer in the DPA harbour area and nearby creek was varying from 70-198 x10^3 N/ m^3 during high tide and 119-167x10^3 N/ m^3during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPA harbour area and nearby creek was varying from 53-184x10^3 N/ m^3 during high tide and80-106x10^3 N/ m^3during low tide of Neap Tide period.

For the evaluation of the Zoo plankton population in DPA OOT jetty area in Path Finder creek and SPM in Vadinar selected 2 sampling locations (1 in jetty area and one near SPM)During spring tide sampling plankton sample were collected at Jetty area and near SPM during consecutive high tide period and low tide period. During Neap tide sampling Plankton samples were collected from jetty area and SPM during consecutive high tide period and low tide period.

The Zooplankton community of the sub surface water in the path finder creek during spring tide was represented by mainly Titinids , Copepods, Medusa, Urochordata , Foraminiferans and 9 larval forms. The Zooplankton community of the sub surface water in the path Finder creeks at Jetty region and SPM during neap tide was represented by mainly Eight groups, Titinids , Copepods, Arrow worms, Urochordata, Ciliates, Medusa , Foraminiferans and 8 larval forms, Zooplankton of the sampling stations at sub surface layer in the DPA OOT Jetty area of path finder creek was 158 x10^3 N/ m^3 during high tide and 84 x10^3 N/ m^3 during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPA SPM area of path finder creek was 113 x10^3 N/ m^3 during high tide and 107x10^3 N/ m^3 during low tide of Spring Tide period.

Zooplankton of the sampling stations at sub surface layer in the DPA OOT jetty area in path finder creek was recorded 110 x10^3 N/ m^3during high tide and 74 x10^3 N/ m^3 during consecutive low tide period of Neap. Zooplankton of the sampling stations at sub surface layer in the DPA SPM area in path finder creek was recorded 83 x10^3 N/ m^3during high tide and 95 x10^3 N/ m^3 during consecutive low tide period of Neap Tide .

Species Richness Indices and Diversity Indices:

Margalef's diversity index (Species Richness)S

At the organismal level, the most widely used biodiversity measures are those based on the number of species present, perhaps adjusted for the number of individuals sampled, Here Margalef's Species richness index (d), or indices that describe the evenness of the distribution of the numbers of individuals among species, are derived.

Margalef's diversity index (Species Richness) S of Zooplankton communities in the stations Kandla creek region and nearby creeks was varying from 4.991-6.051 with an average of 5.578 during the sampling conducted in High tide period. Margalef's diversity index (Species Richness) S of Zooplankton communities varying from 3.935- 5.471 with an average of 4.881 during the sampling conducted in low tide period during Spring tide.

Margalef's diversity index (Species Richness) S of Zooplankton communities in the Kandla creek region and nearby creeks sampling stations was varying from 3.105- 4.744 with an average of 3.919 during the sampling conducted in high tide and varying from2.834- 4.434 with an average of 3.371 during the sampling conducted in low tide during Neap tide period.

Margalef's diversity index (Species Richness) S of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted inconsecutive High tide period and low tide of spring tide was recorded as 6.321 and 5.642 respectively. Margalef's diversity index (Species Richness) S of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 5.5 and 4.066 respectively.

Margalef's diversity index (Species Richness) S of Zooplankton communities near Jetty at Path finder creek was varying from 4.68- 3.253 respectively during the sampling conducted in consecutive High tide period and Low tide period of Neap tide. While Margalef's diversity index (Species Richness) S of Zooplankton

communities near SPM at Path finder creek was varying from 3.168-4.831 respectively during the consecutive High tide and low tide period.

Shannon-Wiener's index:

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.995 - 1.203 (H'(log10)) between selected sampling stations with an average value of 1.133 H'(log10)) during high tide period of spring tide. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.962 -1.214(H'(log10)) between selected sampling stations with an average value of 1.129(H'(log10)) during consecutive low tide period .

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 1.09 - 1.214(H'(log10)) between selected sampling stations with an average value of 1.160(H'(log10)) during high tide period of Neap tide. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range 0.916- 1.194of (H'(log10)) between selected sampling stations with an average value of1.087(H'(log10)) during consecutive low tide period.

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 1.121-1.171 respectively. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling *station near SPM* at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 1.12-0.959 respectively

Shannon-Wiener's Index (H) of Zooplankton communities near jetty at Path finder creek was varying from 0.954-0.870 during the sampling conducted consecutive High tide period and Low tide period of Neap tide. -While Shannon-Wiener's Index (H) of Zooplankton communities near SPM at Path finder creek was varying from 0.758- 0.979 during the consecutive High tide and low tide period.

Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon-Wiener's index increases as both the richness and the evenness of the community increase. This result indicates that diversity of Zooplankton of Kandla Harbour region and nearby creeks

stations is slightly high with very minimum diverse population but very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson's diversity index:

Simpson's index (D) is a measure of diversity, which takes into account both species richness, and an evenness of abundance among the species present. The Simson index is one of the meaningful and robust biodiversity measures available. (Magurran, 2004).

Simpson diversity index (1-D) of Zooplankton communities was below 0.9most of sampling stations in the Kandla Harbour region and nearby creeks during high tide and low tide of spring tide period except few stations, which was varying from 0.780-0.892between selected sampling stations with an average of 0.853during high tide period and was varying from 0.817- 0.910 with an average value of 0.879 between selected sampling stations during low tide

Simpson diversity index (1-D) of Zooplankton communities was below 0.9 at all sampling stationsin the Kandla Harbour region and nearby creeks during high tide and low tide period of neap tide except few, which was varying from 0.872-0.930 between selected sampling stations with an average of 0.898during high tide period and was varying from 0.832--0.923with an average value of 0.887between selected sampling stations during consecutive low tide .This species diversity suggests a relatively few successful species in this habitat during April 2022 sampling.

Simpson diversity index (1-D) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.8221 and 0.8818 respectively. Simpson diversity index (1-D) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.8733 and 0.8337 respectively.

Simpson diversity index (1-D) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of Neap tide was recorded as 0.7728-0.806 respectively. Simpson diversity index (1-D) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.7032 and 0.8275 respectively.

Table 50 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND NEAR BY CREEKS DURING SPRING TIDE IN APRIL 2022

Tide	Sampling Station	Abundance In $Nx10^3/ m^3$	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	198	33/34	97.06	6.051	1.175	0.865
	2	140	29/34	85.29	5.666	1.182	0.8756
	3	181	31/34	91.18	5.771	1.203	0.8921
	4	147	28/34	82.35	5.41	1.111	0.8534
	5	183	27/34	79.41	4.991	0.9953	0.7799
	6	70	20/34	58.82	4.472	1.174	0.9217
LOW TIDE	1	119	23/34	67.65	4.603	1.13	0.8802
	2	167	29/34	85.29	5.471	1.189	0.8965
	3	125	26/34	76.47	5.178	1.214	0.9095
	4	146	27/34	79.41	5.217	1.15	0.8891
	5	125	20/34	58.82	3.935	0.9621	0.8174

Table 51 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA HARBOUR AREAAT KANDLA CREEK AND NEAR BY CREEKS DURING NEAP TIDE IN APRIL 2022

Tide	Sampling Station	Abundance In No x10^3/ m^3	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	184	32/37	86.47	5.944	1.193	0.8923
	2	144	28/37	75.68	5.433	1.214	0.9087
	3	134	28/37	75.68	5.513	1.147	0.8807
	4	179	30/37	81.08	5.59	1.202	0.9028
	5	136	24/37	64.86	4.682	1.09	0.8722
	6	53	15/37	40.54	3.526	1.111	0.9303
LOW TIDE	1	105	25/37	67.57	5.157	1.194	0.9231
	2	96	20/37	54.05	4.163	1.135	0.9178
	3	103	24/37	64.86	4.963	1.182	0.9098
	4	106	21/37	56.76	4.289	1.008	0.8528
	5	80	16/37	43.24	3.423	0.9156	0.8326

Table 52 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND ,NEAR BY CREEKS DURING SPRING TIDE IN APRIL 2022

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton x10^3 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinids	13-21	6/34	17.65
			Copepods	23-79	13/34	38.24
			Arrow worms	0-2	1/34	2.94
			Medusa	0-4	1/34	2.94
			Mysids	0-5	1/34	2.94
			Urochordata	0-6	2/34	5.88
			Foraminferans	2-6	2/34	5.88
			Larval forms	22-98	8/34	23.53
			TOTAL ZOOPLANKTON N/ M^3	70-198	34	
LOW TIDE	Sub surface	5	Tintinids	8-22	6/34	17.65
			Copepods	36-63	13/34	38.24
			Arrow worms	0-2	1/34	2.94
			Medusa	0-4	1/34	2.94
			Mysids	0-2	1/34	2.94
			Urochordata	0-8	2/34	5.88
			Foraminferans	0-6	2/34	5.88
			Larval forms	57-72	8/34	23.53
			TOTAL ZOOPLANKTON N/M^3	119-167	34	

Table 53 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA HARBOUR AREA IN KANDLA CREEK AND , NEAR BY CREEKS DURING NEAP TIDE IN APRIL 2022

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton x10^3 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinids	4-20	4/37	10.81
			Copepods	28-79	14/37	37.84
			Arrow worms	0-1	1/37	2.70
			Mysids	1-19	3/37	8.11
			Urochordata	0-5	2/37	5.41
			Ciliates	0-4	1/37	2.70
			Medusa	0-2	1/37	2.70
			Foraminiferans	0-2	2/37	5.41
			Larval forms	14-69	9/37	24.32
			TOTAL ZOOPLANKTON N/M^3	53-184	37	
LOW TIDE	Sub surface	5	Tintinids	6-13	4/37	10.81
			Copepods	27-50	14/37	37.84
			Arrow worms	0-2	1/37	2.70
			Mysids	6-23	3/37	8.11
			Urochordata	0-1	2/37	5.41
			Ciliates	0-2	1/37	2.70
			Medusa	0-1	1/37	2.70
			Foraminiferans	0-2	2/37	5.41
			Larval forms	20-40	9/37	24.32
			TOTAL ZOOPLANKTON N/M^3	80-106	37	

Table 54 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING SPRING TIDE IN APRIL 2022

Tide	Sampling Station	Abundance In $x10^3$N / m^3	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	158	33/33	100	6.321	1.121	0.8221
	SPM	113	27/33	81.82	5.5	1.12	0.8733
LOW TIDE	Jetty	84	26/33	78.79	5.642	1.171	0.8818
	SPM	107	20/33	60.61	4.066	0.9593	0.8337

Table 55 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING NEAP TIDE IN APRIL 2022

Tide	Sampling Station	Abundance In N$x10^3$/ m^3	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	110	23/30	76.67	4.68	0.9538	0.7728
	SPM	83	15/30	50.00	3.168	0.7575	0.7032
LOW TIDE	Jetty	74	15/30	50.00	3.253	0.8695	0.806
	SPM	95	23/30	76.67	4.831	0.9787	0.8275

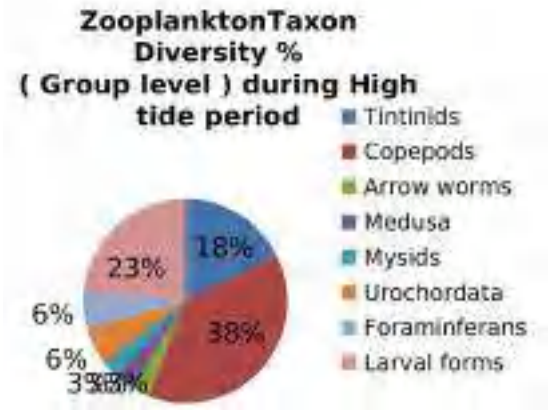
Table 56 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING SPRING TIDE IN APRIL 2022

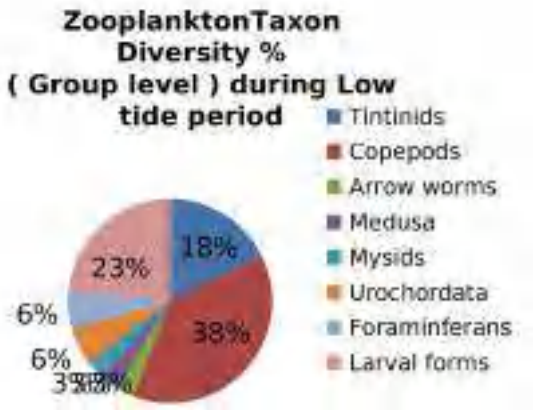
Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^3$ Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	Tintinids	14-19	6/33	18.18
			Copepods	36-43	13/33	39.39
			Urochortata	4-5	2/33	6.06
			Medusa	0-1	1/33	3.03
			Foraminferans	6	2/33	6.06
			Larval forms	48-89	9/33	27.28
			TOTAL ZOOPLANKTON NO/L	113-158	33	
LOW TIDE	Sub surface	2	Tintinids	7-26	6/33	18.18
			Copepods	28-34	13/33	39.39
			Urochortata	1-4	2/33	6.06
			Medusa	0-1	1/33	3.03
			Foraminferans	1-3	2/33	6.06
			Larval forms	42-44	9/33	27.28
			TOTAL ZOOPLANKTON NO/M3	84-107	33	

Table 57 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING NEAP TIDE IN APRIL 2022

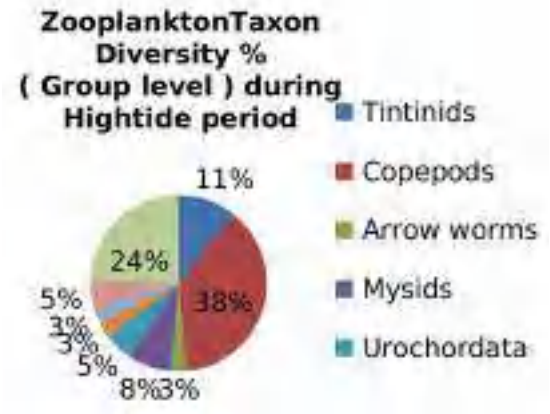
Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^3$ Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	Tintinids	17-23	5/30	16.67
			Copepods	18-20	11/30	36.67
			Arrow worms	0-2	1/30	3.33
			Urochordata	1-3	2/30	6.67
			Ciliates	0-1	1/30	3.33
			Medusa	0-1	1/30	3.33
			Foraminferans	0-1	1/30	3.33
			Larval forms	45-61	8/30	26.67
			TOTAL ZOOPLANKTON	83-110	30	
LOW TIDE	Sub surface	2	Tintinids	9-20	5/30	16.67
			Copepods	29-30	11/30	36.67
			Arrow worms	1-4	1/30	3.33
			Urochordata	2-4	2/30	6.67
			Ciliates	0	1/30	3.33
			Medusa	0	1/30	3.33
			Foraminferans	1	1/30	3.33
			Larval forms	27-41	8/30	26.67
			TOTAL ZOOPLANKTON	74-95	30	

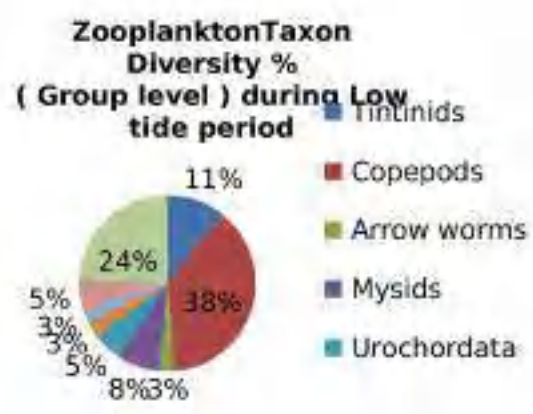
Taxon Diversity % of Zooplankton during High tide and Low tide period of Spring tide In Kandla Creek and nearby Creeks



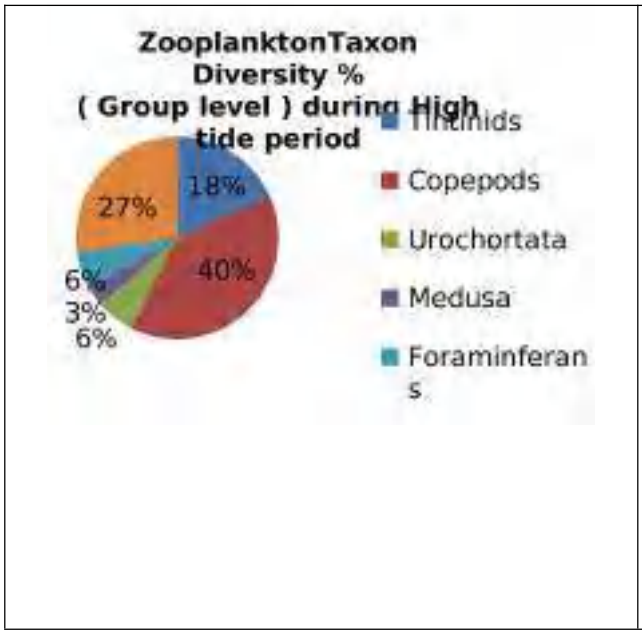


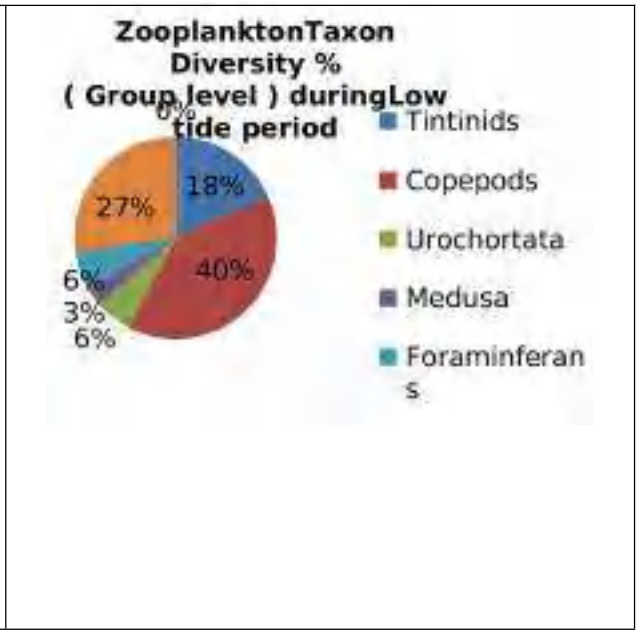
Taxon Diversity % of Zooplankton during High tide and Low tide period of Neap tide In Kandla Creek and nearby Creeks



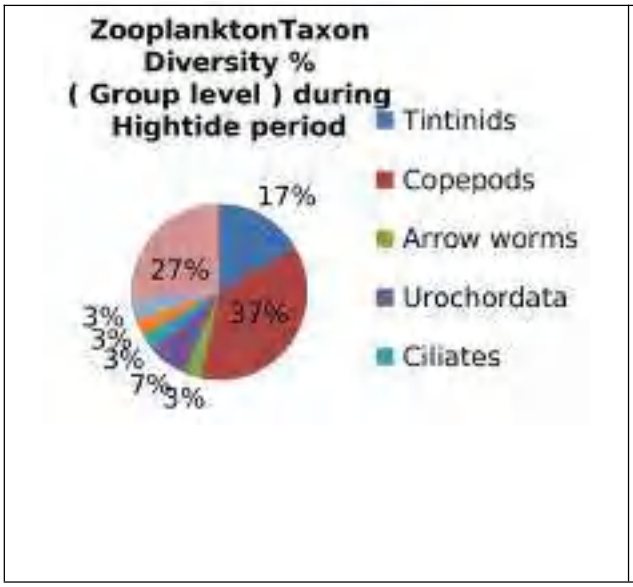


Taxon Diversity % of Zooplankton during High tide and Low tide period of Spring tide In Path Finder Creek and near Jetty





Taxon Diversity % of Zooplankton during High tide and Low tide period of Neap tide In Path Finder Creek near jetty and nearby SPM



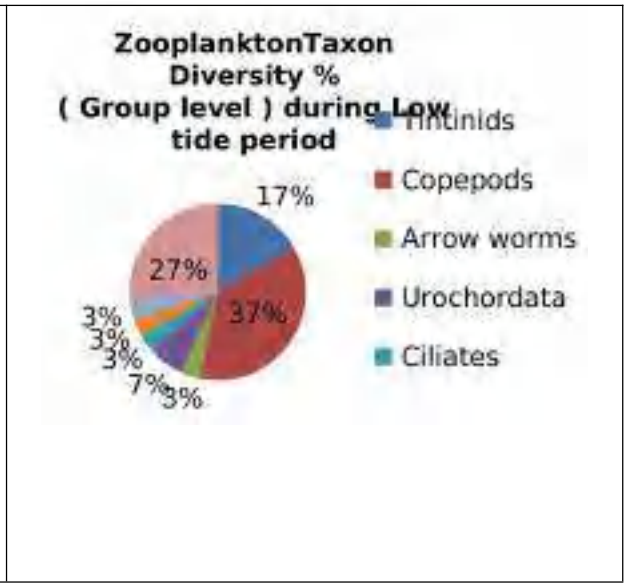


TABLE 58 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS OF DPA HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING SPRING TIDE OF APRIL 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAE	Cyanophyta	Cyanophyceae	Nostocales	Oscillatoriaceae	*Oscillatoria sp.*	B1	Very sparse
			Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B2	Very sparse
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D1	Dominant
			Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D2	Abundant
			Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D3	Very sparse
				Hemiaulaceae	*Cerataulina sp.*	D4	Very sparse
					Eucampia sp	D5	Very sparse
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp	D6	Very sparse

			Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D7	Sparse
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D8	Sparse
			Thalassiosirales	Thalassiosiraceae	*Planktoniella*sp	D9	Very sparse
					Thalassiosira sp	D10	Very sparse
			Triceratiales	Triceratiaceae	*Odontella* sp.	D11	Sparse
					Triceratium sp.	D12	Very sparse
		Bacillariophyceae	Naviculales	Naviculaceae	*Navicula sp*	D13	Very sparse
				Pleurosigmataceae	*Pleurosigma* sp	D14	Sparse
				Pinnulariaceae	*Pinnularia sp*	D15	Very sparse
			Bacillariales	Bacillariaceae	*Bacillaria* sp.	D16	Sparse
					Nitzschia sp	D17	Very sparse

					Pseudo-nitzschia sp	D18	Sparse
			Surirellales	Surirellaceae	*Surirella* sp	D19	Very sparse
		Fragilariophyceae	Thalassionematales	Thalassionemataceae	*Thalassiothrix sp.*	D20	Scattered
					Thalassionema sp.	D21	Very sparse
			Fragilariales	Fragilariaceae	*Asterionellopsis sp*	D22	Very sparse
					Fragilaria sp	D23	Very sparse
					*Synedra*sp	D24	Sparse
DINO FLAGELLATES	Dinoflagellata / Dinozoa	Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Very sparse
			Gonyaulacales	Ceratiaceae	*Ceratium furca*	DF2	Very sparse

TABLE 59 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPA HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING AND NEAP TIDE OF APRIL 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAE	Cyanophyta	Cyanophyceae	Nostocales	Oscillatoriaceae	*Lyngbya sp.*	B1	Very sparse
					Oscillatoria sp.	B2	Very sparse
			Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B3	Very sparse
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D1	Dominant
			Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D2	Abundant
			Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D3	Very sparse
				Hemiaulaceae	*Cerataulina sp.*	D4	Very sparse
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D5	Sparse
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros*sp.	D6	Sparse
			Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D7	Scattered
			Thalassiosirales	Thalassiosiraceae	*Planktoniella*sp	D8	Very sparse
					Thalassiosira sp	D9	Very sparse
			Triceratiales	Triceratiaceae	*Odontella* sp.	D10	Very sparse
					Triceratium sp.	D11	Very sparse
		Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria* sp.	D12	Very sparse

					Nitzschia sp	D13	Very sparse
					Pseudo-nitzschia sp.	D14	Very sparse
			Surirellales	Surirellaceae	*Surirella* sp	D15	Very sparse
			Naviculales	Naviculaceae	*Navicula* sp	D16	Very sparse
				Pleurosigmataceae	*Pleurosigma* sp.	D17	Sparse
		Fragilariophyceae	Thalassionematales	Thalassionemataceae	*Thalassiothrix sp.*	D18	Abundant
					Thalassionema sp.	D19	Very sparse
			Fragilariales	Fragilariaceae	*Asterionellopsis sp*	D20	Very sparse
					Fragilaria sp	D21	Very sparse
					*Synedra*sp	D22	Sparse
			Tabellariales	Tabellariaceae	*Tabellaria* sp	D23	Very sparse
DINO FLAGELLATES	Dinoflagellata / Dinozoa	Noctilucea / Noctiluciphyceae (Dinokaryota)	Noctilucales	Noctilucaceae	*Noctiluca* sp.	DF1	Very sparse
		Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF2	Very sparse
			Gonyaulacales	Ceratiaceae	*Ceratium furca*	DF3	Very sparse
					Ceratium tripos	DF4	Very sparse

TABLE 60 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPA OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING SPRING TIDE OF APRIL 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAE	Cyanophyta	Cyanophyceae	Chlorococcales	Chroococcaceae	*Merismopedia sp.*	B1	Very sparse
			Nostocales	Oscillatoriaceae	*Lyngbya sp.*	B2	Sparse
					Oscillatoria sp.	B3	Very sparse
			Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B4	Very sparse
			Stigonematales	Stigonemataceae	*Stigonema sp.*	B5	Very sparse
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D1	Dominant
					Palmeria sp.	D2	Very sparse
			Biddulphiales	Biddulphiaceae	*Biddulphia* sp	D3	Scattered
			Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D4	Sparse
				Streptothecaceae	*Helicotheca sp*	D5	Very sparse
				Hemiaulaceae	*Cerataulina sp.*	D6	Very sparse
					Eucampia sp	D7	Very sparse
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D8	Dominant
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp	D9	Dominant
			Melosirales	Melosiraceae	*Melosira sp*	D10	Very sparse
			Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D11	Scattered
			Thalassiosirales	Thalassiosiraceae	*Planktoniella* sp	D12	Very sparse

					Thalassiosira sp	D13	Sparse
				Lauderiaceae	*Lauderia*sp	D14	Very sparse
			Triceratiales	Triceratiaceae	*Odontella* sp.	D15	Abundant
					Triceratium sp.	D16	Very sparse
		Bacillariophyceae	Naviculales	Pleurosigmataceae	*Pleurosigma* sp	D17	Sparse
				Pinnulariaceae	*Pinnularia sp*	D18	Very sparse
			Bacillariales	Bacillariaceae	*Bacillaria* sp.	D19	Sparse
					Nitzschia sp	D20	Sparse
					Pseudo-nitzschia sp	D21	Sparse
			Surirellales	Surirellaceae	*Campylodiscus* sp	D22	Very sparse
		Fragilariophyceae	Fragilariales	Fragilariaceae	*Synedra sp.*	D23	Sparse
			Striatellales	Striatellaceae	*Striatella*sp	D24	Very sparse
			Licmophorales	Licmophoraceae	*Licmophora sp.*	D25	Very sparse
			Thalassionematales	Thalassionemataceae	*Thalassiothrix sp.*	D26	Very sparse
					Thalassionema sp.	D27	Very sparse
DINOFLAGELLATES	Dinoflagellata / Dinozoa	Noctilucea / Noctiluciphyceae (Dinokaryota)	Noctilucales	Noctilucaceae	*Noctiluca* sp.	DF1	Sparse
		Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF2	Sparse

			Dinophysales	Dinophysaceae	*Dinophysis sp.*	DF3	Very sparse
			Gonyaulacales	Ceratiaceae	*Ceratium furca*	DF4	Very sparse
					Ceratium tripos	DF5	Sparse

TABLE 61 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPA OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING AND NEAP TIDE OF APRIL 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAE	Cyanophyta	Cyanophyceae	Chlorococcales	Chroococcaceae	*Merismopedia sp.*	B1	Very sparse
			Nostocales	Oscillatoriaceae	*Arthrospira sp.*	B2	Very sparse
					Lyngbya sp.	B3	Very sparse
					Oscillatoria sp.	B4	Very sparse
			Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B5	Very sparse
			Stigonematales	Stigonemataceae	*Stigonema sp.*	B6	Very sparse
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D1	Abundant
			Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D2	Scattered
			Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D3	Sparse
				Hemiaulaceae	*Cerataulina sp.*	D4	Very sparse
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D5	Dominant
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros*sp	D6	Scattered
			Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D7	Sparse
			Thalassiosirales	Thalassiosiraceae	*Planktoniella*sp	D8	Very sparse
					Thalassiosira sp	D9	Very sparse
			Triceratiales	Triceratiaceae	*Odontella sp*	D10	Sparse
					Triceratium sp	D11	Very sparse
		Bacillariophyceae	Naviculales	Naviculaceae	*Navicula* sp	D12	Very sparse

				Pinnulariaceae	*Pinnularia sp*	D13	Very sparse
				Pleurosigmataceae	*Pleurosigma* sp	D14	Very sparse
			Bacillariales	Bacillariaceae	*Bacillaria* sp.	D15	Sparse
					Nitzschia sp	D16	Scattered
					Pseudo-nitzschia sp	D17	Very sparse
		Fragilariophyceae	Fragilariales	Fragilariaceae	*Synedra sp.*	D18	Sparse
			Thalassionematales	Thalassionemataceae	*Thalassiothrix sp.*	D19	Very sparse
			Climacospheniales	Climacospheniaceae	*Climacosphenia sp.*	D20	Very sparse
			Licmophorales	Licmophoraceae	*Licmophora sp.*	D21	Very sparse
DINO FLAGELLATES	Dinoflagellata / Dinozoa	Noctilucea / Noctiluciphyceae (Dinokaryota)	Noctilucales	Noctilucaceae	*Noctiluca* sp.	DF1	Sparse
		Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF2	Very sparse
			Gonyaulacales	Ceratiaceae	*Ceratium furca*	DF3	Very sparse
					Ceratium fusus	DF4	Very sparse
					Ceratium tripos	DF5	Very sparse

TABLE 62 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPA HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEK SDURING SPRING TIDE OF APRIL 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnus sp.*	T1	Sparse
				Codonellidae	*Tintinnopsis failakkaensis*	T2	Sparse
					Tintinnopsis gracilis	T3	Very sparse
					Tintinnopsis mortensenii	T4	Very sparse
					Tintinnopsis radix	T5	Very sparse
				Tintinnidae	*Amphorides sp.*	T6	Very sparse
COPEPODS	ATHROPODA	Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Scattered
					Bestiolina sp.	C2	Very sparse
					Parvocalanus sp.	C3	Sparse
				Eucalanidae	*Subeucalanus sp.*	C4	Very sparse
				Clausocalanidae	*Clausocalanus sp.*	C5	Very sparse
				Centropagidae	*Centropages sp.*	C6	Very sparse
				Acartiidae	*Acartia sp.*	C7	Very sparse
				Temoridae	*Temora sp.*	C8	Very sparse
			Cyclopoida	Oithonidae	*Oithona sp.*	C9	Abundant
			Harpacticoida	Ectinosomatidae	*Microsetella* sp.	C10	Scattered
				Euterpinidae	*Euterpina sp.*	C11	Sparse
				Canthocamptidae	*Canthocamptus sp*	C12	Very sparse
			Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C13	Very sparse

ARROW WORMS	CHAETOGNATHA	Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse
MYSIDS	ATHROPODA CRUSTACEA	Malacostraca	Mysida, Decapoda	Solenoceridae	*Solenocera sp.*	M1	Very sparse
UROCHORDATA	CHORDATA SUB PHYLUM UROCHORDATA	Appendicularia		Oikopleuridae	*Oikopleura sp.*	U1	Very sparse
				Fritillariidae	*Fritillaria sp.*	U2	Very sparse
MEDUSA	PHYLUM CNIDARIA	Hydrozoa			Unidentified medusa	ME1	Very sparse
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of copepods	L1	Dominant
BRACHYURA LARVAE	ARTHROPODA (CRUSTACEA)	Malacostraca Decapoda			Brachyuran zoea larvae	L2	Sparse
BARNACLE LARVAE	ATHROPODA CRUSTACEA	Maxillopoda Thecostraca			Cirripede larvae	L3	Sparse
CYPHONAUTES LARVAE	BRYOZOA				Cyphonautes larvae	L4	Very sparse
ECHINODERMATA LARVAE	ECHINODERMATA				Ophipluutes larvae/ Echinoplutes larvae	L5	Very sparse
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L6	Sparse
POLYCHAETE LARVAE	ANNELIDA	Polychaeta			Trochophore larvae	L7	Very sparse
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of bivalves	L8	Sparse
FORAMINIFERA	FORAMINIFERA	Globothalamea	Rotaliida	Globigerinidae	*Globigerina* sp.	F1	Very sparse
				Rotalliidae	*Rotalia* sp.	F2	Very sparse

TABLE 63 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING OF DPA HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING NEAP TIDE OF APRIL 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnus sp.*	T1	Very sparse
				Codonellidae	*Tintinnopsis failakkaensis*	T2	Sparse
					Tintinnopsis gracilis	T3	Very sparse
					Tintinnopsis radix	T4	Sparse
COPEPODS	ATHROPODA	Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Scattered
					Parvocalanus sp.	C2	Very sparse
				Eucalanidae	*Pareucalanus sp*	C3	Very sparse
					Subeucalanus sp.	C4	Very sparse
				Acartiidae	*Acartia sp.*	C5	Very sparse
				Clausocalanidae	*Clausocalanus sp.*	C6	Very sparse
				Centropagidae	*Centropages sp.*	C7	Very sparse
				Euchaetidae	*Euchaeta sp.*	C8	Very sparse
				Temoridae	*Temora sp.*	C9	Very sparse
			Cyclopoida	Oithonidae	*Oithona sp.*	C10	Abundant
			Harpacticoida	Ectinosomatidae	*Microsetella* sp.	C11	Abundant
				Euterpinidae	*Euterpina sp.*	C12	Very sparse
			Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C13	Very sparse
				Corycaeidae	*Corycaeus sp.*	C14	Very sparse
ARROW WORMS	CHAETOGNATHA	Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse
MYSIDS	ATHROPODA CRUSTACEA	Malacostraca	Mysida, Decapoda	Penaeidae	*Metapenaeus sp.*	M1	Scattered
					Penaeus sp.	M2	Sparse
				Solenoceridae	*Solenocera sp.*	M3	Sparse

UROCHORDATA	CHORDATA SUB PHYLUM UROCHORDATA	Appendicularia		Oikopleuridae	*Oikopleura sp.*	U1	Very sparse
				Fritillariidae	*Fritillaria sp.*	U2	Very sparse
CILIATES	CILIOPHORA	Oligohymenophore a	Sessilida	Zoothamniidae	*Zoothamnium sp.*	CI1	Very sparse
MEDUSA	PHYLUM CNIDARIA	Hydrozoa			Unidentified medusa	ME1	Very sparse
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of copepods	L1	Dominant
BRACHYURA LARVAE	ARTHROPODA (CRUSTACEA)	Malacostraca Decapoda			Brachyuran zoea larvae	L2	Very sparse
BARNACLE LARVAE	ATHROPODA CRUSTACEA	Maxillopoda Thecostraca			Cirripede larvae	L3	Sparse
CYPHONAUTES LARVAE	BRYOZOA				Cyphonautes larvae	L4	Very sparse
FISH LARVAE	CHORDATA SUBPHYLUM: VERTEBRATA	Superclass: Pisces			Fish larvae	L5	Very sparse
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L6	Sparse
ECHINODERMATA LARVAE	ECHINODERMATA				Ophipluutes larvae/ Echinoplutes larvae	L7	Sparse
POLYCHAETE LARVAE	ANNELIDA	Polychaeta			Trochophore larvae	L8	Very sparse
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of bivalves	L9	Very sparse
FORAMINIFERA	FORAMINIFERA	Globothalamea	Rotaliida	Globigerinidae	*Globigerina* sp.	F1	Very sparse
				Rotalliidae	*Rotalia* sp.	F2	Very sparse

TABLE 64 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPA OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING SPRING TIDE OF APRIL 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnus sp.*	T1	Abundant
				Codonellidae	*Tintinnopsis failakkaensis*	T2	Very sparse
					Tintinnopsis gracilis	T3	Very sparse
					Tintinnopsis mortensenii	T4	Very sparse
					Tintinnopsis radix	T5	Sparse
				Xystonellidae	*Favella* sp.	T6	Very sparse
COPEPODS	ATHROPODA	Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Scattered
					Parvocalanus sp.	C2	Very sparse
				Eucalanidae	*Subeucalanus sp.*	C3	Very sparse
				Centropagidae	*Centropages sp.*	C4	Very sparse
				Clausocalanidae	*Clausocalanus sp.*	C5	Very sparse
				Temoridae	*Temora sp.*	C6	Very sparse
			Cyclopoida	Oithonidae	*Oithona sp.*	C7	Scattered
			Harpacticoida	Canthocamptidae	*Canthocamptus sp*	C8	Very sparse
				Clytemnestridae	*Clytemnestra sp.*	C9	Very sparse
				Euterpinidae	*Euterpina sp.*	C10	Very sparse
				Ectinosomatidae	*Microsetella* sp.	C11	Very sparse
			Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C12	Very sparse
				Corycaeidae	*Corycaeus sp.*	C13	Very sparse
UROCHORDATA	CHORDATA	Appendicularia		Oikopleuridae	*Oikopleura sp.*	U1	Sparse

	SUB PHYLUM UROCHORDATA			Fritillariidae	*Fritillaria sp.*	U2	Very sparse
MEDUSA	PHYLUM CNIDARIA	Hydrozoa			Unidentified medusa	ME1	Very sparse
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of copepods	L1	Dominant
ASCIDIAN LARVAE	CHORDATA SUBPHYLUM: TUNICATA	Ascidiacea			Ascidian tadpole larvae	L2	Sparse
BRACHYURA LARVAE	ARTHROPODA (CRUSTACEA)	Malacostraca	Decapoda		Brachyuran zoea larvae	L3	Sparse
BARNACLE LARVAE	ATHROPODA CRUSTACEA	Maxillopoda Thecostraca			Cirripede larvae	L4	Very sparse
CYPHONAUTES LARVAE	BRYOZOA				Cyphonautes larvae	L5	Very sparse
ECHINODERMATA LARVAE	ECHINODERMATA				Ophipluutes larvae/ Echinoplutes larvae	L6	Very sparse
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L7	Very sparse
POLYCHAETE LARVAE	ANNELIDA	Polychaeta			Trochophore larvae	L8	Very sparse
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of bivalves	L9	Very sparse
FORAMINIFERA	FORAMINIFERA	Globothalamea	Rotaliida	Globigerinidae	*Globigerina* sp.	F1	Very sparse
				Rotalliidae	*Rotalia* sp.	F2	Very sparse

TABLE 65 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPA OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING NEAP TIDE OF APRIL 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnus sp.*	T1	Scattered
				Codonellidae	*Tintinnopsis failakkaensis*	T2	Very sparse
					Tintinnopsis mortensenii	T3	Very sparse
					Tintinnopsis radix	T4	Sparse
				Xystonellidae	*Favella* sp.	T5	Sparse
COPEPODS	ATHROPODA	Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Sparse
					Parvocalanus sp.	C2	Very sparse
				Eucalanidae	*Pareucalanus sp.*	C3	Very sparse
				Centropagidae	*Centropages sp.*	C4	Very sparse
			Cyclopoida	Oithonidae	*Oithona sp.*	C5	Abundant
			Harpacticoida	Canthocamptidae	*Canthocamptus sp*	C6	Very sparse
				Clytemnestridae	*Clytemnestra sp.*	C7	Very sparse
				Euterpinidae	*Euterpina sp.*	C8	Very sparse
				Ectinosomatidae	*Microsetella* sp.	C9	Very sparse
			Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C10	Very sparse
				Corycaeidae	*Corycaeus sp.*	C11	Very sparse

ARROW WORMS	CHAETOGNATHA	Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse
UROCHORDATA	CHORDATA SUB PHYLUM UROCHORDATA	Appendicularia		Oikopleuridae	*Oikopleura sp.*	U1	Sparse
				Fritillariidae	*Fritillaria sp.*	U2	Very sparse
CILIATES	CILIOPHORA	Oligohymenophorea	Sessilida	Zoothamniidae	*Zoothamnium sp.*	CI1	Very sparse
MEDUSA	PHYLUM CNIDARIA	Hydrozoa			Unidentified medusa	ME1	Very sparse
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of copepods	L1	Dominant
ASCIDIAN LARVAE	CHORDATA SUBPHYLUM: TUNICATA	Ascidiacea			Ascidian tadpole larvae	L2	Very sparse
BARNACLE LARVAE	ATHROPODA CRUSTACEA	Maxillopoda Thecostraca			Cirripede larvae	L3	Sparse
CYPHONAUTES LARVAE	BRYOZOA				Cyphonautes larvae	L4	Very sparse
ECHINODERMATA LARVAE	ECHINODERMATA				Ophipluutes larvae/ Echinoplutes larvae	L5	Very sparse
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L6	Very sparse
POLYCHAETE LARVAE	ANNELIDA	Polychaeta			Trochophore larvae	L7	Very sparse
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of bivalves	L8	Very sparse
FORAMINIFERA	FORAMINIFERA	Globothalamea	Rotaliida	Rotalliidae	*Rotalia* sp.	F1	Very sparse

BENTHIC ORGANISMS:

Few Benthic organisms were observed in the collected sediments by using the Van-veen grabs during the sampling conducted during spring tide period and Neap tide period from DPA harbour region and nearby creek. The meiobenthic organisms during spring tide were represented by Polychaetes *Dasybranchus* sp., *Prinispo* sp. *Notomastus* sp.,and , During Neap tide Polychates Nereis sp . *Prinispo*, Dasybranchus sp and few Amphipods were detected.

Table 66 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPA HARBOUR AREA CREEKS DURING SPRING TIDE IN APRIL 2022

Benthic fauna	ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS REPRESENTATION BY GROUP						
	DPA HARBOUR			CREEKS			
POLYCHAETES	DPA-1	DPA-2	DPA-3	DPA-4	DPA-5	DPA-6	
Family : Capit*ellidae* *Dasybranchus* sp.	40	60	30	40	20	0	
Family Spionidae *Prinispo* sp.	20	40	20	10	40		
Family : Capit*ellidae* *Notomastus*sp	0	10	20	20	20	0	
Total Polychates N/M^2	60	110	70	70	80		
TOTAL Benthic Fauna NUMBER/ M^2	60	110	70	70	80		

NS : No sample

Table 67 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPA HARBOUR AREA CREEKS DURING NEAP TIDE IN APRIL 2022

Benthic fauna	ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS REPRESENTATION BY GROUP						
	DPA HARBOUR			CREEKS			
POLYCHAETES	DPA-1	DPA-2	DPA-3	DPA-4	DPA-5	DPA-6	
Family : Neridae Nereis sp.	10	20	10	20	10	0	
Family Spionidae *Prinispo* sp.	20	40	10	40	20	0	
Family : Capit*ellidae* *Dasybranchus* sp	50	60	40	20	20	0	
Total Polychaetes							
Un identified Amphipods	10	-	-	20	20	0	
TOTAL Benthic Fauna NUMBER/ M^2	90	120	60	100	70	0	

11.1 Meteorological Data

Temperature

Temperature records indicate that the area experiences tropical coastal climate. The moderating effects of the nearby sea and the fairly high amount of relative humidity in the atmosphere have restricted the variability The seasonal variations of temperature follow closely the course of the sun.

Automatic Weather station (**ID KAZPHOEN424**) have been installed in Seva Sadan - 3 at the Deendayal Port which records the data on Temperature (°C), Relative Humidity (%),Wind speed (kmph), Wind Direction (°), Solar radiation (w/ m^2) and Rainfall mm.

Temperature

The mean day time temperature for Deendayal Port was 26.0 °C. The day-time maximum temperature was 41.6°C. The minimum mean night time temperature recorded was 23.5 °C.

Solar Radiation

The mean Solar Radiation in April was 101.53 w/m^2. The maximum solar radiation recorded in the month of April was 331.7 w/m^2.

Rainfall

There is no any Rainfall in the month of April.

Relative Humidity

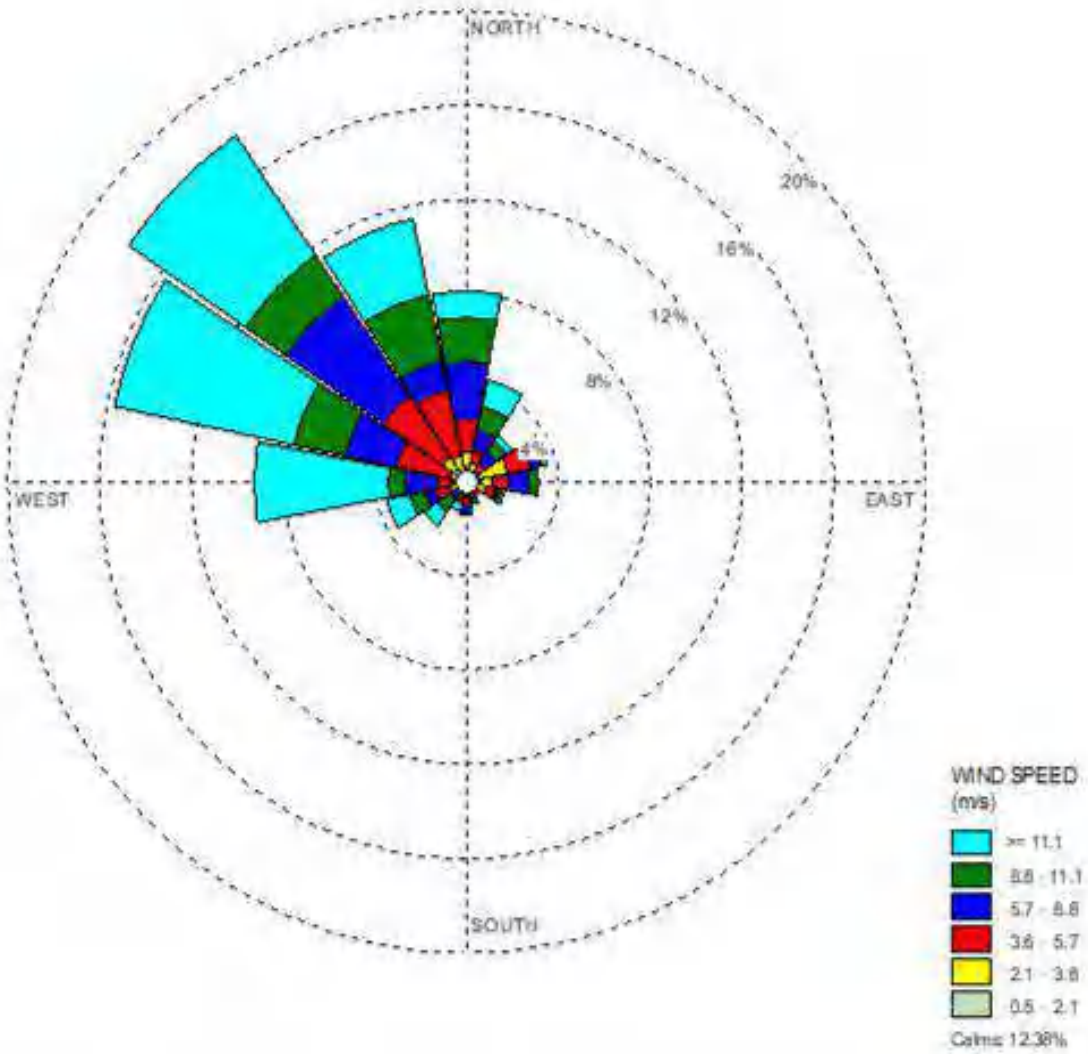
The mean day-time Relative humidity was 16.0 % for the month of April and mean night time Relative humidity was 31.0 %. Maximum Relative humidity recorded during day-time was 95.0 % and maximum Relative humidity recorded during night-time was 67.0%.

Wind Velocity and Wind Direction

The mean wind velocity for the entire month of April was 0.7 m/s. Maximum wind velocity recorded was 34.2 m/s . The wind direction was mostly North West.

WINDROSE PLOT
Windrose April 2022 DPT

DISPLAY
Wind Speed
Direction (blowing from)



COMMENTS:	DATA PERIOD: 2022 Apr 1 - Apr 30 00:00 - 23:00	COMPANY NAME:	
		MODELER:	
	CALM WINDS: 12.38%	TOTAL COUNT: 703 hrs.	
	AVG. WIND SPEED: 8.19 m/s	DATE: 6/4/2022	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

12.0 Conclusive Summary and Remedial measures Suggested

The AAQ monitoring at six locations of Deendayal Port Kandla indicates that the mean PM_{10} values at all locations viz. Coal storage area, Marine Bhavan, Gopalpuri Hospital, Tuna Port, Kandla Colony and Oil Jetty area were found above the permissible standards (100 µg/m^3) and the $PM_{2.5}$ values are found for five locations (Marine Bhavan building, Oil jetty, Gopalpuri , Tuna Port & Estate building) within permissible limit Except Coal Storage area. (Limit 60 µg/m^3).

The AAQ monitoring Vadinar at Admin building found within permissible standards for both PM_{10} (Limit 100 µg/m^3) & $PM_{2.5}$ (Limit 60 µg/m^3)

Drinking water at all the twenty locations was found potable and was within permissible limits of BIS standards (IS 10500).

Noise quality was also within the set permissible standards of an Industrial Area. The noise level observed during day time was >75 dB (A) and at night time was >70 dB (A) during the entire monitoring period.

The sewage treated water of Deendayal Port Colony (Gopalpuri) was in line with the standards set by the Gujarat Pollution Control Board.

Reasons for higher Values of PM_{10}

Large amount of coal is handled at Berth No. 6, 7, 8 and 9. The unloading of coal directly in the truck, using grabs cause coal to spread in air as well as coal dust to fall on ground. This settled coal dust again mixes with the air while trucks travel through it.

Also, the coal laden trucks are not always covered with tarpaulin sheets and these results in spillage of coal from trucks/dumpers during its transit from vessel to yard or storage site. This also increased PM values around marine Bhavan & Coal storage area.

Remedial Measures

The values of PM_{10} & $PM_{2.5}$ during the month of April, 2022 were beyond the permissible limit at all locations mentioned above Except Tuna Port, Vadinar Signal building and Admin building for PM_{10} . Given below are the remedial measures suggest to minimize the Air pollution at Deendayal Port.

During April, 2022 overall ambient air quality of the DPA is within GPCB permissible limits except TSPM, PM_{10}, $PM_{2.5}$ at Coal storage area, and Marine Bhavan. To improve air quality the port is using number of precautionary measures, such as maintained a wide expanse of Green zone, initiated Inter-Terminal Transfer (ITT) of tractor-trailers, Centralized Parking Plaza, providing shore power supply to tugs and port crafts, the use of LED lights at DPA area helps in lower energy consumption and decreases the carbon foot prints in the environment, time to time cleaning of paved and unpaved roads, use of tarpaulin sheets to cover dumpers at project sites etc. are helping to achieve the cleaner and green future at port.

Installed Mist Cannons system to suppresses dust generated in crushing and demolition sites, in material storage, cross-docking of Coal.

Solution towards the Green port:

Practice should be initiated for using mask as preventative measure, to avoid inhalation of dust particle- Mask advised in sensitive areas.

Use of renewable energy like solar energy should be optimal and ensure to work continuously.

Display of Environmental Initiative Boards and create awareness towards public.

Stay sanitized of public transport and all basic items at public interaction places as much as possible.

Technology like Electric cart, Inter-Terminal Transfer (ITT) are worthy selection to reduce Port operation efficiency and fuel cost.

Limit the Activity and time of Exposure in Sensitive Area Prior planning.

Conventional RTGCs should be altered as E-RTGCs counting inside the portcompletely.

New scanning technology and new high power Tugs are reducing operation timing and CO2 Emission are good creativity.

Initiate Natural Gas (CNG) as fuel by all buses and trucks.

Guidelines for Coal Handling by GPCB should be strictly followed. (http://gpcb.gov.in/pdf/coal-handling-guidelines.pdf)

ENVIRONMENTAL MONITORING REPORT FOR DEENDAYAL PORT AUTHORITY

REPORT	:	DCPL/DPA/21-22/27
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ENVIRONMENTAL MONITORING PLAN FOR DEENDAYAL PORT ENVIRONMENTALMONITORING REPORT- July 2022

1. EXECUTIVE SUMMARY

Monitoring of various environmental aspects of the Deendayal port by M/s Detox Corporation Pvt. Ltd. has been carried out through collection of samples, analysis of the same, comparing results with respect to the national standards and any other relevant standards by GBCB/CPCB/MoEF& CC to identify non conformity in the Environment of the Deendayal Port. The results shall address the identified impacts and suggest measures to minimize the environmental impact due to various operations at Deendayal Port.

A) Ambient Air

The monitoring of Ambient Air quality at 6 locations at Deendayal Port Authority Kandla and 2 at Vadinar Port on 24 hourly basis for TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2, NH_3 in twice a Week at Gopalpuri, Tuna Port, Marine Bhavan building, Coal storage area, Estate building, Oil jetty and at Vadinar port, Vadinar Jetty and Vadinar colony area using respirable dust sampler, Fine particulate sampler and gaseous sampler.

The TSPM values in month of July 2022 were found 687 µg/m^3 maximum at Coal Storage area on 29.07.2022 and minimum 118 µg/m^3 at Tuna Port on 01.07. 2022. The PM_{10} values were found from 550 µg/m^3 maximum at Coal Storage area on 01.07.2022 and minimum 73 µg/m^3 at Tuna Port on 15.07. 2022. The $PM_{2.5}$ values were found from 177 µg/m^3 maximum at Coal Storage area on 29.07. 2022 and minimum 33 µg/m^{3}at Tuna Port on 01.07 2022. The PM_{10} and $PM_{2.5}$ values were found for four locations (Marine Bhavan building, Coal storage area, Estate building, Oil jetty) to above the permissible limit. The PM_{10} & $PM_{2.5}$ values were found for four locations (Gopalpuri Hospital , Vadinar Signal building & Admin building) mostly within permissible limit.

The overall values of July for SO_2 were found maximum of 6.64 µg/m^{3}and minimum of 1.09 µg/m^3, NO_2 were found maximum 23.07 µg/m^3 and minimum 9.47 µg/m^3, NH_3 were found maximum 11.23 µg/m^3 and minimum 4.59 µg/m^3, C_6H_6 were found maximum 1.22 µg/m^3 and minimum 1.00 µg/m^3, CO were found maximum 2.23 mg/m^3 and minimum of 1.08 mg/m^3 , CO_2 were found maximum 2758 ppm and minimum of 285 ppm and NMHC were found BQL (Below Quantification Limit).

B) Marine Ecology (Flora and Fauna) / Marine Water / Sediments:

The results obtained from the study for the month of July 2022 for biological and ecological parameters in marine water for Arabian Sea at surrounding area of Deendayal Port Authority (DPA) was not adversely affected by Port activities.

C) Drinking Water Quality

Drinking water is water intended for human consumption for drinking and cooking purposes from designated source. The drinking water being supplied to Deendayal Port was safe for drinking purpose. At all drinking water monitoring stations around port area were found to be as per the drinking water specifications given in IS 10500:2012 as per tested parameters only.

The average results for 20 locations were as: pH were found Min 7.38 and maximum 8.60, TDS were found min 660 mg/l and Max found 920 mg/l, Chloride were found Min 75.17 mg/l and Max 205.46 mg/l, Total Hardness were found Min 150 mg/l and Max 350 mg/l and Calcium were found Min 19.93 mg/l and Max 56.11 mg/l, colour found colourless and odour were odourless. In all water samples BOD, Heavy metal like manganese, Hexavalent chromium, Copper, Cadmium, Arsenic, Mercury, Lead, zinc all are found BQL (Below Quantification Limit). The bacterial count (E-coli & Coliform) is absent in all drinking water samples.

D) Monitoring Performance of Sewage Treatment Plant

It was seen that the performance of STP at Deendayal Township, DPA STP Plant and Vadinar STP plant was satisfactory by overall. The treatment plant was well maintained during [July 2022] with considerable removal efficiency achieving the standards prescribed for final disposal. The average results for 3 locations as per below. Two locations (Gopalpuri & DPA STP) and one location at Vadinar. The pH were found 7.21 to Max 7.44,Total Suspended Solids were found 35 to 69 mg/l ,Residual Chlorine were below Detection Limit (Less Than 0.5) , COD were found 20.5 to 70.7 mg/l and 3day BOD @ 27 °C were found 4 to 18 mg/l.

E) Weather

The mean day time temperature for Deendayal Port was 25.6 °C. The day-time maximum temperature was 34.3°C. The mean night time temperature recorded was 28.4 °C. The mean Solar Radiation in July month was 115.72 w/m^2. The maximum solar radiation was recorded 623.2 w/m^2 in 18th July and the minimum solar radiation was recorded 0.23 w/m^2 in 27th July. The mean Relative humidity was 88.15 % for the month of July. Maximum Relative humidity was recorded 99.0 % and minimum Relative humidity was recorded 47 %. The average wind velocity for the entire month of July was 1.56 m/s. Maximum wind velocity was recorded 13.8 m/s. The wind direction was mostly North West.

F) Noise

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. The Day Time Noise Level (SPL) in all 13 locations at Deendayal Port ranged from 49.6 dB(A) to 70.9 dB(A) and it was within the permissible limits of 75 dB(A) for the industrial area for the daytime. The Night Time Average Noise Level (SPL) in all 13 locations of Deendayal Port ranged from 46.6 dB to 66.2 dB(A) and it was within the permissible limits of 70 dB(A) for the industrial area for the night time.

2.0 Introduction

About Deendayal Port

The Deendayal Port is situated in the Kandla Creek and is 90 kms. From the mouth of Gulf of Kachchh. Latitude: 23° 01" N Longitude: 70° 13"E. Deendayal Port's journey began in 1931 with construction of RCC Jetty by Maharao Khengarji. After partition, Deendayal Port's success story has continued and it rise to the No. 1 Port in India in the year 2007-08 and since then retained the position for the 15 consecutive year. On 31.03.2016, Deendayal Port created history by handling 100 MMT cargoes in a year, the first Major Port to achieve the milestone. Kandla, also known as the Deendayal Port Authority is a seaport in Kutch District of Gujarat state in western India, near the city of Gandhidham. Located on the Gulf of Kutch, it is one of major ports on west coast. Kandla was constructed in the 1950s as the chief seaport serving western India, after the partition of India from Pakistan left the port of Karachi in Pakistan. The Port of Deendayal is located on the Gulf of Kutch on the northwestern coast of India some 256 nautical miles North West of the Port of Karachi in Pakistan and over 430 nautical miles north-northwest of the Port of Mumbai (Bombay). It is the largest port of India by volume of cargo handled. Kandla history Deendayal Port Authority, India's busiest major port in recent years, is gearing to add substantial cargo handling capacity with private sector participation. The west coast port handled 72,225 million tonnes of cargo in 2008-09, over 11% more than 64,920 million tonnes handled in2007-08. Even as much of this growth has come from handling of crude oil imports, mainly for Essar Oil's Vadinar refinery in Gujarat, the port is also taking measures to boost non-POL cargo. Last fiscal, POL traffic accounted for 63 per cent of the total cargo handled at Deendayal Port, as against 59% in 2007-08. Although Deendayal Port Authority officials declined to elaborate given the ongoing election code of conduct, it is reliably learnt that the port will soon initiate the process of selecting developers for four clean cargo berths that together aim to handle 8 million tonnes of cargo. The four berths will be supported by a 14 m draft capable of handling 75,000 dwt vessels.

The Deendayal Port Authority had commissioned the Off-shore Oil Terminal facilities at Vadinar in the year 1978, for which M/s. Indian Oil Corporation Limited (IOCL) provided Single Bouy Mooring (SBM) system, having a capacity of 54 MMTPA, which was first of its kind in India. Further, significant. Quantum of infrastructural up-gradation has been affected & excellent maritime infrastructure been created at Vadinar for the 32MMTPA Essar Oil Refinery in Jamnagar District. Monitoring of various environmental aspects of the Deendayal port by M/s Detox Corporation Pvt. Ltd. has been carried out through collection of samples, analysis of the same, comparing results with respect to the prescribed standards by GPCB/CPCB/MoEF& CC. The results shall address the identified impacts and suggest measures to minimize the environmental impact due to various operations at Deendayal Port. The environmental monitoring is carried out as per the Environment Management and Monitoring Plan submitted by Detox Corporation Pvt. Ltd

3. Introduction

Air pollutants are added in the atmosphere from variety of sources that change the composition of atmosphere and affect the biotic environment. The concentration of air pollutants depend not only on the quantities that are emitted from air pollution sources but also on the ability of the atmosphere to either absorb or disperse these emissions. The air pollution concentration vary spatially and temporarily causing the air pollution pattern to change with different locations and time due to changes in meteorological and topographical condition. The sources of air pollutants include vehicles, industries, domestic sources and natural sources. Because of the presence of high amount of air pollutants in the ambient air, the health of the population and property is getting adversely affected. In order to arrest the deterioration in air quality, Govt. of India has enacted Air (Prevention and Control of Pollution) Act in 1981. The responsibility has been further emphasized under Environment (Protection) Act, 1986. It is necessary to assess the present and anticipated air pollution through continuous air quality survey/monitoring programs. Therefore, Central Pollution

Control Board had started National Ambient Air Quality Monitoring (NAAQM) Network during 1984 - 85 at national level. The programme was later renamed as National Air Quality Monitoring Programme (NAMP).

3.1 Ambient Air Quality Monitoring

As per the Environmental Monitoring Plan of Deendayal Port Authority, Air monitoring was carried out at six identified locations at Deendayal Port and two locations at Vadinar Port.

- **Air Quality Monitoring Methodology**

  Air quality is measured in all the stations, for 24 hour for Total Suspended Particulate Matter (TSPM), PM_{10}, $PM_{2.5}$, SO_2, NO_2, NH_3, NMHC& Benzene, and Grab-sampling for CO & CO_2 measurements. The Air samplers are operated for a period of 24 hours and after a continuous operation of 8 hours for gaseous parameters. The reagents for $SO_{2:-}$ Mercuric Chloride, Potassium Chloride and EDTA used. For $NO_{2:-}$ Sodium Hydroxide and Sodium Arsenite. For NH_3 need Conc. Sulphuric Acid and Distilled water was used. By replacing 3 times the reagents per day for each parameter namely, SO_2, NO_2. The GFA filter paper and PTFE Membrane bound filter paper are used for a period of 24 hours to obtain one sample each of TSPM, PM_{10}& $PM_{2.5}$. The AAQ samples are collected two consecutive days a week as per CPCB guidelines, from all the eight locations as mentioned in the EMP.

3.2 Results

The ambient air quality monitoring data for six stations, viz. Marine Bhavan, Oil Jetty, Port Colony, Gopalpuri Hospital, Tuna Port and Nr. Coal Storage Area for the month of July 2022 are given in Tables 1 to 6. The ambient air quality monitoring data for two stations at Vadinar (Nr. Admin Building &Nr. Signal Building) are given in Tables 7 to 8.

Note: AL1 To AL8 are Air Monitoring Location 1 to 8. Where AL1 Marine Bhavan, AL2 Oil Jetty, AL3 Estate Office, AL4 Gopalpuri Hospital, AL5 Coal Storage, AL6 Tuna Port, AL7 Signal Building (Vadinar) and AL8 Admin Building (Vadinar).

Location 1: Marine Bhavan (AL1)

Table 1 : Results of Air Pollutant Concentration at Marine Bhavan										
Parameter	**Date**	**TSPM [µg/m3]**	**PM_{10} [µg/m3]**	**$PM_{2.5}$ [µg/m3]**	**SO_2 [µg/m3]**		**NO_2 [µg/m3]**		**NH_3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL1 – 1	01.07.2022	167	97	57	0.73	1.57	20.08	14.31	9.53	9.44
					2.18		12.47		8.70	
					1.81		10.39		10.08	
AL1 – 2	05.07.2022	185	127	52	2.90	2.90	11.77	11.77	11.74	10.31
					3.26		13.16		10.08	
					2.54		10.39		9.12	
AL1 – 3	11.07.2022	223	148	68	4.35	4.11	18.01	17.31	8.98	9.62
					2.54		20.08		10.36	
					5.44		13.85		9.53	
AL1 – 4	15.07.2022	193	126	59	3.63	2.66	10.39	12.00	11.46	9.25
					2.54		11.08		8.56	
					1.81		14.54		7.74	
AL1 – 5	18.07.2022	262	174	76	2.90	2.90	19.39	17.55	5.25	8.84
					2.54		18.01		10.22	
					3.26		15.24		11.05	
AL1 - 6	22.07.2022	304	212	86	5.08	4.71	21.47	20.78	9.81	7.83
					4.71		22.16		7.04	
					4.35		18.70		6.63	
AL1 - 7	25.07.2022	261	177	78	6.16	5.56	20.78	18.01	8.01	8.15
					5.44		17.31		9.53	
					5.08		15.93		6.91	
AL1 – 8	29.07.2022	301	202	90	3.63	4.23	16.62	14.08	10.91	10.27
					4.35		14.54		8.84	
					4.71		11.08		11.05	
Monthly Average		237	158	71		3.58		15.73		9.21
Standard Deviation		53	40	14		1.29		3.18		0.90

Table 1 : Results of Air Pollutant Concentration at Marine Bhavan					
Parameter	**Date**	**C_6H_6 [µg/m3]**	***NMHC**	**CO [mg/m3]**	**CO_2 [ppm]**
Sampling Period		**8 hr**		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**	**ppm**	**4.0 mg/m3**	**-**
AL1 – 1	01.07.2022	1.15	BQL	1.63	615
AL1 – 2	05.07.2022	1.12	BQL	1.5	1123
AL1 – 3	11.07.2022	1.04	BQL	1.89	1792
AL1 – 4	15.07.2022	1.15	BQL	2.11	1075
AL1 – 5	18.07.2022	1.12	BQL	1.08	2563
AL1 - 6	22.07.2022	1.18	BQL	1.78	632
AL1 - 7	25.07.2022	1.04	BQL	2.23	1023
AL1 - 8	29.07.2022	1.18	BQL	2.19	1429
Monthly Average		**1.12**	**-**	**1.80**	**1282**
Standard Deviation		**0.06**	**-**	**0.39**	**646**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

At Marine Bhavan, the overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, $NO_2$and NH_3 is attributed mainly by motor vehicle emission produced from various types of automobiles (both diesel and petrol driven). Moreover, the loading and unloading of Food Grains and Timber at Jetty no. 1 and 2 also contributes to the high levels of TSPM and PM_{10}. The mean TSPM value at Marine Bhavan was 237 µg/m^3, The mean PM_{10} value was 158 µg/m^3, $PM_{2.5}$ value was 71 µg/m^3 which is above the permissible limit. The average values of SO_2, $NO_2$and NH_3 were within the permissible limit. The average values of SO_2, $NO_2$and NH_3 were 3.58 µg/ m^3, 15.73 µg/ m^3 & 9.21 µg/ m^3 respectively. These were within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Marine Bhavan. The mean Benzene concentration was 1.12 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.80 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 2: Oil Jetty (AL2)

Table 2 : Results of Air Pollutant Concentration at Oil Jetty										
	Date	**TSPM [µg/m3]**	**PM_{10} [µg/m3]**	**$PM_{2.5}$ [µg/m3]**	**SO_2 [µg/m3]**		NO_2**[µg/m3]**		**NH_3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL2 -1	01.07.2022	156	91	54	3.26 5.08 2.90	3.75	10.39 8.31 11.08	9.93	7.04 5.39 8.56	7.00
AL2 -2	05.07.2022	227	147	69	1.45 3.63 5.44	3.51	11.77 9.00 12.47	11.08	6.63 9.53 8.84	8.33
AL2 -3	11.07.2022	253	172	74	6.89 8.34 4.71	6.65	24.24 19.39 14.54	19.39	7.46 10.08 11.05	9.53
AL2 -4	15.07.2022	236	160	65	3.26 1.45 2.90	2.54	13.16 15.24 16.62	15.01	10.22 11.46 12.02	11.23
AL2 – 5	18.07.2022	315	208	92	4.30 3.63 3.26	3.73	22.16 17.31 16.62	18.70	7.46 6.63 7.87	7.32
AL2 – 6	22.07.2022	232	171	58	5.80 4.71 3.99	4.83	13.85 17.31 15.93	15.70	4.97 6.91 8.98	6.95
AL2 – 7	25.07.2022	182	111	59	2.54 1.81 1.09	1.81	20.78 15.24 13.85	16.62	10.64 8.43 7.87	8.98
AL2 -8	29.07.2022	181	122	54	2.90 5.44 4.71	4.35	11.77 13.16 14.54	13.16	5.53 9.81 10.22	8.52
Monthly Average		223	148	66		3.90		14.95		8.48
Standard Deviation		50	38	13		1.47		3.39		1.46

Table 2 : Results of Air Pollutant Concentration at Oil Jetty					
		C_6H_6 [µg/m3]		CO [mg/m3]	CO_2 [ppm]
Sampling Period	**Date**	**8 hr**	***NMHC**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL2 -1	01.07.2022	1.12	BQL	1.62	869
AL2 -2	05.07.2022	1.15	BQL	1.69	1181
AL2 -3	11.07.2022	1.02	BQL	1.69	1259
AL2 -4	15.07.2022	1.17	BQL	1.94	1882
AL2 – 5	18.07.2022	1.22	BQL	1.77	1790
AL2 – 6	22.07.2022	1.21	BQL	2.11	633
AL2 -7	25.07.2022	1.12	BQL	1.75	780
AL2 -8	29.07.2022	1.02	BQL	2.06	1842
Monthly Average		**1.13**	**-**	**1.83**	**1280**
Standard Deviation		**0.08**	**-**	**0.18**	**505**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

Oil Jetty Area, the overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, $NO_2$and NH_3 was mainly by motor vehicle emission produced from various types of vehicles at Oil Jetty Area. The mean TSPM values at Oil Jetty was 223 µg/m^3. The mean PM_{10} value was 148 µg/m^3, $PM_{2.5}$ value was 66 µg/m^3 which is above the permissible limit. The average values of SO_2, $NO_2$and NH_3 were within the permissible limit, The mean concentration of SO_2, NO_2 and NH_3 were 3.90 µg/m^3, 14.95 µg/m^3 and 8.48 µg/m^3 respectively.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Oil Jetty. The mean Benzene concentration was 1.13 µg/m^3 which was well below the permissible limit of 5.0 µg/m^3, NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.83 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 3: Kandla Colony – Estate Office (AL-3)

Table 3 : Results of Air Pollutant Concentration at Estate Office										
Parameter	**Date**	**TSPM [µg/m3]**	**PM_{10} [µg/m3]**	**$PM_{2.5}$ [µg/m3]**	**SO_2 [µg/m3]**		**NO_2[µg/m3]**		**NH_3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL3 – 1	01.07.2022	175	108	65	1.81 2.54 0.73	1.69	22.42 25.34 21.45	23.07	6.12 5.45 4.21	5.26
AL3 – 2	05.07.2022	261	170	83	2.54 3.99 4.35	3.63	17.87 12.13 13.47	14.49	6.14 8.75 4.69	6.53
AL3 – 3	11.07.2022	315	207	93	5.80 3.63 4.35	4.59	14.21 18.54 11.87	14.87	9.78 8.31 7.12	8.40
AL3 – 4	15.07.2022	272	184	81	2.18 3.26 4.71	3.38	17.25 11.54 16.78	15.19	8.64 9.87 9.13	9.21
AL3 – 5	18.07.2022	336	220	98	6.53 5.44 3.99	5.32	17.52 20.78 12.11	16.80	5.63 6.12 8.72	6.82
AL3 – 6	22.07.2022	311	234	68	4.71 2.90 3.26	3.62	15.24 13.36 18.26	15.62	5.11 6.48 6.32	5.97
AL3 – 7	25.07.2022	228	141	78	1.45 3.99 2.90	2.78	15.87 16.42 19.35	17.21	9.21 8.32 8.73	8.75
AL3 – 8	29.07.2022	284	184	96	4.71 5.08 4.35	4.71	12.45 13.10 11.85	12.47	5.36 7.56 10.23	7.72
Monthly Average		273	181	83		3.72		16.22		7.33
Standard Deviation		52	42	12		1.16		3.13		1.41

Table 3 : Results of Air Pollutant Concentration at Estate Office					
		C_6H_6 [µg/m3]		CO [mg/m3]	CO_2 [ppm]
Sampling Period	**Date**	**8 hr**	***MNHC**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL3 -1	01.07.2022	1.03	BQL	1.61	531
AL3 -2	05.07.2022	1.04	BQL	1.47	915
AL3 -3	11.07.2022	1.15	BQL	1.74	1119
AL3 -4	15.07.2022	1.14	BQL	2.06	1278
AL3 – 5	18.07.2022	1.16	BQL	2.05	1669
AL3 – 6	22.07.2022	1.03	BQL	2.18	688
AL3 – 7	25.07.2022	1.06	BQL	2.06	686
AL3 – 8	29.07.2022	1.08	BQL	2.23	1791
Monthly Average		**1.09**	**-**	**1.93**	**1085**
Standard Deviation		**0.06**	**-**	**0.28**	**468**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, $NO_2$and NH_3 at Kandla Port Colony was attributed by vehicle emission produced from trucks and heavy duty vehicles that pass through the road outside Kandla Port Colony. The mean TSPM values at Kandla port Colony were 273 µg/m^3, The mean PM_{10} value was 181 µg/m^3, $PM_{2.5}$ value was 83 µg/m^3 which is above the permissible limit. The average values of SO_2, NO_2 and NH_3 were 3.72 µg/m^3, 16.22 µg/m^3 and 7.33 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Kandla Port Colony. The mean Benzene concentration was 1.09 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.93 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 4: Gopalpuri Hospital (AL-4)

Table 4 : Results of Air Pollutant Concentration at Gopalpuri Hospital

Parameter	Date	TSPM [µg/m3]	PM_{10} [µg/m3]	$PM_{2.5}$ [µg/m3]	SO_2 [µg/m3]		NO_2[µg/m3]		NH_3 [µg/m3]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit			100 µg/m3	60 µg/m3		80 µg/m3		80 µg/m3		400 µg/m3
AL4 -1	01.07.2022	133	86	42	1.54	2.62	14.12	13.95	6.65	7.43
					4.21		9.89		9.89	
					2.11		17.85		5.75	
AL4 -2	05.07.2022	158	99	53	1.35	2.17	10.21	11.56	4.36	5.50
					2.01		12.32		6.35	
					3.14		12.14		5.78	
AL4 -3	11.07.2022	170	104	57	2.65	3.10	15.65	16.55	4.12	4.59
					3.45		15.24		5.65	
					3.21		18.75		4.01	
AL4 -4	15.07.2022	133	87	42	4.12	3.13	21.32	17.26	5.69	5.45
					2.17		14.56		6.35	
					3.11		15.89		4.32	
AL4 – 5	18.07.2022	166	103	58	4.13	3.66	17.23	14.27	4.87	6.53
					3.21		11.25		5.96	
					3.64		14.32		8.75	
AL4 – 6	22.07.2022	181	116	60	5.78	4.77	21.12	20.38	6.32	6.43
					4.32		22.45		4.35	
					4.21		17.56		8.63	
AL4 – 7	25.07.2022	215	130	74	2.21	3.15	15.18	18.91	8.32	7.09
					3.12		21.56		8.75	
					4.11		19.98		4.21	
AL4 – 8	29.07.2022	220	135	82	4.32	4.43	14.56	12.81	5.36	6.01
					3.21		13.32		8.45	
					5.75		10.56		4.21	
Monthly Average		172	107	58		3.38		15.71		6.13
Standard Deviation		33	18	14		0.87		3.07		0.93

Table 4 : Results of Air Pollutant Concentration at Gopalpuri Hospital					
		C_6H_6 [µg/m3]		CO [mg/m3]	CO_2 [ppm]
Sampling Period	**Date**	**8 hr**	***NMHC**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL4 -1	01.07.2022	1.13	BQL	1.48	500
AL4 -2	05.07.2022	1.17	BQL	1.42	1544
AL4 -3	11.07.2022	1.15	BQL	1.74	1119
AL4 -4	15.07.2022	1.12	BQL	1.79	1576
AL4 – 5	18.07.2022	1.07	BQL	1.73	1578
AL4 – 6	22.07.2022	1.14	BQL	2.21	870
AL4 – 7	25.07.2022	1.02	BQL	2.19	1277
AL4 – 8	29.07.2022	1.05	BQL	2.19	1682
Monthly Average		**1.11**	**-**	**1.84**	**1268**
Standard Deviation		**0.05**	**-**	**0.32**	**416**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 at Gopalpuri Hospital was attributed by vehicle emission produced from light motor vehicles of the colony residents. The mean TSPM values at Gopalpuri Hospital were 172 µg/m^3, the mean PM_{10} value was 107 µg/m^3 which is slightly above the permissible limit, $PM_{2.5}$ value was 58 µg/m^3 which is within the permissible limit. The average values of SO_2, NO_2 and NH_3 were 4.32 µg/m^3, 17.98 µg/m^3 and 7.47 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Gopalpuri Hospital. The mean Benzene concentration was 1.10 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.74 mg/m^3 which is well below the permissible limit of 4.0 mg/m^3.

Location 5: Coal Storage Area (AL-5)

Table 5 : Results of Air Pollutant Concentration at Coal Storage Area

Parameter	Date	TSPM [µg/m3]	PM_{10} [µg/m3]	$PM_{2.5}$ [µg/m3]	SO_2 [µg/m3]		NO_2 [µg/m3]		NH_3 [µg/m3]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit			100 µg/m3	60 µg/m3		80 µg/m3		80 µg/m3		400 µg/m3
AL5 – 1	01.07.2022	684	550	130	4.35	4.11	21.45	19.36	5.14	6.06
					4.71		15.35		4.32	
					3.26		21.28		8.72	
AL5 – 2	05.07.2022	359	243	109	6.24	4.93	14.35	19.38	10.56	10.29
					5.89		21.65		11.32	
					2.65		22.14		8.98	
AL5 – 3	11.07.2022	453	321	124	7.58	6.01	15.27	17.62	6.56	6.24
					6.32		18.34		4.26	
					4.12		19.25		7.89	
AL5 – 4	15.07.2022	490	350	131	5.23	6.25	22.14	19.98	8.69	8.26
					7.21		24.11		6.98	
					6.32		13.68		9.12	
AL5 – 5	18.07.2022	596	426	154	4.58	3.31	17.25	18.29	8.36	6.01
					2.36		21.65		4.56	
					2.98		15.96		5.12	
AL5 – 6	22.07.2022	521	391	127	2.64	2.31	23.61	19.47	9.25	8.32
					1.98		20.58		6.38	
					2.31		14.23		9.32	
AL5 – 7	25.07.2022	630	462	156	4.65	4.73	11.68	13.12	7.12	7.06
					5.32		12.35		8.36	
					4.23		15.32		5.69	
AL5 – 8	29.07.2022	687	503	177	2.31	2.93	17.29	16.66	9.34	7.52
					2.12		14.36		5.89	
					4.35		18.32		7.32	
Monthly Average		553	406	139		4.32		17.98		7.47
Standard Deviation		117	101	22		1.42		2.26		1.47

Table 5 : Results of Air Pollutant Concentration at Coal Storage Area					
		C_6H_6 [µg/m3]		CO [mg/m3]	CO_2 [ppm]
Sampling Period	**Date**	**8 hr**	***NMHC**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL5 – 1	01.07.2022	1.08	BQL	1.54	510
AL5 – 2	05.07.2022	1	BQL	1.32	755
AL5 – 3	11.07.2022	1.06	BQL	1.51	2758
AL5 – 4	15.07.2022	1.12	BQL	1.69	2648
AL5 – 5	18.07.2022	1.05	BQL	1.97	1761
AL5 – 6	22.07.2022	1.2	BQL	1.59	723
AL5 – 7	25.07.2022	1.16	BQL	2.19	802
AL5 – 8	29.07.2022	1.11	BQL	2.08	2366
Monthly Average		**1.10**	**-**	**1.74**	**1540**
Standard Deviation		**0.06**	**-**	**0.31**	**951**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, $NO_2$and NH_3 at Coal Storage Area was comparatively highest among all the locations of Air Quality monitoring in Kandla Port. High values of TSPM, $PM_{10,}$ $PM_{2.5}$, SO_2, NO_2 at this location was due to lifting of coal with grab and other coal handling processes near Berth no. 6 & 7. Moreover, the traffic was also heavy around this place for transport of coal thus emissions produced from heavy vehicles. The mean TSPM values at Coal storage were 553 µg/m^3. The mean PM_{10} values were 406 µg/m^3, The $PM_{2.5}$ values were 139 µg/m^3 which is well above the permissible limit. The average values of SO_2, $NO_2$and NH_3 were 4.32 µg/m^3, 17.98 µg/m^3 and 7.47 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Coal Storage Area. The mean Benzene concentration was1.10 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.74 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 6: Tuna Port (AL-6)

Table 6 : Results of Air Pollutant Concentration at Tuna Port										
Parameters	**Date**	**TSPM [µg/m3]**	**PM_{10} [µg/m3]**	**$PM_{2.5}$ [µg/m3]**	**SO_2 [µg/m3]**		**NO_2 [µg/m3]**		**NH_3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL6 -1	01.07.2022	118	78	33	3.63 2.90 1.81	2.78	21.36 12.58 15.63	16.52	9.63 8.75 10.11	9.50
AL6 – 2	05.07.2022	128	84	40	2.18 3.26 5.66	3.70	12.47 15.93 14.54	14.31	6.65 9.39 8.66	8.23
AL6 – 3	11.07.2022	144	91	45	4.35 3.99 5.44	4.59	22.58 18.25 14.36	18.40	5.31 4.56 5.32	5.06
AL6 – 4	15.07.2022	119	73	38	2.69 3.32 2.98	3.00	8.85 11.36 12.55	10.92	6.75 8.12 4.69	6.52
AL6 – 5	18.07.2022	143	89	44	4.71 3.63 5.80	4.71	20.98 18.25 14.36	17.86	9.35 10.36 9.53	9.75
AL6 – 6	22.07.2022	149	95	49	5.08 3.99 6.16	5.08	24.35 22.14 19.36	21.95	8.25 5.98 4.98	6.40
AL6 – 7	25.07.2022	144	87	46	5.44 2.90 5.44	4.59	21.17 18.25 19.30	19.57	7.74 8.29 6.08	7.37
AL6 – 8	29.07.2022	148	94	50	4.35 4.71 5.80	4.95	17.26 12.35 12.34	13.98	10.23 7.35 8.23	8.60
Monthly Average		137	86	43		4.18		16.69		7.68
Standard Deviation		13	8	6		0.90		3.52		1.63

Table 6 : Results of Air Pollutant Concentration at Tuna Port					
		C_6H_6 [µg/m3]		CO [mg/m3]	CO_2 [ppm]
Sampling Period	**Date**	**8 hr**	***NMHC**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL6 -1	01.07.2022	1.02	BQL	1.68	460
AL6 – 2	05.07.2022	1.19	BQL	1.56	495
AL6 – 3	11.07.2022	1.02	BQL	2.1	1133
AL6 – 4	15.07.2022	1.09	BQL	2.06	1818
AL6 – 5	18.07.2022	1.01	BQL	1.36	1240
AL6 – 6	22.07.2022	1.15	BQL	2.14	549
AL6 – 7	25.07.2022	1	BQL	2.17	921
AL6 – 8	29.07.2022	1.15	BQL	1.88	1268
Monthly Average		**1.08**	**-**	**1.87**	**986**
Standard Deviation		**0.08**	**-**	**0.30**	**474**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The mean TSPM values at Tuna Port was137 µg/m^3, the mean PM_{10} value was 86 µg/m^3, the mean $PM_{2.5}$ value was 43 µg/m^3 which is within the permissible limit. The average values of SO_2, $NO_2$and NH_3 were 4.18 µg/m^3, 16.69 µg/m^3 and 7.68 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Tuna Port. The mean Benzene concentration was 1.08 µg/m3, well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.87 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 7: Signal Building (Vadinar) (AL-7)

Table 7 : Results of Air Pollutant Concentration at Signal building Vadinar

Parameters	Date	TSPM [µg/m3]	PM_{10} [µg/m3]	$PM_{2.5}$ [µg/m3]	SO_2 [µg/m3]		NO_2 [µg/m3]		NH_3 [µg/m3]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit			100 µg/m3	60 µg/m3		80 µg/m3		80 µg/m3		400 µg/m3
AL7 -1	02.07.2022	150	99	45	4.71	3.14	13.85	14.08	5.66	6.45
					3.63		16.62		7.60	
					1.09		11.77		6.08	
AL7 -2	05.07.2022	137	89	41	5.80	5.56	12.47	15.24	9.53	8.10
					4.71		15.24		6.77	
					6.16		18.01		8.01	
AL7 -3	08.07.2022	146	91	52	1.81	2.66	13.16	12.93	5.39	6.77
					3.63		14.54		7.04	
					2.54		11.08		7.87	
AL7 -4	12.07.2022	185	110	68	5.08	3.99	18.01	18.01	8.98	9.39
					2.18		18.70		9.12	
					4.71		17.31		10.08	
AL7 -5	15.07.2022	179	100	60	1.81	1.57	14.54	13.62	7.74	6.26
					0.73		15.93		5.80	
					2.18		10.39		5.25	
AL7 -6	19.07.2022	175	122	75	2.54	3.75	19.39	19.39	8.15	8.38
					3.99		18.70		9.81	
					4.71		20.08		7.18	
AL7 -7	22.07.2022	151	98	49	6.16	4.59	14.54	15.23	6.49	6.08
					3.26		13.85		5.94	
					4.35		17.31		5.80	
AL7-8	26.07.2022	189	117	66	1.45	3.39	13.16	12.47	4.80	5.38
					3.63		12.47		5.39	
					5.08		11.77		5.94	
AL7-9	29.07.2022	164	103	55	6.16	4.35	14.54	12.23	6.35	6.21
					4.35		11.77		5.66	
					2.54		10.39		6.63	
Monthly Average		164	103	57		4		15		7
Standard Deviation		19	11	11		1		2		1

Table 7 : Results of Air Pollutant Concentration at Signal building Vadinar					
Sampling Period	Date	C_6H_6 [µg/m^3]	*NMHC	CO [mg/m^3]	CO_2 [ppm]
		8 hr		Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m^3		4.0 mg/m^3	
AL7 -1	02.07.2022	1.16	BQL	1.57	446
AL7 -2	05.07.2022	1.1	BQL	1.43	425
AL7 -3	08.07.2022	1.21	BQL	1.27	597
AL7 -4	12.07.2022	1.08	BQL	1.31	502
AL7 -5	15.07.2022	1.12	BQL	1.81	550
AL7 -6	19.07.2022	1.08	BQL	2.05	315
AL7 -7	22.07.2022	1.06	BQL	2.16	537
AL7 -8	26.07.2022	1	BQL	1.97	285
AL7 -9	29.07.2022	1.02		1.87	380
Monthly Average		**1.1**	**-**	**1.7**	**457**
Standard Deviation		**0.06**	**-**	**0.35**	**112**

*NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The mean TSPM values at Signal building Vadinar 164 µg/m^3, the mean PM_{10} value was 103µg/m^3 which is slightly above the permissible limit, the mean $PM_{2.5}$ value was 57 µg/m^{3}which is within the permissible limit. The average values of SO_2, NO_2 and NH_3 were 4 µg/m^3, 15 µg/m^3 and 7 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Vadinar Port. The mean Benzene concentration was 1.10 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.70 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 8: Admin Building (Vadinar) (AL-8)

Table 8 : Results of Air Pollutant Concentration at Admin Building Vadinar

Parameters	Date	TSPM [µg/m3]	PM_{10} [µg/m3]	$PM_{2.5}$ [µg/m3]	SO_2 [µg/m3]		NO_2 [µg/m3]		NH_3 [µg/m3]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit			100 µg/m3	60 µg/m3		80 µg/m3		80 µg/m3		400 µg/m3
AL8 -1	02.07.2022	157	104	49	3.26	2.66	11.77	11.08	7.04	6.49
					1.81		11.08		6.49	
					2.90		10.39		5.94	
AL8 -2	05.07.2022	161	105	50	5.08	3.75	15.93	15.93	8.15	7.09
					3.63		17.31		5.25	
					2.54		14.54		7.87	
AL8 -3	08.07.2022	134	88	41	2.18	3.51	9.70	12.01	6.77	8.70
					4.35		12.47		10.22	
					3.99		13.85		9.12	
AL8 -4	12.07.2022	196	118	70	5.44	4.71	17.31	14.08	7.60	6.17
					3.99		13.16		5.25	
					4.71		11.77		5.66	
AL8 -5	15.07.2022	184	116	55	1.45	2.18	10.39	9.47	7.87	7.32
					2.18		8.31		8.01	
					2.90		9.70		6.08	
AL8 -6	19.07.2022	138	93	43	3.99	3.26	15.24	16.85	5.53	5.67
					3.26		17.31		6.22	
					2.54		18.01		5.25	
AL8 -7	22.07.2022	164	102	58	0.73	1.09	8.31	9.69	8.70	7.60
					1.09		9.00		6.77	
					1.45		11.77		7.32	
AL8-8	26.07.2022	163	104	52	2.18	2.06	10.39	12.93	6.49	8.61
					1.81		15.93		9.12	
					2.18		12.47		10.22	
AL8-9	29.07.2022	170	98	59	3.26	3.38	13.16	13.62	5.66	6.26
					4.35		11.77		6.22	
					2.54		15.93		6.91	
Monthly Average		163	103	53		3		13		7
Standard Deviation		20	10	9		1		3		1

Table 8 : Results of Air Pollutant Concentration at Admin Building Vadinar					
		C_6H_6 [µg/m3]		CO [mg/m3]	CO_2 [ppm]
Sampling Period	Date	8 hr	*NMHC	Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m3		4.0 mg/m3	-
AL8 -1	02.07.2022	1.08	BQL	1.54	451
AL8 -2	05.07.2022	1.11	BQL	1.3	474
AL8 -3	08.07.2022	1.13	BQL	1.61	514
AL8 -4	12.07.2022	1.04	BQL	1.58	498
AL8 -5	15.07.2022	1.05	BQL	2.01	501
AL8 -6	19.07.2022	1.18	BQL	1.99	337
AL8 -7	22.07.2022	1.17	BQL	1.7	491
AL8 -8	26.07.2022	1.17	BQL	2.08	437
AL8 -9	29.07.2022	1.1	BQL	1.52	456
Monthly Average		**1.12**	**-**	**1.73**	**463**
Standard Deviation		**0.06**	**-**	**0.27**	**57**

* NMHC- Non- Methane Hydrocarbon
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The mean TSPM value at Admin Building Vadinar was 163 µg/m^3. The mean PM_{10} values were 103 µg/m^3 which is slightly above the permissible limit, $PM_{2.5}$ value was 53 µg/m^3 which is within the permissible limit. The average values of SO_2, NO_2 and NH_3 were 3.0 µg/m^3, 13.0 µg/m^3 and 7.0 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Admin Building, Vadinar Port. The mean Benzene concentration was 1.162 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.73 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

3.3 Observations and Conclusion

During the monitoring period, the overall Ambient Air Quality of the port area was found within permissible levels for various gaseous pollutants. However, Total Suspended Particulate matter as TSPM, Particulate matter as PM_{10} and $PM_{2.5}$ was found to exceed the limits at locations like Near Coal storage area, Marine Bhavan, Estate Office and Oil Jetty. The concentration of PM_{10} was slightly higher at Gopalpuri Hospital, Admin building Vadinar & Signal building Vadinar while the concentration of $PM_{2.5}$ was found within permissible limit. Only at Tuna port, all parameters of ambient air quality were found within the limit.

4.1 Meteorological Data

Automatic Weather station (ID KAZPHOEN424) have been installed in Seva Sadan - 3 at the Deendayal Port which records the data on Temperature (°C), Relative Humidity (%),Wind speed (kmph),Wind Direction (°),Solar radiation (w/m^2) and Rainfall mm.

Temperature

The mean day time temperature for Deendayal Port was 25.6 °C. The day-time maximum temperature was 34.3°C. The mean night time temperature recorded was 28.4 °C.

Solar Radiation

The mean Solar Radiation in July month was 115.72 w/m^2. The maximum solar radiation was recorded 623.2 w/m^2 in 18th July and the minimum solar radiation was recorded 0.23 w/m^2 in 27th July

Rainfall

The total Rainfall in the month of July was recorded 6.5 mm.

Relative Humidity

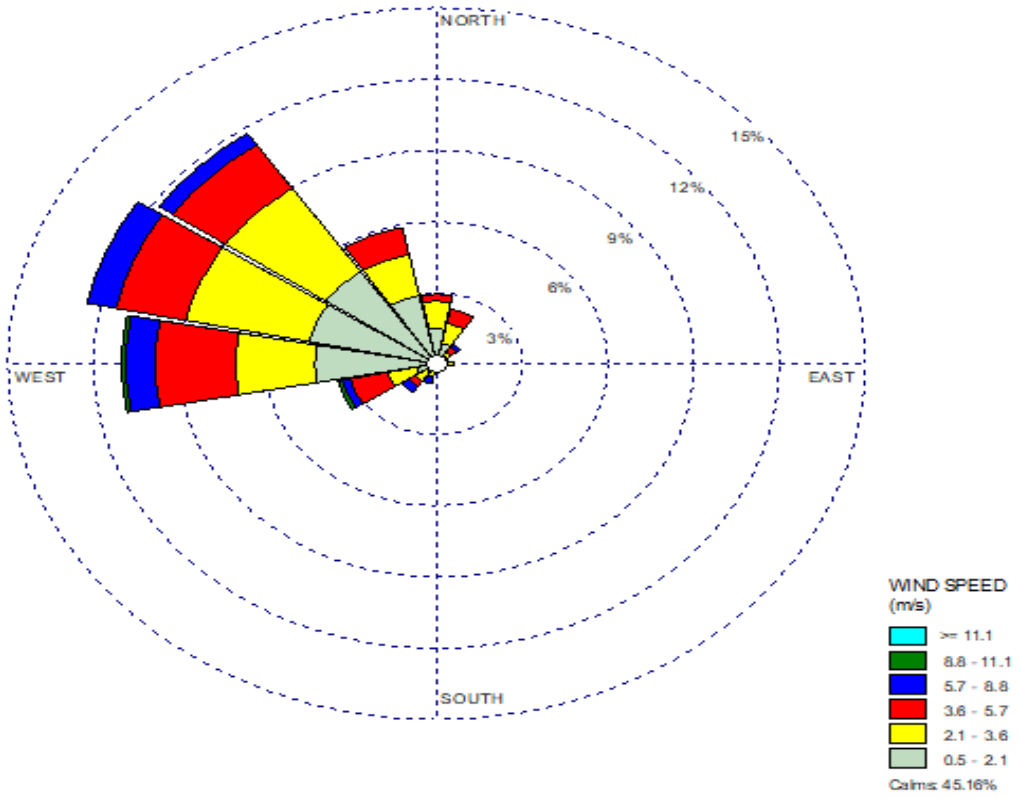
The mean Relative humidity was 88.15 % for the month of July. Maximum Relative humidity was recorded 99.0 % and minimum Relative humidity was recorded 47 %.

Wind Velocity and Wind Direction

The average wind velocity for the entire month of July was 1.56 m/s. Maximum wind velocity was recorded 13.8 m/s. The wind direction was mostly North West.

WINDROSE PLOT:
DPT - Kutch Windrose July-22

DISPLAY:
Wind Speed
Direction (blowing from)



COMMENTS:	DATA PERIOD:	COMPANY NAME:	
	2022 **Jul 1 - Jul 31** **00:00 - 23:00**	MODELER:	
	CALM WINDS: **45.16%**	TOTAL COUNT: **682 hrs.**	
	AVG. WIND SPEED: **1.55 m/s**	DATE: **8/20/2022**	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

Drinking Water Monitoring

5.0 Drinking Water Quality Monitoring

Drinking Water Quality Monitoring was carried out at twenty stations at Kandla, Vadinar & Township Area of Deendayal Port.

5.1 Drinking Water Monitoring Methodology

Drinking water samples were collected from 20 locations as prescribed in the tender document. Samples for physico-chemical analysis were collected in 2 Carboys and samples for microbiological parameters were collected in sterilized bottles. These samples were then analyzed in laboratory for various drinking water parameters at Kandla Lab/Surat.

The Sampling was done as per IS 3025 Part-1, analysis was done as per IS3025/APHA standard methods and, the analysis results compare with IS 10500:2012. The water samples were analyzed for various parameters, viz. Color , Odor, Turbidity , Conductivity , pH , Chlorides , TDS, Total Hardness, Iron , Sulphate , Salinity , DO, BOD, Na, K, Ca, Mg, F, NO_3, NO_2, Mn, Cr-6, Cu, Cd, As, Hg, Pb, Zn, Bacterial Count (cfu) .

5.2 Results

The Drinking Water Quality monitoring data for 20 stations are given in below from table No. 9 to Table No. 15

Table 9: Drinking Water Quality Monitoring Parameters for Nirman Building 1 (23° 0' 27"E, 70° 13' 21"N) P & C building (23° 0' 33"E 70° 13' 20"N) & Main Gate (North) at Kandla (23° 0' 26.97"E, 70° 13' 21.87"N)

Sr. No.	Parameter	Unit	Nirman Building 1	P & C building	Main Gate North	Acceptable Limits as per IS 10500 :2012 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 :
1	pH	-	8.48	8.18	8.6	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved	mg/l	634	610	560	500	2000
3	Turbidity	NTU	1	0.2	1	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	1313	1210	1110	NS*	NS*
7	BOD	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	160.36	145.32	120.27	250	1000
9	Total Hardness	mg/l	340	240	200	200	600
10	Calcium	mg/l	40.08	48.10	52.10	75	200
11	Salinity	‰	0.29	0.26	0.22	NS*	NS*
12	Mg as Mg	mg/l	58.32	29.16	17.01	30	100
13	Fluorides as F	mg/l	0.22	0.31	0.13	1	1.5
14	Sulphate as SO_4	mg/l	27.72	24.26	21.49	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	0.40	0.28	0.81	45	No Relaxation
17	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
18	Sodium as Na	mg/l	98.57	91.74	88.00	NS*	NS*
19	Potassium as K	mg/l	3.59	5.94	3.04	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe- 0.009 mg/l, Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu- 0.004 mg/l, Cd- 0.003 mg/l, As- 0.003mg/l, Hg- 0.001 mg/l, Pb- 0.006mg/l, Zinc- 0.021 mg/l).

Table 10: Drinking Water Quality Monitoring Parameters for Canteen, (23° 2' 17.2674"E, 70° 13' 18.2814"N) West Gate – I(23° 59' 40.48"E, 70° 12' 50.96"N) & Wharf Area (22° 59' 52.2"E,70° 13' 22.95"N) at Kandla

Sr. No.	Parameter	Unit	Canteen	West Gate – I	Wharf Area	Acceptable Limits as per IS 10500 :	Permissible Limits in the absence of Alternate Source as per IS 10500 :
1	pH	-	7.63	7.6	7.57	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	650	620	600	500	2000
3	Turbidity	NTU	1	0.6	1	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	1260	1240	1760	NS*	NS*
7	BOD	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	145.32	130.29	120.27	250	1000
9	Total Hardness	mg/l	210	210	230	75	600
10	Calcium	mg/l	56.11	52.10	48.10	30	200
11	Salinity	‰	0.26	0.26	0.24	NS*	NS*
12	Mg as Mg	mg/l	17.01	19.44	26.73	0.3	100
13	Fluorides as F	mg/l	0.29	0.18	0.16	1	1.5
14	Sulphate as SO_4	mg/l	31.65	28.18	21.25	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	8.26	2.62	0.60	45	No Relaxation
17	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
18	Sodium as Na	mg/l	96.98	97.46	93.40	NS*	NS*
19	Potassium as K	mg/l	4.61	3.19	3.75	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100 ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified,

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 11:Drinking Water Quality Monitoring Parameters for Sewa sadan – 3,(23° 0' 22.55"E, 70° 13' 15.34"N) Workshop I (23° 0' 33.74"E, 70° 13' 20.05"N)&Custom Building (23° 1' 8.70"E, 70° 12' 52.0"N) at Kandla

Sr. No.	Parameter	Unit	Sewa Sadan – 3	Workshop	Custom Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.66	7.75	7.95	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	540	460	659	500	2000
3	Turbidity	NTU	1	0.7	0.5	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	1182	940	1333	NS*	NS*
7	BOD	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	100.22	145.32	125.28	250	1000
9	Total Hardness	mg/l	200	170	240	200	600
10	Calcium	mg/l	44.09	40.08	48.10	75	200
11	Salinity	‰	0.22	0.18	0.26	NS*	NS*
12	Mg as Mg	mg/l	21.87	17.01	29.16	30	100
13	Fluorides as F	mg/l	0.15	1.16	0.26	1	1.5
14	Sulphate as SO_4	mg/l	24.03	21.02	37.43	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	2.21	0.20	0.94	45	100
17	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	1.0
18	Sodium as Na	mg/l	86.43	76.83	98.64	NS*	NS*
19	Potassium as K	mg/l	2.94	2.73	3.39	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 12:Drinking Water Quality Monitoring Parameters for Port Colony Kandla(23° 11' 14.9"E, 70° 12' 48.4"N) Hospital Kandla 23° 1' 5.02"E, 70° 12' 44.38"N)& A.O. Building (23° 3' 42.89"E, 70° 8' 41.5"N) atGandhidham

Sr. No.	Parameter	Unit	Port Colony Kandla	Hospital Kandla	A.O. Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.92	7.65	7.71	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	595	697	920	500	2000
3	Turbidity	NTU	1	1	1	1	5
4	Odour	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	1149	1399	1220	NS*	NS*
7	BOD	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	145.32	205.46	115.26	250	1000
9	Total Hardness	mg/l	170	190	310	200	600
10	Calcium	mg/l	44.09	40.08	48.10	75	200
11	Salinity	‰	0.23	0.26	0.37	NS*	NS*
12	Mg as Mg	mg/l	14.58	21.87	46.17	30	100
13	Fluorides as F	mg/l	0.07	0.40	0.45	1	1.5
14	Sulphate as SO_4	mg/l	25.41	40.43	62.84	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	0.40	0.54	7.38	45	100
17	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	1.0
18	Sodium as Na	mg/l	88.56	102.22	187.70	NS*	NS*
19	Potassium as K	mg/l	2.94	3.08	3.79	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified,

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 13: Drinking Water Quality Monitoring Parameters for School Gopalpuri,(23° 5' 1.03"E, 70° 7' 55.42"N) Guest House (23° 4' 43.14"E, 70° 7' 51.92"N) & E - Type Quarter(23° 4' 59.90"E, 70° 7' 56.72"N) at Gopalpuri, Gandhidham

Sr. No.	Parameter	Unit	Gopalpuri School	Guest House	E - Type Quarter	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.72	7.61	7.56	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	603	497	495	500	2000
3	Turbidity	NTU	0.8	0.4	1	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	1221	969	952	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	90.20	100.22	95.21	250	1000
9	Total Hardness	mg/l	240	210	180	200	600
10	Calcium	mg/l	40.08	40.08	40.08	75	200
11	Salinity	‰	0.21	0.16	0.18	NS*	NS*
12	Mg as Mg	mg/l	34.02	26.73	19.44	30	100
13	Fluorides as F	mg/l	0.23	0.26	0.35	1	1.5
14	Sulphate as SO_4	mg/l	30.03	25.18	20.10	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	0.74	0.87	0.60	45	100
17	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	1.0
18	Sodium as Na	mg/l	88.51	71.94	70.96	NS*	NS*
19	Potassium as K	mg/l	4.36	2.59	2.72	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100 ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified,

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 14:Drinking Water Quality Monitoring Parameters for F - Type Quarter, (23° 4' 38.45"E, 70° 8' 8.63"N) Hospital Gopalpuri (23° 4' 54.09"E, 70° 8' 7.5"N) & Tuna Port (23° 58' 23.06"E, 70° 5' 35.6"N)

Sr. No.	Parameter	Unit	F - Type Quarter	Hospital Gopalpuri	Tuna Port	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.6	8.38	7.88	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	492	518	1970	500	2000
3	Turbidity	NTU	1	0.6	1	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	1020	1020	3250	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	100.22	75.17	74.97	250	1000
9	Total Hardness	mg/l	190	220	350	200	600
10	Calcium	mg/l	44.09	48.10	40.08	75	200
11	Salinity	‰	0.17	0.18	0.14	NS*	NS*
12	Mg as Mg	mg/l	19.44	24.3	60.75	30	100
13	Fluorides as F	mg/l	0.33	0.23	1.39	1	1.5
14	Sulphate as SO_4	mg/l	21.95	25.64	123.60	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	1.41	2.48	4.03	45	100
17	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	1.0
18	Sodium as Na	mg/l	73.97	77.65	460.00	NS*	NS*
19	Potassium as K	mg/l	2.68	3.54	6.80	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified, BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 15: Drinking Water Quality Monitoring Parameters for Vadinar Jetty (22° 25' 51.73"E, 69° 41' 36.62"N) & Port Colony (22° 30' 26.25"E, 69° 39' 45.03"N) at Vadinar

Sr. No.	Parameter	Unit	Vadinar Jetty	Port Colony Vadinar	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.46	7.38	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	480	468	500	2000
3	Turbidity	NTU	1.00	0.30	1	5
4	Odor	-	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	5	15
6	Conductivity	µs/cm	940	945	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	104.97	89.97	250	1000
9	Total Hardness	mg/l	150	160	200	600
10	Calcium	mg/l	19.93	20.41	75	200
11	Salinity	‰	0.16	0.10	NS*	NS*
12	Mg as Mg	mg/l	85.05	72.90	30	100
13	Fluorides as F	mg/l	0.31	0.27	1	1.5
14	Sulphate as SO_4	mg/l	53.82	50.24	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	1.95	0.67	45	100
17	Iron as Fe	mg/l	BQL	BQL	0.3	1.0
18	Sodium as Na	mg/l	94.9	74.2	NS*	NS*
19	Potassium as K	mg/l	BQL(1.88)	BQL(1.85)	NS*	NS*
20	Manganese	mg/l	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent

*NS: Not Specified,

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

5.3 Results & Discussion

The colour of all drinking water samples was found Colourless and odour of the samples also agreeable. All parameters were found within the specified limit as per the Drinking water Standard.

pH

The pH values for drinking water samples were ranges from 7.38-8.60 and mean value was 7.81. All the sampling points showed pH values within the prescribed limit by Indian Standards.

Total Dissolved Solids (TDS)

TDS values in the studied area varied between 460-920 mg/l. None of the sampling points showed higher TDS values than the prescribed limit by Indian standards.

Conductivity

Electrical Conductivity is the ability of a solution to transfer (conduct) electric current. Conductivity is used to measure the concentration of dissolved solids which have been ionized in a polar solution such as water. The conductivity in the samples collected during the month of July ranged from 940-1760µs/cm and mean value was 1167 µs/cm.

BOD

BOD value in the studied area was found Below Quantification Limit (2.0 mg/l). IS 10500:2012 does not show any standard values for BOD in drinking water.

Chlorides

Excessive chloride concentration increase rates of corrosion of metals in the distribution system. This can lead to increased concentration of metals in the supply. Chloride value in the studied area varied between 75.17 – 205.46 mg/l and mean value was 120.24 mg/l. The Chloride was found within the Permissible limit of the Drinking Water Standard.

Calcium

Calcium value in the studied area varied between 19.93 – 56.11 mg/l and mean was 42.70 mg/l. The Calcium values were found to be within the Permissible limit of the Drinking Water Standard. If calcium is present beyond the maximum acceptable limit, it causes incrustation of pipes.

Magnesium

Magnesium value in the studied area varied between 14.58 - 85.05 mg/l and mean value was 33.05 mg/l. All the locations had Magnesium within the prescribed limits of 30-100 mg/L.

Total Hardness

Hardness value in the studied area varied between 150- 350 mg/l and mean was 220 mg/l. The values of total hardness were found within the Permissible limit of the Drinking Water Standard (200-600 mg/L).

Iron

Iron value in the studied area was found Below Quantification Limit (0.009 mg/l) and hence well below the permissible limit as per Indian Standards is 0.3 mg/L. The excess amount of iron causes slight toxicity; gives stringent taste to water.

Fluoride

Fluoride value in the studied area varied between 0.07 – 1.39 mg/l and mean was 0.37 mg/l. The Fluoride values were in line the permissible limit as per Indian Standards is 1.0-1.5 mg/L. Moderate amounts lead to dental effects, but long-term ingestion of large amounts can lead to potentially severe skeletal problems.

Sulphates

Sulphate value in the studied area varied between 20.10 – 62.84 mg/l and mean was 31.19 mg/l. All the sampling points showed sulphate values within the prescribed limits by Indian Standards (200-400 mg/L). Sulphate content in drinking water exceeding the 400 mg/L imparts bitter taste.

Nitrites (NO_2) and Nitrates (NO_3)

Nitrite values in all the water samples were found Below Quantification Limit (0.1 mg/l). There were no specified standard values for Nitrites in Drinking water. The minimum Nitrate value in drinking water of DPA was ranges from 0.20-8.26 mg/l which is well within the permissible limit of the Drinking water Standard.

Salinity

Salinity in drinking water in the present samples collected ranged from 0.10 to 0.37 ‰.There are no prescribed Indian standards for salinity in Drinking water**.**

Sodium and Potassium Salts

Sodium values in the samples collected ranged from 70.96- 460.0 mg/l and Potassium salts ranged from 2.59 to 6.80 mg/l. There are no prescribed limits of Sodium and Potassium in Indian standards for Drinking water**.**

Heavy Metals in Drinking Water

In the present study period drinking water samples were analyzed for Mn, Cr, Cu, Cd, As, Hg, Pb and Zn. All these heavy metals were well Below the Quantification limits prescribed by the Indian Standards.

Bacteriological Study

Analysis of the bacteriological parameter (E-coli and total coliform) at all location shows that Bacteria were not detectable. This shows that drinking water samples were safe for human consumption as per tested parameters.

5.4 Conclusions

These results were compared with acceptable limits as prescribed in IS 10500:2012–Drinking Water Specification. It was seen from the analysis data that during the study period the water was safe for human consumption as per analyzed parameters only at all drinking water monitoring stations.

6.0 Noise Level Monitoring

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. Noise Monitoring was done at 13 stations at Kandla, Vadinar and Township area.

6.1 Method of Monitoring

Sampling was done at all stations for 24 hour period. Data was recorded using automated sound level meter. The intensity of sound was measured in sound pressure level (SPL) and common unit of measurement is decibel (dB).

6.2 Results

Table 16: Noise Monitoring data for ten locations of Deendayal Port and three locations of Vadinar Port

Sr. No.	Location	Day Time Average Noise Level (SPL) in dB(A)	Night Time Average Noise Level (SPL) in dB(A)
	Sampling Time	**6:00 am to 10:00 PM**	**10:00PM to 6:00 AM**
1	Marine Bhavan	58.4	56.1
2	Nirman Building 1	62.9	59.2
3	Tuna Port	56.8	55.2
4	Main Gate North	69.2	64.4
5	West Gate I	69.3	63.2
6	Canteen Area	63.0	55.6
7	Main Road	72.2	66.2
8	ATM Building	70.4	65.2
9	Wharf Area /Jetty Area	70.9	63.8
10	Port & Custom Office	49.6	46.6
Vadinar Port			
11	Entrance Gate of Vadinar Port	56.6	55.1
12	Nr. Port Colony, Vadinar	63.9	54.1
13	Nr. Vadinar Jetty	56.0	56.3

6.3 Conclusions

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. The Day Time Noise Level (SPL) in all 13 locations at Deendayal Port ranged from 49.6 dB(A) to 70.9 dB(A) and it was within the permissible limits of 75 dB(A) for the industrial area for the daytime. The Night Time Average Noise Level (SPL) in all 13 locations of Deendayal Port ranged from 46.6 dB to 66.2 dB(A) and it was within the permissible limits of 70 dB(A) for the industrial area for the night time.

7.0 Soil Monitoring

Sampling and analysis of soil samples were undertaken at six locations within the study area (Deendayal Port and Vadinar Port) as a part of EMP. The soil sampling locations are initially decided based on the locations as provided in the tender document of the Deendayal Port.

7.1 Methodology

The soil samples were collected in the month of July 2022. The samples collected from the all locations are homogeneous representative of each location. At random locations were identified at each location and soil was dug from 30 cm below the surface. It was uniformly mixed before homogenizing the soil samples. The samples were filled in polythene bags, labeled in the field with number and site name and sent to laboratory for analysis.

7.2 Results

Table-17: Chemical Characteristics of Soil in the Study Area for Tuna port,(22° 58' 10.18"E, 70° 6' 3.7"N) IFFCO plant (23° 26' 8.37"E, 70° 13' 4.4"N), Khori creek, (22° 58' 10.18"E, 70° 6' 3.7"N) Nakti Creek,(23° 2' 1.10"E, 70° 9' 33.6"N) DPA admin site,(22° 26' 30.9"E, 69° 40' 37.03"N) DPA colony(22° 23' 57.09"E, 69° 42' 49.42"N)

Sr. No.	Parameter	Unit	Station Name					
			SL1	SL2	SL3	SL4	SL5	SL6
			Tuna Port	IFFCO Plant	Khori Creek	Nakti Creek	DPA Admin Site	DPA Colony
			Near main gate of Port	10 m away from main	Sand from creek after tide		Vadinar	
1	Texture		Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	pH	-	7.58	7.94	7.64	8.01	8.03	8.57
3	Electrical Conductivity	µs/cm	34,800.00	11,000.00	22,980.00	24,990.0	490.0	786.0
4	Moisture	%	16.40	7.76	5.74	30.79	8.76	4.88
5	Total Organic Carbon	%	0.39	0.24	0.16	0.71	1.94	0.64
6	Alkalinity	mg/kg	80.08	70.07	40.04	50.05	20.02	24.02
7	Total Nitrogen	%	0.03	0.02	0.01	0.06	0.17	0.06
8	Chloride	mg/kg	3,772.0	1,241.0	2,184.0	2,531.0	79.4	179.0
9	Sulphate	mg/kg	1,407.00	738.00	2,270.00	673.04	22.08	17.05
10	Phosphorus	mg/kg	2.80	3.06	6.20	2.20	BQL	BQL
11	Potassium	mg/kg	110.41	85.96	54.22	171.18	17.11	39.36
12	Sodium	mg/kg	2,425.00	1,168.00	1,374.00	1,761.00	63.55	109.55
13	Calcium	mg/kg	200.40	172.34	216.43	156.31	396.79	260.90
14	Copper as Cu	mg/kg	16.60	61.60	18.00	24.40	74.50	56.30
15	Lead as Pb	mg/kg	BQL	BQL	6.90	6.20	BQL	BQL
16	Nickel as Ni	mg/kg	14.60	31.20	11.50	35.80	18.10	26.80
17	Zinc as Zn	mg/kg	24.00	92.70	17.70	52.60	74.00	37.20
18	Cadmium as Cd	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (TN: 0.001%, Cd: 1.0mg/kg).

7.3 Discussion

- The data shows that value of pH ranges from 7.58 at Tuna Port (Near Main Gate of Port) to 8.01 at (Nakti Creek) and mean was 7.79 at Deendayal Port. Atr Vadinar Port the pH was ranges from 8.03 DPA Admin Site to 8.57 at DPA colony and mean was 8.30 indicating that all soil samples were neutral to slight basic. Tuna Port sample showed maximum conductivity of 34800µs/cm and minimum was 1100 µs/cm, while Vadinar location showed maximum conductivity of 490 µs/cm and minimum was 786 µs/cm at DPA Colony mean was 638 µs/c.
- Total organic Carbon ranged from 0.16 % to 0.71 % at Deendayal Port and mean was 0.38. At Vadinar Port, organic Carbon range from 0.64% to 1.94 % and mean was 1.29 %.
- The concentration of Phosphorus and Potassium in the soil samples varies from 2.20 mg/kg at Nakti Creek to 6.20 mg/kg at Khori Creek and 54.22 mg at Khori creek to 171.18 mg/kg at Nakti Creek at Deendayal Port and mean was 105.44 mg/kg at Deendayal Port. The concentration of Phosphorous was found BQL at Vadinar and mean concentration of Potassium at Vadinar site was 28.24 mg/kg.

These differences in NPK in soil at different locations are due to the dissimilar nature of soil at each of the locations. Samples SL3 & SL4 (Khori Creek & Nakti Creek) were of saline nature as they were coastal soil; where as other locations are inland locations and have different chemical properties.

Heavy Metals in the Soil

Traces of Copper, Lead, Nickel and Zinc were observed in the soil samples collected from all the four locations of Deendayal Port and two locations of Vadinar Port. Cadmium metal was below detection limit in the Soil.

7.4 Conclusion

The soils of Deendayal Port and Vadinar Port appears to be neutral to basic with varying levels of Chloride, Sulphate, NPK and Calcium. As the nature of soil at different locations are different with respect to its proximity to the sea, the samples showed high degree of variations in their chemical properties.

8.0 Sewage Treatment Plant Monitoring

This involves safe collection of waste water (spent/used water) from wash areas, bathroom, industrial units, etc., waste from toilets of various buildings and its conveyance to the treatment plant and final disposal in conformity with the requirement and guidelines of State Pollution Control Board and other statutory bodies.

8.1 Methodology for STP Monitoring

To monitor the working efficiency of Sewage Treatment Plant (STP), STP Inlet and Outlet Samples were collected once a week. Locations selected are namely Gopalpuri Township, Deendayal Port and Vadinar. Samples were collected in 1 lit. Carboys and were analyzed in laboratory for various parameters.

8.2 Results

Table 18: Sewage Water Monitoring at Kandla STP (1st Week)

Date of Sampling	06.07.2022

Sr. No.	**Parameters**	**Unit**	**Results**		**GPCB Prescribed Limit**
			DPA STP I/L	**DPA STP O/L**	
1	pH	-	7.44	7.26	6.5 - 8.5
2	Total Suspended Solids	mg/l	143	49	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	88	30	100
5	BOD @ 27 °C	mg/l	28.0	13.0	30
Aeration Tank					
6	MLSS	mg/l	16.0		
7	MLVSS	%	90.0		

Table 19: Sewage Water Monitoring at Kandla STP (2nd Week)

Date of Sampling	15.07.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.56	7.31	6.5 - 8.5
2	Total Suspended Solids	mg/l	87	57	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	70	30	100
5	BOD @ 27 °C	mg/l	22.0	10.0	30
Aeration Tank					
6	MLSS	mg/l	22.0		
7	MLVSS	%	87.0		

Table 20: Sewage Water Monitoring at Kandla STP (3rd Week)

Date of Sampling	19.07.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.56	7.29	6.5 - 8.5
2	Total Suspended Solids	mg/l	98	69	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	70	60	100
5	BOD @ 27 °C	mg/l	21.0	17.0	30
Aeration Tank					
6	MLSS	mg/l	14.0		
7	MLVSS	%	90.0		

Table 21: Sewage Water Monitoring at Kandla STP (4th Week)

Date of Sampling	26.07.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.44	7.32	6.5 - 8.5
2	Total Suspended Solids	mg/l	101	64	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	80	40	100
5	BOD @ 27 °C	mg/l	21.0	12.0	30
Aeration Tank					
6	MLSS	mg/l	12.0		
7	MLVSS	%	92.0		

Table 22: Sewage Water Monitoring at Gopalpuri STP (1st Week)

Date of Sampling	06.07.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Gopalpuri STP I/L	Gopalpuri STP O/L	
1	pH	-	7.56	7.31	6.5 - 8.5
2	Total Suspended Solids	mg/l	55	40	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	70	50	100
5	BOD @ 27 °C	mg/l	28.0	19.0	30
Aeration Tank					
6	MLSS	mg/l	32.0		
7	MLVSS	%	88.0		

Table 23: Sewage Water Monitoring at Gopalpuri STP (2nd Week)

Date of Sampling	15.07.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Gopalpuri STP I/L	Gopalpuri STP O/L	
1	pH	-	7.65	7.41	6.5 - 8.5
2	Total Suspended Solids	mg/l	78	62.0	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	72.0	50.0	100
5	BOD @ 27 °C	mg/l	24.0	15.0	30
Aeration Tank					
6	MLSS	mg/l	38.0		
7	MLVSS	%	89.0		

Table 24: Sewage Water Monitoring at Gopalpuri STP (3rd Week)

Date of Sampling	19.07.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Gopalpuri STP I/L	Gopalpuri STP O/L	
1	pH	-	7.45	7.23	6.5 - 8.5
2	Total Suspended Solids	mg/l	72	35	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	50	20	100
5	BOD @ 27 °C	mg/l	14.0	4.0	30
Aeration Tank					
6	MLSS	mg/l	36.0		
7	MLVSS	%	87.0		

Table 25: Sewage Water Monitoring at Gopalpuri STP (4th Week)

Date of Sampling	26.07.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Gopalpuri STP I/L	Gopalpuri STP O/L	
1	pH	-	7.56	7.28	6.5 - 8.5
2	Total Suspended Solids	mg/l	72	40	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	60	20	100
5	BOD @ 27 °C	mg/l	18.0	4.0	30
Aeration Tank					
6	MLSS	mg/l	32.0		
7	MLVSS	%	89.0		

Table 26: Sewage Water Monitoring at Vadinar STP (1st Week)

Date of Sampling	06.07.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar O/L	
1	pH	-	7.61	7.44	6.5 - 8.5
2	Total Suspended Solids	mg/l	100	59.6	100
3	Residual Chlorine	mg/		<0.5	-
4	COD	mg/l	101.0	51	100
5	BOD @ 27 °C	mg/l	34.0	18.0	30

Table 27: Sewage Water Monitoring at Vadinar STP (2nd Week)

Date of Sampling	15.07.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar O/L	
1	pH	-	7.45	7.21	6.5 - 8.5
2	Total Suspended Solids	mg/l	89	40	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	80	48	100
5	BOD @ 27 °C	mg/l	28.0	16.0	30

Table 28: Sewage Water Monitoring at Vadinar STP (3rd Week)

Date of Sampling	19.07.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar O/L	
1	pH	-	7.51	7.32	6.5 - 8.5
2	Total Suspended Solids	mg/l	107.5	36.1	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	131.3	50.5	100
5	BOD @ 27 °C	mg/l	-	-	30

Table 29: Sewage Water Monitoring at Vadinar STP (4th Week)

Date of Sampling	21.06.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar O/L	
1	pH	-	7.33	7.21	6.5 - 8.5
2	Total Suspended Solids	mg/l	99.8	44.9	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	121.2	70.7	100
5	BOD @ 27 °C	mg/l	-	-	30

8.3 Conclusions:

The GPCB specification for pH, TSS, Residual Chlorine, COD and BOD for STP outlet were 6.5 to 8.5, 100 mg/l, 0.5 mg/l, 100 mg/l and 30 mg/l respectively. The outlet values for pH were ranges from 7.23-7.4, 7.26-7.32, and 7.21-7.44 at Gopalpuri, KPT and Vadinar respectively. The Total Suspended Solids values were 35-62 mg/l, 49-69 mg/l, 36.1-59.6 mg/l at Gopalpuri, KPT and Vadinar respectively. The COD values were ranges from 20.5-50 mg/l, 30-60 mg/l, and 48-70.7 at Gopalpuri, KPT and Vadinar respectively. The BOD values were ranges from 4-19 mg/l, 10-17 mg/l, and 16-18 mg/l at Gopalpuri, KPT and Vadinar respectively. At all sampling location Residual Chlorine were found below detectable limit. All parameters for STP outlet are within limit.

9.0 Marine Water Monitoring

Marine Water Quality

The Forty Second Amendment to the Constitution in 1976 underscored the importance of 'green thinking'. Article 48A enjoins the state to protect and improve the environment and safeguard the forests and wildlife in the country. Further, Article 51A (g) states that the "fundamental duty of every citizen is to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures".

Policy Statement for Abatement of Pollution (1992) has suggested developing relevant legislation and regulation, fiscal incentives, voluntary agreements and educational programs and information campaigns. It emphasizes the need for integration by incorporating environmental considerations into decision making at all levels by adopting frameworks namely, pollution prevention at source, application of best practicable solution, ensure polluter pays for control of pollution, focus on heavily polluted areas and river stretches and involve public in decision-making. The National Conservation Strategy and Policy Statement on Environment and Development, (1992) aimed at "integrating environmental concerns with developmental imperatives to meet the challenges by redirecting the thrust of our developmental process so that the basic needs of our people could be fulfilled by making judicious and sustainable use of natural resources." The priorities mentioned in this policy document include the sustainable use of land and water resources, prevention and control of pollution and preservation of biodiversity.

The National Water Policy, (2002) contains provisions for developing, conserving, sustainable utilizing and managing this important water resources and need to be governed by national perspectives.

Sampling Stations

The monitoring of marine environment for the study of biological and ecological parameters was carried out on 07th & 08th July-2022 in harbor regions of DPA & Vadinar during Neap tide period of New moon phase of Lunar Cycle. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 15th& 16thJuly 2022 in harbor regions of DPA & Vadinar during Spring tide period first quarter of Lunar Cycle.

Plankton samples from sub surface layer was collected both during high tide period and low tide period from 3 water quality monitoring stations of DPA harbour area and two stations in Nakti creek and one station in Khori creek. The same sampling schedule was repeated during consecutive spring tide and neap tide in same month. Plankton samples from sub surface layer was collected both during high tide period and low tide period from 1 water quality monitoring stations near Vadinar jetty area during spring tide and neap tide in this month. Collected water samples were processed for estimation of Chlorophyll- a, Pheophytin- a, qualitative & quantitative evaluation of phytoplankton, qualitative & quantitative evaluation zooplanktons (density and their population).

Sampling Locations

Offshore monitoring requirement	Number of locations
Offshore Installations	3 in Kandla creek 2 in Nakti creek 1 in Khori creek 1 near Vadinar Jetty 1 near 1st SBM
Total Number of locations	**8**

9.1 Marine Water Quality and Results

Marine water quality of marine waters of Deendayal Port Harbor waters, Khori & Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each month. The results of marine water quality from table no 30 to 37.

Table 30: Marine Water Quality Monitoring Parameters for location near DPA colony

Sr. No.	Parameters	Unit	Kandla Creek Near DPA colony (1)			
			23°0'58"N 70°13'22."E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.45	7.35	7.59	7.55
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	‰	32.1	33.0	31.2	32.1
5	Turbidity	NTU	42	45	46	47
6	Total Dissolved Solids	mg/l	41443	40010	39820.0	41830.0
7	Total Suspended Solids	mg/l	778	662	612.5	738.8
8	Total Solids	mg/l	42300	40708	40608.0	42620.0
9	DO	mg/l	5.2	5.1	5.4	5.3
10	COD	mg/l	96.0	86.0	90.0	88.0
11	BOD	mg/l	BQL	BQL	0.46	0.36
12	Silica	mg/l	0.52	0.40	0.37	0.04
13	Phosphate	mg/l	0.49	0.19	2183	1594
14	Sulphate	mg/l	1593.9	1524.6	2.15	1.81
15	Nitrate	mg/l	2.48	4.70	0.15	0.15
16	Nitrite	mg/l	0.19	0.16	721.44	761.52
17	Calcium	mg/l	601.20	641.28	1628.1	1652.4
18	Magnesium	mg/l	1215	1409.4	11445.0	10540.0
19	Sodium	mg/l	11830.0	10956.0	312.0	402.0
20	Potassium	mg/l	372.0	358.0	0.44	1.16
21	Iron	mg/l	2.08	0.59	0.46	0.36
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 31: Marine Water Quality Monitoring Parameters for location near passenger Jetty One at Kandla

Sr. No.	Parameters	Unit	Near passenger Jetty One (2)			
			23° 0'18 "N 70°13'31"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.26	7.31	7.46	7.43
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	‰	33.9	32.6	30.2	30.8
5	Turbidity	NTU	38	37	43	42
6	Total Dissolved Solids	mg/l	41332	40820	39530.0	38950.0
7	Total Suspended Solids	mg/l	748	649	492.8	486.1
8	Total Solids	mg/l	42120	41489	40090.0	40014.0
9	DO	mg/l	4.9	4.8	5.4	4.9
10	COD	mg/l	68.0	64.0	72.0	70.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.46	0.38	0.64	0.24
13	Phosphate	mg/l	0.23	0.25	0.30	0.42
14	Sulphate	mg/l	1201.2	2148.3	1917	1594
15	Nitrate	mg/l	4.83	1.88	4.56	2.82
16	Nitrite	mg/l	0.11	0.12	0.11	0.06
17	Calcium	mg/l	561.12	521.04	681.36	641.28
18	Magnesium	mg/l	1287.9	1458	1701	1676.7
19	Sodium	mg/l	9307.0	9674.0	10330.0	10169.0
20	Potassium	mg/l	348.0	359.0	412.0	409.0
21	Iron	mg/l	0.56	1.42	1.12	0.63
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Nitrite: 0.05mg/lCu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 32: Marine Water Quality Monitoring Parameters for location Near Coal Berth

Sr. No.	Parameters	Unit	Near Coal Berth			
			22°59'12"N 70°13'40"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.51	7.48	7.51	7.6
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	‰	31.2	30.3	33.5	32.6
5	Turbidity	NTU	46	41	39	40
6	Total Dissolved Solids	mg/l	38446	41706	41150.0	41485.0
7	Total Suspended Solids	mg/l	553	844	638.8	897.9
8	Total Solids	mg/l	40048	42674	42019.0	42420.0
9	DO	mg/l	4.7	4.6	4.8	5.1
10	COD	mg/l	68.0	62.0	78.0	74.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.72	0.60	0.84	0.48
13	Phosphate	mg/l	0.29	0.36	0.31	0.38
14	Sulphate	mg/l	1663.2	1085	1675	2056
15	Nitrate	mg/l	2.62	2.95	2.28	1.95
16	Nitrite	mg/l	0.07	BQL	BQL	BQL
17	Calcium	mg/l	681.36	721.44	681.36	721.44
18	Magnesium	mg/l	1287.9	996.3	1749.6	1701
19	Sodium	mg/l	9033.0	9741.0	11250.0	10718.0
20	Potassium	mg/l	365.0	261.0	461.0	514.0
21	Iron	mg/l	1.25	BQL	1.69	4.86
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 33: Marine Water Quality Monitoring Parameters for location Khori creek at Kandla

Sr. No.	Parameters	Unit	DPA 4			
			Near 15/16 Berth			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.35	7.23	7.45	7.38
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	‰	31.7	32.6	30.8	30.3
5	Turbidity	NTU	39	40	42	41
6	Total Dissolved Solids	mg/l	42949	41470	38743.0	38808.0
7	Total Suspended Solids	mg/l	819	844	598.8	694.7
8	Total Solids	mg/l	43780	42514	40019.0	40078.0
9	DO	mg/l	4.5	5	5.2	4.7
10	COD	mg/l	52.0	50.0	62.0	57.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.48	0.40	0.66	0.80
13	Phosphate	mg/l	0.20	0.24	0.27	0.31
14	Sulphate	mg/l	9286.2	1640.1	1917	1698
15	Nitrate	mg/l	2.55	6.38	3.22	4.77
16	Nitrite	mg/l	0.08	0.09	0.07	0.10
17	Calcium	mg/l	601.20	561.12	641.28	721.44
18	Magnesium	mg/l	1555.2	1628.1	1701	1628.1
19	Sodium	mg/l	11668.0	11259.0	10829.0	10623.0
20	Potassium	mg/l	358.0	341.0	483.0	498.0
21	Iron	mg/l	0.12	0.46	0.72	0.10
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 34: Marine Water Quality Monitoring Parameters for location Nakti Creek near Tuna Port

Sr. No.	Parameters	Unit	Nakti Creek Near Tuna Port			
			22°57'49."N 70° 7'0.67"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.45	7.41	7.49	7.55
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	‰	33.0	32.1	30.1	32.1
5	Turbidity	NTU	42	43	45	40
6	Total Dissolved Solids	mg/l	39660	40260	35000.0	36084.0
7	Total Suspended Solids	mg/l	850	736	482.2	741.8
8	Total Solids	mg/l	40520	41086	39682.0	41978.0
9	DO	mg/l	5.3	5.1	4.6	5
10	COD	mg/l	95.0	86.0	90.0	87.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.59	0.56	0.56	0.52
13	Phosphate	mg/l	0.52	0.64	0.34	0.23
14	Sulphate	mg/l	2333.1	6675.9	1698	2056
15	Nitrate	mg/l	0.81	3.69	4.50	2.95
16	Nitrite	mg/l	0.07	0.11	0.06	0.10
17	Calcium	mg/l	681.36	641.28	761.52	641.28
18	Magnesium	mg/l	1506.6	1628.1	1652.4	1701
19	Sodium	mg/l	10156.0	8153.0	10356.0	9985.0
20	Potassium	mg/l	361.0	373.0	427.0	302.0
21	Iron	mg/l	1.51	4.27	0.72	0.73
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 35: Marine Water Quality Monitoring Parameters for location Nakti Creek Near NH-8A at Kandla

Sr. No.	Parameters	Unit	Nakti Creek Near NH-8A			
			23° 02'01"N 70° 09'31"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.49	Sampling not possible during Low Tide	7.52	Sampling not possible during Low Tide
2	Color	-	Colorless		Colorless	
3	Odor	-	Odorless		Odorless	
4	Salinity	‰	31.7		32.8	
5	Turbidity	NTU	47		39	
6	Total Dissolved Solids	mg/l	41800		42238.0	
7	Total Suspended Solids	mg/l	389		366.6	
8	Total Solids	mg/l	42198		43114.0	
9	DO	mg/l	4.6		4.7	
10	COD	mg/l	110.0		106.0	
11	BOD	mg/l	BQL		BQL	
12	Silica	mg/l	0.72		0.68	
13	Phosphate	mg/l	0.26		0.38	
14	Sulphate	mg/l	8662.5		2795	
15	Nitrate	mg/l	1.07		3.42	
16	Nitrite	mg/l	0.14		0.11	
17	Calcium	mg/l	721.44		601.2	
18	Magnesium	mg/l	1020.6		1773.9	
19	Sodium	mg/l	10900.0		11557.0	
20	Potassium	mg/l	364.0		533.0	
21	Iron	mg/l	0.55		BQL	
22	Chromium	mg/l	BQL		BQL	
23	Copper	mg/l	BQL		BQL	
24	Arsenic	mg/l	BQL		BQL	
25	Cadmium	mg/l	BQL		BQL	
26	Mercury	mg/l	BQL		BQL	
27	Lead	mg/l	BQL		BQL	
28	Zinc	mg/l	BQL		BQL	

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 36: Marine Water Quality Monitoring Parameters for locations Nr. Vadinar Jetty

Sr. No.	Parameters	Unit	Nr.Vadinar Jetty			
			22°26'25.26"N 69°40'20.41"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.32	7.26	7.45	7.48
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	‰	31.2	32.6	31.8	31.2
5	Turbidity	NTU	46	41	38	41
6	Total Dissolved Solids	mg/l	40970	41360	39140.0	38310.0
7	Total Suspended Solids	mg/l	350	368	401.3	310.2
8	Total Solids	mg/l	42032	41736	40102.0	40462.0
9	DO	mg/l	4.5	4.3	4.8	5.0
10	COD	mg/l	70.0	74.0	74.0	72.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.80	0.52	0.84	0.66
13	Phosphate	mg/l	0.31	1.16	0.40	0.42
14	Sulphate	mg/l	3026.1	1201.2	3095	2564
15	Nitrate	mg/l	0.80	2.01	4.16	5.30
16	Nitrite	mg/l	0.06	0.07	0.10	0.09
17	Calcium	mg/l	601.20	521.04	561.12	601.2
18	Magnesium	mg/l	1166.4	1142.1	1749.6	1773.9
19	Sodium	mg/l	9530.0	9609.0	11043.0	10980.0
20	Potassium	mg/l	331.0	360.0	536.0	400.0
21	Iron	mg/l	0.38	0.28	0.27	0.96
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 37: Marine Water Quality Monitoring Parameters for locations Nr. Vadinar SPM

Sr. No.	Parameters	Unit	Nr.Vadinar SPM			
			22°30'56.15"N 69°42'12.07"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.40	7.20	7.44	7.37
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	‰	33.0	33.9	31.7	31.8
5	Turbidity	NTU	43.0	40.0	38.0	36.0
6	Total Dissolved Solids	mg/l	41810.0	41200.0	42920.0	43060.0
7	Total Suspended Solids	mg/l	313.0	358.0	337.9	462.2
8	Total Solids	721.44	42140.0	41584.0	44400.0	44460.0
9	DO	mg/l	4.6	4.4	3.9	3.8
10	COD	mg/l	89.0	90.0	92.0	96.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.68	0.71	0.78	0.80
13	Phosphate	mg/l	0.11	0.38	0.49	0.54
14	Sulphate	mg/l	831.6	1940.4	2287	2888
15	Nitrate	mg/l	0.19	0.27	2.28	3.02
16	Nitrite	mg/l	BQL	BQL	0.07	0.05
17	Calcium	mg/l	641.28	561.12	721.44	681.36
18	Magnesium	mg/l	972	996.3	1628.1	1628.1
19	Sodium	mg/l	9756.0	9892.0	10620.0	10180.0
20	Potassium	mg/l	372.0	361.0	378.0	344.0
21	Iron	mg/l	BQL	0.1	BQL	BQL
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

9.2 Results & Discussion for Marine water samples

Marine water quality of Deendayal Port Harbor waters, Khori and Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each month. The Heavy metal analyzed and found below quantification limit.

pH

The limit of pH value for drinking water was 7.28 to 7.65. During spring tide the pH values was ranges from 7.23-7.51 at KPT and 7.20-7.40 at Vadinar while during Neap Tide pH values was ranges from 7.38-7.60 at KPT and 7.30-7.48 at Vadinar.

Color and Odour

All marine samples was found odourless and Colourless at all locations.

Total Dissolved Solids (TDS)

TDS values in the studied area during Sring Tide varied between 38446 to 42949 mg/l at KPT and 40970 to 41810 mg/l at Near Vadinar while during Neap Tide TDS values was varied 12238 to 42238 mg/l at KPT and 38310 to 43060 mg/l at Near Vadinar.

Calcium

Calcium value in the studied area during Spring Tide varied between 521.04 to 721.44 mg/l at KPT and 521.64 to 641.28 mg/l at Near Vadinar while during Neap Tide calcium values between 561.12 to 761.52 mg/l at KPT and 601.20 to721.49 at Vadinar.

Magnesium

Magnesium value in the studied area during Spring Tide varied between 996.30 to 1628.10 mg/l at KPT and 972.00 to 1666.40 mg/l at Near Vadinar while during Neap Tide calcium values between 1628.10 to 1773.90 mg/l at KPT and 1628.10 to 1773.90 at Vadinar.

Iron

Iron values in the studied area during Spring Tide was found 0.12 to 4.27 mg/l at KPT and 0.38 to 0.10 mg/l at Vadinar while during Neap Tide the iron values was varied 0.10 to 4.86 mg/l at KPT and 0.27 to 0.96 at Vadinar.

Sulphates

Sulphate values in the studied area during Spring Tide was found 1085 to 9286 mg/l at KPT and 831.60 to 03026.10 mg/l at Vadinar while during Neap Tide the Sulphate values was varied 1593.90 to 3095.40 mg/l at KPT and 2286.90 to 2888.00 at Vadinar.

Salinity

Salinity values in the studied area during Spring Tide was found 30.33 to 33.95 ‰ at KPT and 31.23 to 33.95 ‰ at Vadinar while during Neap Tide the Salinity values was varied 30.10 to 33.50 ‰ at KPT and 30.78 to 31.80 at Vadinar.

Sodium and Potassium Salts

During Spring Tide the Sodium values ranged from 8153-11830 mg/l at KPT & 9530-9892 mg/l at Vadinar and Potassium salts ranged from 261-373 mg/l at KPT & 331-372 mg/l at Vadinar while during Neap Tide the sodium values was ranges from 9985-11557 mg/l at KPT & 10180-11043 mg/l at Vadinar and Potassium salts ranged from 553 -344 mg/l at KPT & 344-536 mg/l at Vadinar.

DO

From the studied samples, DO in marine water during Spring Tide was found in ranges from 4.5 - 5.3 mg/l at KPT and 4.3-4.6 mg/l at Vadinar while during Neap Tide 3.80-5.40 mg/l at KPT and 3.80-5.30 mg/l at Vadinar.

BOD

BOD in marine water in the studied samples was found Below Quantification limit. Which is under than 5.0 mg/l

Heavy Metals in Marine Water

In the present study period marine water samples were analyzed for Cr, Cu, Cd, As, Hg, Pb and Zn. All these heavy metals were well Below the Quantification limits prescribed by the Indian Standards.

9.3 Conclusion

In the present study period marine water samples were analyzed and found inline as per Primary Water Quality criteria for class SW-IV WATERS (For Harbour Waters).

10.0 Marine Sediments

Sediment samples were collected with Van Veen Grab from the six locations in Kandla Port Waters and two locations in Vadinar Port. Samples were collected and preserved in silver foil in ice box to prevent the contamination/decaying of the samples.

10.1 Results

The Sediment Quality results are given in below from table no. 38& 39.

Table 38: Results of Analysis of Sediment of Kandla & Vadinar Port (Neap Tide)

Sr. No.	Parameters	Unit	DPA – 1	DPA - 2	DPA - 3	DPA - 4	DPA - 5	Jetty	SPM
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	2.72	3.87	2.94	2.51	2.14	5.84	4.10
3	Organic Carbon	mg/kg	1.58	2.24	1.71	1.46	1.24	3.39	2.38
4	Inorganic Phosphate	mg/kg	109.00	119.00	121.00	128.00	142.00	166.00	154.00
5	Moisture	%	12.20	26.26	12.16	8.88	19.20	32.26	34.44
6	Aluminium	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
7	Silica	mg/kg	23.80	12.60	24.66	26.20	32.12	42.66	48.62
8	Phosphate	mg/kg	2.98	1.10	1.36	1.30	2.32	BQL	1.80
9	Sulphate	mg/kg	352.00	457.27	717.15	475.52	506.93	964.14	570.00
10	Nitrite	mg/kg	0.12	0.11	0.11	0.11	0.12	0.11	0.13
11	Nitrate	mg/kg	BQL	BQL	BQL	BQL	BQL	11.20	12.82
12	Calcium	mg/kg	109.02	144.29	56.91	112.22	106.61	134.66	160.32
13	Magnesium	mg/kg	101.57	150.66	140.45	94.77	122.47	222.10	184.68
14	Sodium	mg/kg	166.90	599.10	205.00	152.00	227.00	492.00	360.00
15	Potassium	mg/kg	19.00	54.60	10.88	18.25	28.72	48.06	30.75
16	Chromium	mg/kg	5.50	89.70	9.40	10.20	45.90	103.20	72.20
17	Nickel	mg/kg	BQL	29.80	BQL	BQL	12.40	30.40	24.10
18	Copper	mg/kg	BQL	12.00	BQL	BQL	BQL	22.40	12.60
19	Zinc	mg/kg	BQL	55.50	BQL	BQL	18.40	46.90	34.60
20	Cadmium	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
21	Lead	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
22	Mercury	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
23	Arsenic	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL

*ND - Not Detected, BQL: Below Quantification Limit (NO3:10.0mg/kg, Cd: 1.0mg/kg, Hg: 1.0mg/kg, As: 1.0mg/kg).

Table 39 : Results of Analysis of Sediment of Kandla & Vadinar Port (Spring Tide)

Sr. No.	Parameters	Unit	DPA – 1	DPA - 2	DPA - 3	DPA - 4	DPA - 5	Jetty	SPM
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	2.90	3.91	3.36	1.66	1.69	3.78	4.24
3	Organic Carbon	mg/kg	1.68	2.27	1.95	0.96	0.98	2.19	2.46
4	Inorganic Phosphate	mg/kg	112.00	106.00	126.00	124.00	118.00	130.00	136.00
5	Moisture	%	9.57	19.76	8.92	7.78	5.97	34.60	22.70
6	Aluminium	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
7	Silica	mg/kg	22.20	14.20	16.00	18.00	24.20	39.60	40.00
8	Phosphate	mg/kg	2.60	BQL	1.31	2.82	3.02	1.46	2.09
9	Sulphate	mg/kg	375.86	571.44	793.00	520.97	563.60	884.41	526.54
10	Nitrite	mg/kg	0.12	0.11	0.11	0.10	0.12	0.10	0.11
11	Nitrate	mg/kg	BQL	BQL	BQL	BQL	BQL	11.00	11.24
12	Calcium	mg/kg	144.30	206.20	222.42	178.02	116.00	124.25	96.16
13	Magnesium	mg/kg	60.03	66.42	36.16	41.32	48.60	255.15	208.98
14	Sodium	mg/kg	431.48	569.60	427.94	2501.22	367.58	1175.67	922.29
15	Potassium	mg/kg	30.98	77.27	32.22	252.03	32.28	152.86	145.70
16	Chromium	mg/kg	18.20	87.70	22.40	17.20	25.40	111.90	79.50
17	Nickel	mg/kg	BQL	30.20	BQL	BQL	5.10	51.20	30.90
18	Copper	mg/kg	BQL	16.10	BQL	BQL	BQL	32.90	16.70
19	Zinc	mg/kg	16.30	57.60	5.40	BQL	12.00	99.60	40.60
20	Cadmium	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
21	Lead	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
22	Mercury	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
23	Arsenic	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL

*ND - Not Detected, BQL: Below Quantification Limit (NO3:10.0mg/kg,Cd: 1.0mg/kg,Hg: 1.0mg/kg, As: 1.0mg/kg)

10.2 Discussion of Marine Sediment samples

Marine Sediments of Deendayal Port Harbor waters, Khori and Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each month. The Heavy metal analyzed and found below quantification limit.

10.3 Conclusion

The soil types are majority Sandy loamy. Also all heavy metals found below Quantification limit wise Al,Pb, Cd, Hg , AS and Nitrate for some locations.

11.1 INTRODUCTION:

Sampling Stations:

The monitoring of marine environment for the study of biological and ecological Parameters was carried out on7thJuly2022 in harbour region of DPT at Kandla Creek, and on 8th July 2022 in creeks near by the port during Neap tide. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 16th July ,2022 in harbour region of DPT at Kandla Creek and on17nd July, 2022in creeks near by the port during spring tidal condition.

Plankton samples from sub surface layer was collected both during high tide period and low tide period from 3 water quality monitoring stations of KPT harbour area and two stations in Nakti creek and one station in Khori creek. Sampling at second sampling station of Nakti creek was possible only during high tide period. The same sampling schedule was repeated during consecutive spring and neap tide in same month.

Plankton samples from sub surface layer were collected during high tide period and low tide period from monitoring station near Vadinar jetty at Path Finder Creek during Neap tide on 07/07/2022 and Spring tide period on 14/07/2022.Collected water samples were processed for estimation of Chlorophyll- a, Pheophytin- a, qualitative &quantitative evaluation of phytoplankton, qualitative &quantitative evaluation zooplankton density and their population).

TABLE #40 SAMPLING LOCATIONS

monitoring requirement	Number of locations
Kandla creek	3 in Kandla creek
Nakti creek	2 in Nakti creek
Khori Creek	1 in Khori creek
Vadinar jetty	1 near Vadinar Jetty
SPM	1 near I stSPM
Total Number of locations	**8**

Sampling methodology adopted:

A marine sampling is an estimation of the body of information in the population. The theory of the sampling design is depending upon the underlying frequency distribution of the population of interest. The requirement for useful water sampling is to collect a representative sample of suitable volume from the specified depth and retain it free from contamination during retrieval.

50 litres of the water sample were collected from Sub surface by using bucket. From the collected water sample 1 litres of water sample were taken in an opaque plastic bottle for chlorophyll estimation, thereafter plankton samples were collected by using filtration assembly with nilyobolt cloth of 20µm mesh size.

Samples Processing for chlorophyll estimation:

Samples for the chlorophyll estimation were preserved in ice box on board in darkness to avoid degradation in opaque container covered with aluminium foil. Immediately after reaching the shore after sampling, 1 litre of collected water sample was filtered through GF/F filters (pore size 0.45 µm) by using vacuum filtration assembly. After vacuum filtration the glass micro fiber filter paper was grunted in tissue grinder, macerating of glass fiber filter paper along with the filtrate was done in 90% aqueous Acetone in the glass tissue grinder with glass grinding tube. Glass fiber filter paper will assist breaking the cell during grinding and chlorophyll content was extracted with 10 ml of 90% Acetone, under cold dark conditions along with saturated magnesium carbonate solution in glass screw cap tubes. After an extraction period of 24 hours, the samples were transferred to calibrated centrifuge tubes and adjusted the volume to original volume with 90% aqueous acetone solution to make up the evaporation loss. The extract was clarified by using centrifuge in closed tubes. The clarified extracts were then decanted in clean cuvette and optical density was observed at wavelength 664, 665 nm. By using corrected optical density, Chlorophyll-a value was calculated as given in (APHA, 1998).

PLANKTON:

The entire area open water in the sea is the pelagic realm. Pelagic organisms live in the open sea. In contrast to the pelagic realm, the benthic realm comprises organisms and zone of the bottom of the sea. Vertically the pelagic realm can be dividing into two zones based on light penetration; upper photic or euphotic zone and lower dark water mass, aphotic zone below the photic zone.

The term plankton is general term for organisms have such limited powers of locomotion that they are at the mercy of the prevailing water movement. Plankton is subdivided to phytoplankton and zooplankton. Phytoplankton is free floating organisms that are capable of photosynthesis and zooplankton is the various free-floating animals.

Pelagic zone, represents the entire ocean water column from the surface to the deepest depths, is home to a diverse community of organisms. Differences in their locomotive ability categorize the organisms in the pelagic realm into two, ***plankton*** and ***nekton*** (Lalli and Parsons, 1997). ***Plankton*** consists of all organisms drifting in the water and is unable to swim against water currents, whereas ***Nekton*** includes organisms having strong locomotive power. Ecological studies on the plankton community, which form the base of the aquatic food chain, help in the better understanding of the dynamics and functioning of the marine ecosystem. The term 'Plankton' first coined by Victor Hensen (1887), Plankton, (Greek word: *planktos*meaning "passively drifting or wandering") is defined as drifting or free-floating organisms that inhabit the pelagic zone of water. Based on their mode of nutrition planktonic organisms are categorised into phytoplankton (organisms having an autotrophic mode of nutrition) and zooplankton (organisms having a heterotrophic mode of nutrition).

Phytoplankton in the marine environment:

Phytoplankton is free floating unicellular, filamentous and colonial eutrophic organisms that grow in aquatic environments whose movement is more or less dependent upon water currents. These micro flora acts as primary producers as well as the basis of food chain, source of protein, bio purifier and bio indicators of the aquatic ecosystems of which diverse array of the life depends. They are considered as an important component of aquatic flora, play a key role in maintaining equilibrium between abiotic and biotic components of aquatic ecosystem.

The phytoplankton includes a wide range of photosynthetic and phototrophic organisms. Marine phytoplankton is mostly microscopic and unicellular floating flora, which are the primary producers that support the pelagic food-chain. The two most prominent groups of phytoplankton are diatoms (Bacillariophyceae) and dinoflagellates (Dinophyceae).The phytoplankton those normally captured in the net from the Gulf of Kutch is normally dominated by these two major groups; diatoms and dinoflagellates. Phytoplankton also include numerous and diverse collection of extremely small, motile algae which are termed micro flagellates (naked flagellates) as well as and Cyanophytes (blue-green algae).

Algae are an ecologically important group in most aquatic ecosystems and have been an important component of biological monitoring programs. Algae are ideally suited for water quality assessment because they have rapid reproduction rates and very short life cycles, making them valuable indicators of short-term impacts.

Aquatic populations are impacted by anthropogenic stress, resulting in a variety of alterations in the biological integrity of aquatic systems. Algae can serve as an indicator of the degree of

deterioration of water quality, and many algal indicators have been used to assess environmental status.

Zooplankton in the marine environment:

Zooplankton includes a taxonomically and morphologically diverse community of heterotrophic organisms that drift in the waters of the world's oceans. Qualitative and quantitative studies on zooplankton community are a prerequisite to delineate the ecological processes active in the marine ecosystem. Zooplankton community plays a pivotal role in the pelagic food web as the primary consumers of phytoplankton and act as the food source for organisms in the higher trophic levels, particularly the economically essential groups such as fish larvae and fishes. They also function in the cycling of elements in the marine ecosystem. The dynamics of the zooplankton community, their reproduction, and growth and survival rate are all significant factors determining the recruitment and abundance of fish stocks as they form an essential food for larval, juvenile and adult fishes (Beaugrand et al., 2004). Zooplankton grazing in the marine environment controls the primaryProduction and helps in determining the pelagic ecosystem (Banse, 1995). Through grazing in surface waters and following the production of sinking faecal matters and also by the active transportation of dissolved and particulate matter to deeper waters via vertical migration, they help in the transport of organic carbon to deep ocean layers and thus act as key drivers of biological pump' in the marine ecosystem. Zooplankton grazing and metabolism also, transform particulate organic matter into dissolved forms, promoting primary producer community, microbial demineralization, and particle export to the ocean's interior.

The categorisation of zooplankton into various ecological groups is based on several factors such as duration of planktonic life, size, food preferences and habitat. As they vary significantly in size from microscopic to metazoic forms, the classification of zooplankton based on size has paramount importance in the field of quantitative plankton research.

Based on the duration of planktonic life, zooplankton are categorised into Holoplankton (organisms which complete their entire lifecycle as plankton) and Meroplankton (organisms which are planktonic during the early part of their lives such as the larval stages of benthic and nektonic organisms). Tychoplankton are organisms which live a brief planktonic life, such as the benthic crustaceans (Cumaceans, mysids, isopods) which ascend to the watercolumn at night for feeding and certain ectoparasitic copepods, they leave the host and spend their life as plankton during their breeding cycle.

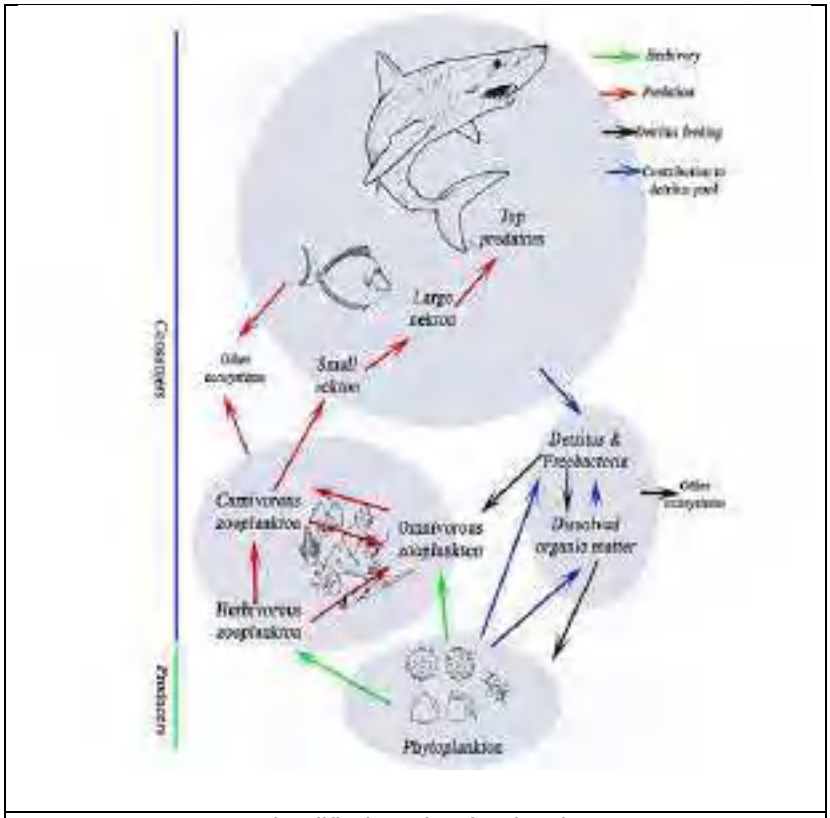
Zooplankton can be subdivided into holoplankton, i.e., permanent members of the plankton (e.g., Calanoid copepods), and meroplankton, i.e., temporary members in the plankton e.g., larvae of fish, shrimp, and crab). The meroplankton group consists of larval and young stages of animals

that will adopt a different lifestyle once they mature. In contrast to phytoplankton which consist of a relatively smaller variety of organisms, Zooplankton are extremely divers, consist of a host of larval and adult forms representing many animal phylum.

Among the zooplankton one group always dominate than others; members of sub class copepods (Phylum Athropoda) and Tintinids (Phylum Protozoa) among the net planktons. These small animals are of vital importance in marine ecosystem as one of the primary herbivores animals in the sea, and it is they provide vital link between primary producer (autotrophs) and numerous small and large marine consumers.

As their community structure and function are highly susceptible to changes in the environmental conditions regular monitoring of their distribution as well as their interactions with various physicochemical parameters is inevitable for the sustainable management of the ecosystem (Kusum et al., 2014). Of all the marine zooplankton groups, copepods mainly Calanoid copepods are the dominant groups in marine subtropical and tropical waters and exhibit considerable diversity in morphology and habitats they occupy (Madhupratap, 1991;)

It has been well established that potential of pelagic fishes viz. finfishes, crustaceans, molluscs and marine mammals either directly or indirectly depend on zooplankton. The herbivorous zooplankton is efficient grazers of the phytoplankton and is referred to as living machines transforming plant material into animal tissue. Hence, they play an essential role as the intermediaries for nutrients/energy transfer between primary and tertiary trophic levels. Due to their large density, shorter lifespan, drifting nature, high group/species diversity and different tolerance to the stress, they used as the indicator organisms for the physical, chemical and biological processes in the aquatic ecosystem (Ghajbhiye, 2002).



Simplified marine food web

Spatial distribution of Plankton:

A characteristic of plankton population is that they tend to occur in patches, which are varying spatially on a scale of few meters to far as few kilo meters in distance. They also vary in time scale, season as well as vertically in the water column. It is this patchiness and its constant changes in time and spot, that has made it so difficult for plankton biologist to learn about the ecology of plankton. The biological factors that cause this patchiness is due to the ability of zooplankton to migrate vertically and graze out the phytoplankton at a rapid rate that can create patchiness. Similarly, the active swimming ability by certain zooplankton organisms can cause to aggregate in dense group.

At its most extreme, because the water in which plankton is suspended is constantly moving, each sample taken by the plankton biologists remain a different volume of water, so each sample is unique and replicate does not exist.

Plankton July also exhibit vertical patchiness. Physical factors contribute to this type of patchiness include light intensity, nutrients and density gradients in the water column.

Phytoplankton in particular tends to be unequally distributed vertically, which leads to the existence of different concentration of a chlorophyll value between photic zone and below the photic zone.

Methodology adopted for Plankton sampling:

Mixed plankton sample were obtained from the sub surface layer at each sampling locations by towing the net horizontally with the weight. After the tow of about 15-30minutes, plankton net was pulled up and washed down to the tail and collected the plankton adhered to plankton net in the collection bucket at the bottom by springing outer and inner surface of the net with sea water, while the net was hanging with the mouth upward. For quantitative evaluation 50 L water samples were collected from subsurface layer and filtered through 20µm mesh size net by using bucket and filtration assembly.

Preservation and storage:

Both filtered plankton and those collected from the plankton net were preserved with 5% buffered formalin and stored in 1L plastic container for further processing in the laboratory.

Sample concentration:

The collected plankton samples were concentrated by using centrifuge and made up to 50 ml with 5% formalin -Glycerine mixture.

Taxonomic evaluation:

Before processing, the sample was mixed carefully and a subsample was taken with a calibrated Stempel-pipette. 1 ml of the concentrated plankton samples were transferred on a glass slide with automatic pipette. The plankton sample on the glass slides were stained by using Lugol's iodine and added glycerine to avoid drying while observation. The plankton samples were identified by using Labex triangular Research microscope with photographic attachment. Microphotographs of the plankton samples were taken for record as well as for confirming the identification. The bigger sized zooplankton was observed through dissecting stereomicroscope with magnification of 20-30 x. Plankton organisms in the whole slide were identified to the lowest axon possible. A thorough literature search was conducted for the identification of the different groups of zooplankton that were encountered

Cell counts by drop count method:

The common glass slide mounted with a 1ml of concentrated phytoplankton/zooplankton sample in glycerol and covered with cover slip 22x 60mm was placed under the compound microscope provided with a mechanical stage. The plankton was then counted from the microscopic field of the left top corner of the slide. Then slide is moved horizontally along the right side and plankton in each microscopic field was thus counted. When first microscopic field row was finished the next consecutive row was adjusted using the mechanical device of the stage. In this way all the plankton present in entire microscopic field are counted. From this total number in 1ml of the

concentrated plankton, total number of plankton in the original volume of sample filtered was calculated as units/L.

BENTHIC ORGANISMS:

Benthos is those organisms that are associated with the sea bed or benthic habitats. Epi- benthic organisms live attached to a hard substratum or rooted to a shallow depth below the surface. In fauna organisms live below the sediment–water interface. Interstitial organisms live and move in pore water among sedimentary grains.

Because the benthic organisms are often collected and separated on sieves, a classification based on the overall size is used. Macro benthos include organisms whose shortest dimension is greater than or equal to 0.5 mm. Meio benthos are smaller than 0.5mm but larger than 42µ in size.

The terms such as macro fauna and Meio fauna generally have little relevance with taxonomic classification. The terms Meio fauna and macro fauna depend on the size. Meio fauna were considered as good bioassay of community health and rather sensitive indicators of environmental changes

SAMPLING METHODOLOGY ADOPTED FOR SUB TIDAL REGION:

Van veen sampler ($0.09m^2$) was used for sampling bottom sediments. Two sets of sediments were sampled from each location, one for macro fauna and other for Meio fauna. The macro fauna in the sediments were sieved on board to separate out the organisms. The fixation of Meio fauna is normally done by bulk fixation of the sediment sample. The bulk fixation is done by using 10% formalin (Buffered with borate). The organisms were preserved with seawater as diluting agent.

Sample sieving:

Sediments samples were sieved to extract the organisms. Sieving was performed carefully as possible to avoid any damage to the animals. The large portion of the sediment was split in to smaller portions and mixed with sea water in a bucket. The cohesive lumps were broken down by continuous stirring. The disaggregated sediments were then passed through the sieves.

Sample staining:

Sorting of the Meio fauna from the sieve is difficult task especially in the preserved material, because organisms are not easily detectable. To facilitate the animal detection the entire sample retained on the sieve after sieving operation were stained by immersing the sieve in a flat bottom tub with 1% Rose Bangal stain; a protein stain. A staining period of 10-30 minutes is sufficient for sample detection.

DIVERSITY INDICES:

On the whole, diversity indices provide more information about community composition than simply species richness (number of species present); they also, take the relative abundances of different species into account. Based on this fact, diversity indices therefore depend not only on species richness but on the evenness, or equitability, with which individuals are distributed among the different species (Magurram, A. E. (1988)

A diversity index is a measure of species diversity within a community that consists of co-occurring populations of several (two or more) different species. It includes two components: richness and evenness. Richness is the measure of the number of different species within a sample showing that more the types of species in a community, the higher is the diversity or greater is the richness. Evenness is the measure of relative abundance of the different species with in a community.

The basic idea of diversity index is to obtain a quantitative estimate of biological variability that can be used to compare biological entities composed of discrete components in space and time (CarolH.R.*etal*. 1998). Biodiversity is commonly expressed through indices based on species richness and species abundances (Whittaker 1972, Lande 1996, Purvis and Hector 2000). Biodiversity indices are a non-parametric tool used to describe the relationship between species number and abundance. The most widely used bio diversity indices are Shannon Weiner index and Simpson's index.

A diversity Index is a single statistic that incorporates information on richness and evenness. The diversity measures that incorporate the two concepts JULY be termed heterogeneity measures (Magurran, 2004).

Any study intended to interpret causes and effect of adverse impact on Biodiversity of communities require suitable measures to evaluate specie richness and Diversity. The former is number of species in community, while latter is a function of relative frequency of different species. Species richness is the iconic measure of biological diversity (Magurran, 2004). Several indices have been created to measure the diversity of species; however, the most widely used in the last decades are the Shannon (1948) and Simpson (1949) (Buzas and Hayek 1996; Gorelick 2006), with the components of diversity: richness (*S)* and evenness (*J)*

Simpson's diversity index

Simpson's index (**D**) is a measure of diversity, which takes into account both species richness, and evenness of abundance among the species present. The Simpson index is one of the meaningful and robust biodiversity measures available. (Magurran ,2004).

The formula for calculating D is presented as:

$$D = \frac{\sum n_i(n_i - 1)}{N(N-1)}$$

Where n_i = the total number of organisms of each individual species

N = the total number of organisms of all species

The value of D ranges from 0 to 1. With this index, 0 represents infinite diversity and, 1, no diversity. When D increases diversity decreases. Simpson's index is therefore usually expressed as 1-D or 1/D. (Magurran, 2004)

Low species diversity suggests:

- relatively few successful species in the habitat
- the environment is quite stressful with relatively few ecological niches and only a few organisms are really well adapted to that environment
- food webs which are relatively simple
- change in the environment would probably have quite serious effects

High species diversity suggests:

- a greater number of successful species and a more stable ecosystem
- more ecological niches are available and the environment is less likely to be hostile complex food webs
- environmental change is less likely to be damaging to the ecosystem as a whole

Species richness indices

The species richness***(S)*** is simply the number of species present in an ecosystem. Species richness Indices of species richness are widely used to quantify or monitor the effects of anthropogenic disturbance. A decline in species richness JULY be concomitant with severe or chronic human-induced perturbation (Fair Fair weather 1990,) Species richness measures have traditionally been the mainstay in assessing the effects of environmental degradation on the biodiversity of natural assemblages of organisms (Clarke &Warwick, 2001)

Species richness is the iconic measure of biological diversity (Magurran, 2004). The species richness***(S)*** is simply the number of species present in an ecosystem. This index makes no use of relative abundances. The term species richness was coined by McIntosh (1967) and oldest and most intuitive measure of biological diversity (Magurran, 2004).

Margalef's diversity index is a species richness index. Margalef's Species richness index (d), or indices that describe the evenness of the distribution of the numbers of individuals among species, were derived.

The value of a diversity index increases both when the number of types increases and when evenness increases. For a given number of types, the value of diversity index is maximised when all types are equally abundant (Rosenzweig, M. L. (1995).

Shannon-Wiener's index:

An index of diversity commonly used in plankton community analyses is the Shannon-Wiener's index **(H),** which emphasizes not only the number of species (richness or variety), but also the apportionment of the numbers of individuals among the species (Odum 1971 and Reish 1984). Shannon-Wiener's index **(H**) reproduces community parameters to a single numberby using an equation.

Shannon and Weiner index represents entropy. It is a diversity index taking into account the number of individuals as well as the number of taxa. It varies from 0 for communities with only single taxa to high values for community with many taxa each with few individuals. This index can also determine the pollution status of a water body. Normal values range from 0 to 4. This index is a combination of species present and the evenness of the species. Examining the diversity in the range of polluted and unpolluted ecosystems, Wilham and Dorris (1968) concluded that the values of the index greater than 3 indicate clean water, values in the range of 1 to 3 are characterized by moderate pollution and values less than 1 are characterized as heavily polluted

$$H' = -\sum_{i=1}^{s} \frac{n_i}{N} \ln\left(\frac{n_i}{N}\right)$$

RESULTS:

CHLOROPHYLL-a:

Water Samples for the chlorophyll estimation were collected from sub surface layer during high tide and low tide period of the tidal cycle for each sampling locations and analysed for Chlorophyll -a and after acidification for Pheophytin –a. Chlorophyll- a value was used as algal biomass indicator (APHA, 1998) Algal biomass was estimated by converting Chlorophyll value.

In the sub surface water chlorophyll-a was varying from 0.2.04-0.746 mg/m^{3}with an average value 0.380mg/m^{3}of in harbour region of DPT in Kandla Creek during sampling done in spring tide period of July 2022. In the nearby creeks chlorophyll-a was varying from 0.205- 0.497 mg/m3.with an average value 0.351mg/m^{3}Pheophytin –a level was below detectable limit- the all the sampling stations during springtide.

In the sub surface water chlorophyll-a was varying from 0.205- 0.613mg/m^{3}with an average value 0.400 mg/m^3.in harbour region of DPTin Kandla Creek during sampling done in Neap tide period of July 2022. In the nearby creeks chlorophyll-a was varying from 0.204- 0.512 mg/m^3 with an average value 0.343mg/m^3.Pheophytin –a level was below detectable limit- the all the sampling stations.

In the sub surface water chlorophyll-a was varying from 0.307- 0.614mg/m^3 in harbour region of DPT OOT in path finder Creek during sampling done in spring tide period of July 2022. In the sub surface

water chlorophyll-a was varying from 0.204-0.323 mg/m^3.in harbour region of DPT OOT in path finder Creek during sampling done in Neap Tide periodof July 2022

TABLE #41 VARIATIONS IN CHLOROPHYLL –a PHEOPHYTIN- a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPT HARBOUR AREA IN KANDLA CREEK ,NEAR BY CREEKS AND DPT OOT JETTY IN PATH FINDER CREEK AND SPM NEAR VADINARDURING SPRING TIDE IN JULY 2022

Sr. No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPT HARBOUR AREA KANDLA CREEK					
1	KPT1	High tide	0.410	BDL	27.47
		Low tide	0.746	BDL	49.98
2	KPT 2	High tide	0.204	BDL	13.67
		Low tide	0.410	BDL	27.47
3	KPT 3	High tide	0.204	BDL	13.67
		Low tide	0.306	BDL	20.50
CREEKS					
4	KPT-4 Khori-I	High tide	0.205	BDL	13.74
		Low tide	0.322	BDL	21.57
5	KPT-5 Nakti-I	High tide	0.424	BDL	28.41
		Low tide	0.305	BDL	20.44
6	KPT-6 Nakti-II	High tide	0.497	BDL	33.30
PATHFINDER CREEK VADINAR					
7	VADINAR-I jetty	High tide	0.307	BDL	20.57
8		Low tide	0.614	BDL	41.14
9	SPM	High tide	0.353	BDL	23.65
10	SPM	Low tide	0.526	BDL	35.24

BDL: Below Detectable Limit.

TABLE #42 VARIATIONS IN CHLOROPHYLL –a PHEOPHYTIN- a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS AND DPT OOT JETTY IN PATH FINDER CREEK AND SPM NEAR VADINARDURING NEAP TIDE IN JULY 2022

Sr. No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPT HARBOUR AREA KANDLA CREEK					
1	KPT1	High tide	0.528	BDL	35.38
		Low tide	0.613	BDL	41.07
2	KPT 2	High tide	0.322	BDL	21.57
		Low tide	0.291	BDL	19.50
3	KPT 3	High tide	0.441	BDL	29.55
		Low tide	0.205	BDL	13.74
CREEKS					
4	KPT-4 Khori-I	High tide	0.338	BDL	22.65
		Low tide	0.512	BDL	34.30
5	KPT-5 Nakti-I	High tide	0.204	BDL	13.67
		Low tide	0.420	BDL	28.14
6	KPT-6 Nakti-II	High tide	0.240	BDL	16.08
PATHFINDER CREEK VADINAR					
7	VADINAR-I jetty	High tide	0.204	BDL	13.67
8		Low tide	0.302	BDL	20.23
9	SPM	High tide	0.306	BDL	20.50
10	SPM	Low tide	0.323	BDL	21.64

BDL: Below Detectable Limit.

PHYTOPLANKTON POPULATION:

For the evaluation of the Phytoplankton population in DPT harbour area and within the immediate surroundings of the port, sampling was conducted from 5 sampling locations (3 in harbour area and two in Nakti creek) during high tide period and low tide period of spring tide and neap tide.

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by, Diatoms, blue green algae and Dinoflagellates during spring tide period.Diatoms were represented by 19genera. Blue green was represented by 5genera and Dinoflagellates were represented by 4 genera during the sampling conducted in spring tide in JULY, 2022. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 50-210units/ L during high tide period and78-113units/ L during low tide of Spring Tide.

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by Diatoms, Blue green algae and Dinoflagellates during Neap tide period. Diatoms were represented by 26genera,Blue green algae were represented 5 genera and Dinoflagellates with3 genera during the sampling conducted in Neap tide in July, 2022. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from43-224units/ L during high tide period and 121-185units/ L during low tide of Neap Tide.

For the evaluation of the Phytoplankton population in DPT OOT jetty area in Path Finder creek sampling was conducted from two sampling locations; jetty area during high tide period and low tide of spring tide and Neap tide period.

The phytoplankton community of the sub surface water in the path finder creeks was represented by Diatoms, Blue green algae and Dinoflagellates during spring tide period. Diatoms were represented by 24genera, Blue Green algae by 2 genera and Dinoflagellates 4 genera each during the sampling conducted in spring tide in July, 2022. Phytoplankton of the sampling stations at sub surface layer in the harbour area was 227units/ L during high tide period and 216units/ L during low tide of Spring Tide. Phytoplankton of the sampling stations at sub surface layer in the *SPM area* was varying from 179units/ L during high tide period and 168 units/ L during low tide of Spring Tide.

The phytoplankton community of the sub surface water in the path finder creeks was represented by Diatoms, Blue green and Dinoflagellates during Neap tide period. Diatoms were represented by 28 genera and Blue green algae4 genera and Dinoflagellates by 2generaduring the sampling conducted in Neap tide in JULY, 2022. Phytoplankton of the sampling stations at sub surface path finder creek near OOT Jetty was varying from 251units/ L during high tide period and 230units/ L

during low tide of Neap Tide. Phytoplankton of the sampling stations at sub surface path finder creek near SPM area was varying from 195 units/ L during high tide period and 219 units/ L during low tide of Neap Tide.

Species Richness Indices and Diversity Indices:

Margalef's diversity index (Species Richness)S

At the organismal level, the most widely used biodiversity measures are those based on the number of species present, perhaps adjusted for the number of individuals sampled, Here Margalef's Species richness index (d), or indices that describe the evenness of the distribution of the numbers of individuals among species, are derived.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek and nearby creeks sampling stations was varying from 2.812- 3. 586with an average of 3.231during the sampling conducted in High tide period of spring tide.While Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek region and nearby creeks was varying from2.054- 2.750 with an average of 2.429during the consecutive low tide period.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations in Kandla creek and nearby creeks was varying from 1.900- 3.761 with an average of 2.918during the sampling conducted in High tide period of Neap tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek region and nearby creeks was varying from1.750- 4.047 with an average of3.018 during consecutive low tide.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations was3.687 at OOT jetty area and 2.506at SPM area during the sampling conducted in High tide period of spring tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the path finder creek near OOT jetty was 3.163 and 3.513at SPM during the consecutive low tide period.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations was 4.525 at OOT jetty area and 3.224 at SPM area during the sampling conducted in High tide period of Neap tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the path finder creek near OOT jetty was 4.046 and SPM area was 3.897 during the consecutive low tide period.

Shannon-Wiener's index:

Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.736- 0.843 (H'(log10)) between selected sampling stations with an average value of

0.796during high tide period of spring tide at Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.7008 - 0.802(H'(log10)) between selected sampling stations with an average value of 0.754 during consecutive low tide at Kandla creek and nearby creeks.

Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.698 –0.912 (H'(log10)) between selected sampling stations with an average value of 0.827during high tide period of neap tide at Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.695-0.869(H'(log10)) between selected sampling stations with an average value of 0.787 during consecutive low tide at Kandla creek and nearby creeks.

Shannon-Wiener's Index (H) of phytoplankton communities in the stations was 0.911at OOT jetty area and 0.838 at SPM area during the sampling conducted in High tide period of spring tide. While Shannon-Wiener's Index (H) of phytoplankton communities in the path finder creek near OOT jetty was 0.755and 0.840at SPM during the consecutive low tide period.

Shannon-Wiener's Index (H) of phytoplankton communities in the stations was 0.924 at OOT jetty area and 0.758 at SPM area during the sampling conducted in High tide period of Neap tide. While Shannon-Wiener's Index (H) of phytoplankton communities in the path finder creek near OOT jetty was 0.923and at SPM area was0.903during the consecutive low tide period.

Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon-Wiener's index increases as both the richness and the evenness of the community increase. This result indicates that diversity of phytoplankton of Kandla Harbour region and nearby creeks is less but with abundant population of few, with relatively few ecological niches and only very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson's diversity index:

Simpson's index (D) is a measure of diversity, which takes into account both species richness, and an evenness of abundance among the species present. The Simson index is one of the meaningful and robust biodiversity measures available. (Magurran,2004).

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks, which was varying from 0.729- 0.813 between selected sampling stations with an average of0.763during high tide period of spring tide. Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks except few, which was varying from

0.738- 0.794between selected sampling stations with an average of 0.761during consecutive low tide.

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations except few in Kandla Harbour region and nearby creeks, during high tide period and low tide period during neap tide also, which was varying from 0.735- 0.847with an average value of 0.800between selected sampling stations during high tide period and 0.747- 0.797varying from with an average value of 0.770between selected sampling stations during consecutive low tide period Low species diversity suggests a relatively few successful species in this habitat.

Simpson diversity index (1-D) of phytoplankton communities in the stations was 0.804at OOT jetty area and0.823at SPM area during the sampling conducted in High tide period of spring tide at Path finder creek. While Simpson diversity index (1-D) of phytoplankton communities in the path finder creek near OOT jetty was 0.689and 0.788at SPM during the consecutive low tide period in the path finder creek.

Simpson diversity index (1-D) of phytoplankton communities in the stations was 0.797at OOT jetty area and 0.674at SPM area during the sampling conducted in High tide period of Neap tide at Path finder Creek. While Simpson diversity index (1-D) of phytoplankton communities in the path finder creek near OOT jetty was 0.802and at SPM area was 0.803during the consecutive low tide period.

High species diversity suggests a greater number of successful species and a more stable ecosystem more ecological niches are available and the environment is less likely to be hostile complex food webs environmental change is less likely to be damaging to the ecosystem as a whole.

Table # 43 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND ,NEAR BY CREEKS DURING SPRING TIDE IN JULY 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% Of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	200	20/28	71.43	3.586	0.7726	0.7294
	2	145	18/28	64.29	3.416	0.8434	0.7697
	3	181	17/28	60.71	3.078	0.8151	0.7752
	4	210	20/28	71.43	3.553	0.7891	0.7478
	5	165	16/28	57.14	2.938	0.7362	0.7435
	6	50	12/28	42.86	2.812	0.8227	0.8131
LOW TIDE	1	113	14/28	50.00	2.75	0.802	0.7876
	2	98	13/28	46.43	2.617	0.7394	0.7391
	3	80	10/28	35.71	2.054	0.7008	0.7383
	4	94	11/28	39.29	2.201	0.7401	0.7442
	5	78	12/28	42.86	2.525	0.7921	0.7942

Table # 44 HYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND ,NEAR BY CREEKS DURING NEAP TIDE IN JULY 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	204	21/34	61.76	3.761	0.8479	0.7931
	2	180	15/34	44.12	2.696	0.8108	0.7914
	3	224	21/34	61.76	3.696	0.8556	0.8047
	4	165	18/34	52.94	3.329	0.912	0.8316
	5	193	11/34	32.35	1.9	0.6987	0.7353
	6	43	9/34	26.47	2.127	0.8373	0.8472
LOW TIDE	1	121	15/34	44.12	2.919	0.7709	0.7696
	2	140	21/34	61.76	4.047	0.8694	0.7977
	3	122	16/34	47.06	3.122	0.8033	0.7853
	4	171	10/34	29.41	1.75	0.6957	0.7505
	5	185	18/34	52.94	3.256	0.7999	0.7471

Table # 45 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND, NEAR BY CREEKS DURING SPRING TIDE IN JULY2022

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	DIATOMS	38-197	19/28	67.86
			BLUE GREEN	3-12	5/28	17.86
			DINOFLAGELLATES	0-5	4/28	14.28
			TOTAL PHYTO PLANKTON	**50-210**	**28**	
LOW TIDE	Sub surface	5	DIATOMS	71-101	19/28	67.86
			BLUE GREEN	2-177	5/28	17.86
			DINOFLAGELLATES	0-1	4/28	14.28
			TOTAL PHYTO PLANKTON	**78-113**	**28**	

TABLE # 46 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND, NEAR BY CREEKS DURING NEAP TIDE IN JULY 2022

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	DIATOMS	31-214	26/34	76.47
			BLUE GREEN	1-12	5/34	14.71
			DINOFLAGELLATES	1-3	3/34	8.82
			TOTAL PHYTO PLANKTON	**43-224**	**34**	
LOW TIDE	Sub surface	5	DIATOMS	118-182	26/34	76.47
			BLUE GREEN	0-3	5/34	14.71
			DINOFLAGELLATES	0-2	3/34	8.82
			TOTAL PHYTO PLANKTON	**121-185**	**34**	

TABLE # 47 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT OOT AT PATH FINDER CREEK , VADINAR &NEAR BY SPM, DURING SPRING TIDE IN JULY 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	jetty	227	21/30	70.00	3.687	0.911	0.8049
	SPM	179	14/30	46.67	2.506	0.8379	0.8234
LOW TIDE	jetty	216	18/30	60.00	3.163	0.755	0.6889
	SPM	168	19/30	63.33	3.513	0.8405	0.7882

TABLE # 48 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING NEAP TIDE IN JULY 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	251	26/34	76.47	4.525	0.9246	0.7971
	SPM	195	18/34	52.94	3.224	0.7584	0.674
LOW TIDE	Jetty	230	23/34	67.65	4.046	0.9232	0.8016
	SPM	219	22/34	64.71	3.897	0.9029	0.8031

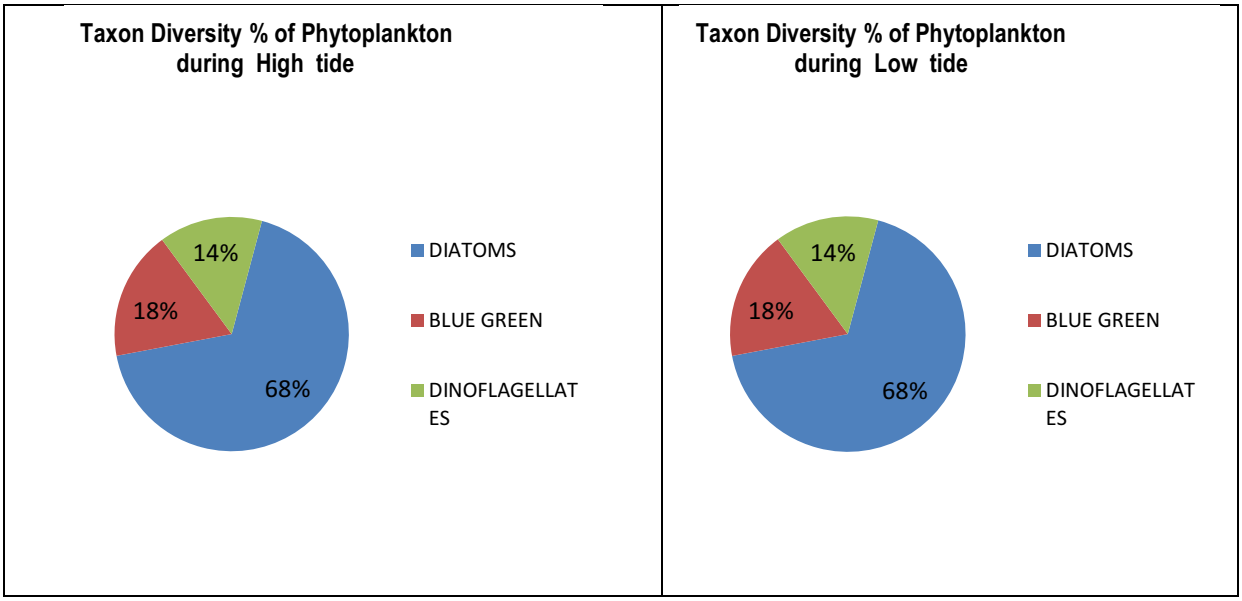
TABLE # 49 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPTOOT AT PATH FINDER CREEK,VADINAR & NEAR BY SPM, DURING SPRING TIDE IN JULY 2022

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	BLUE GREEN	0-2	2/30	6.67
			DIATOMS	178-222	24/30	80.00
			DINOFLAGELLATES	1-3	4/30	13.33
			TOTAL PHYTO PLANKTON	**179-227**		
LOW TIDE	Sub surface	2	BLUE GREEN	1-5	2/30	6.67
			DIATOMS	166-210	24/30	80.00
			DINOFLAGELLATES	1	4/30	13.33
			TOTAL PHYTO PLANKTON	**168-216**		

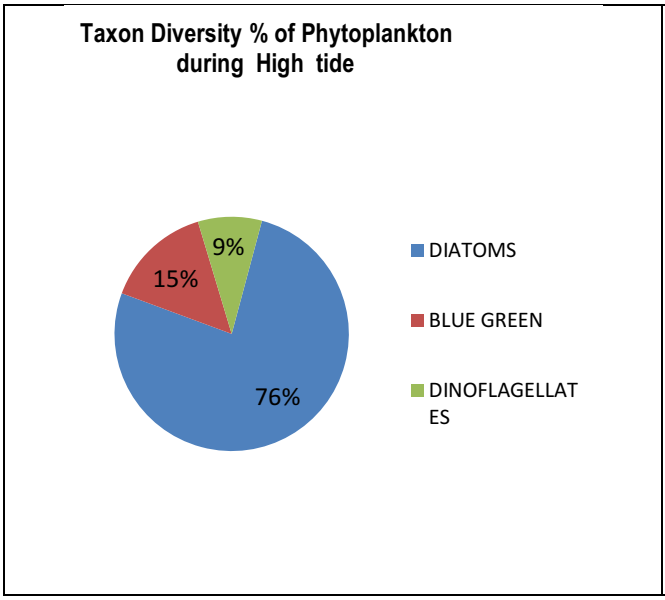
Table # 50 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPTOOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING NEAP TIDE IN JULY 2022

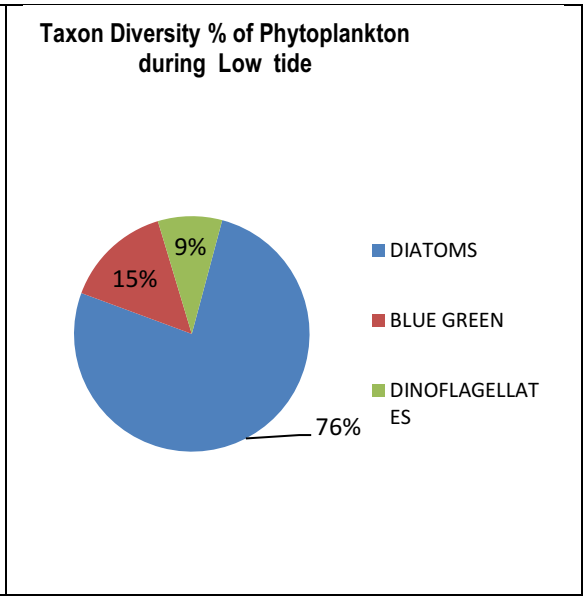
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	BLUE GREEN	3-6	4/34	11.76
			DIATOMS	191-243	28/34	82.36
			DINOFLAGELLATES	1-2	2/34	5.88
			TOTAL PHYTO PLANKTON	**195-251**	34	
LOW TIDE	Sub surface	2	BLUE GREEN	2	28/34	11.76
			DIATOMS	217-227	2/34	82.36
			DINOFLAGELLATES	0-1	2/34	5.88
			TOTAL PHYTO PLANKTON	**219-230**	34	

Taxon Diversity % of Phytoplankton during High tide and Low tide period during spring tide in Kandala creek and nearby creeks

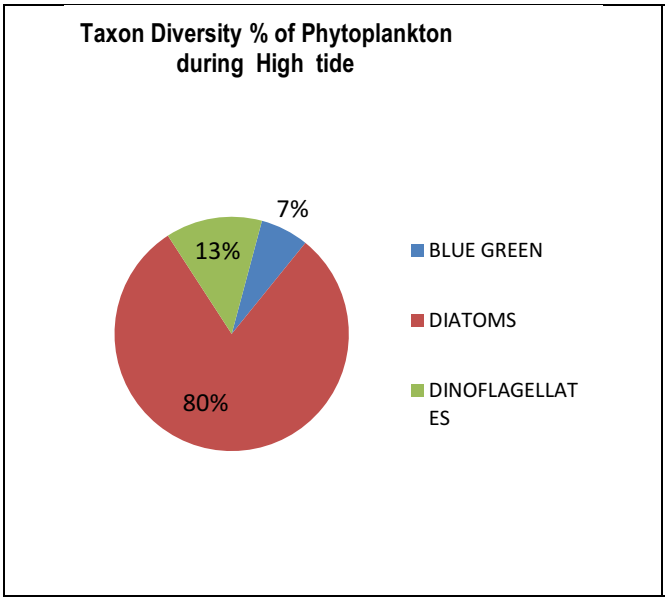


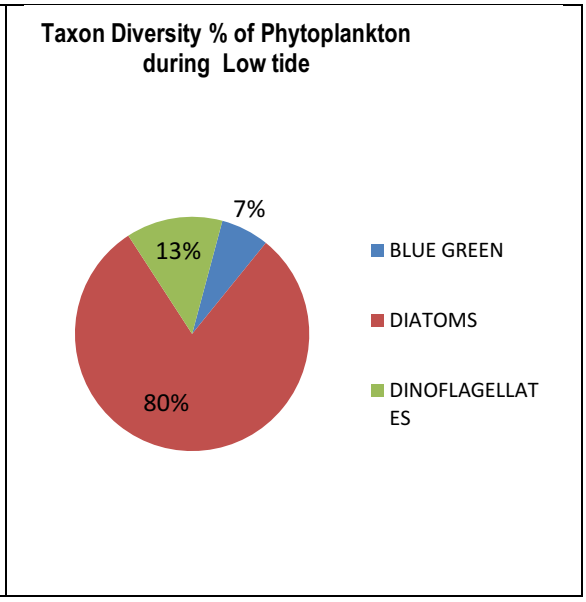
Taxon Diversity % of Phytoplankton during High tide and Low tide period during Neap tide in Kandala creek and nearby creeks



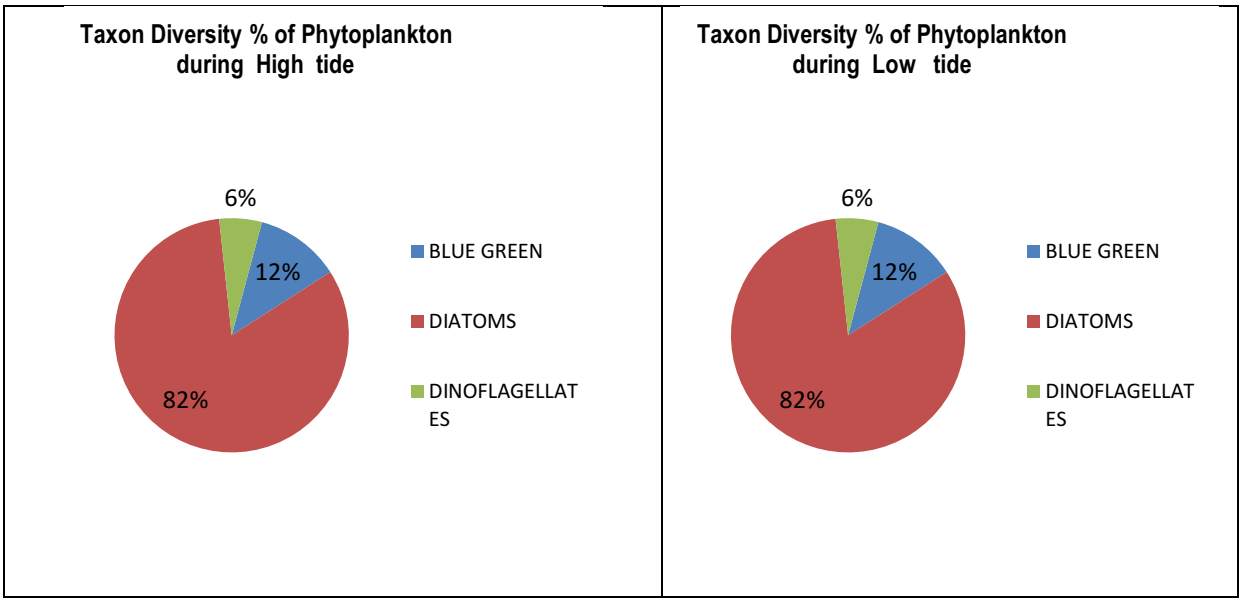


Taxon Diversity % of Phytoplankton during High tide and Low tide period during spring tide in Path Finder Creek, Vadinar





Taxon Diversity % of Phytoplankton during High tide and Low tide period during Neap tide in Path Finder Creek, Vadinar



For the evaluation of the Zooplankton population in DPT harbour area and within the immediate surroundings of the port sampling was conducted from 6 sampling locations (3 in harbour area and two in Nakti creek and one in Khori creek) during high tide period and low tide period of spring tide and Neap tide in JULY, 2022. The Zooplankton community of the sub surface water in the harbour and nearby creeks during spring tide was represented by mainly eight groups; Tintinnids, Copepods, Arrow worms, MEDUSA, Urochordata, Ciliates, Foraminiferans, Nematodes and 8 larval forms. The Zooplankton community of the sub surface water in the harbour and nearby creeks during neap tide was represented by mainly six groups; Tintinnids, Copepods, Rotifers, Arrow worms, Ciliates, Nematode and 8 larval forms.

Zooplankton of the sampling stations at sub surface layer in the DPT harbour area and nearby creek was varying from 33-146 x10^3 N/ m^3 during high tide and 65-107x10^3 N/ m^3during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPT harbour area and nearby creek was varying from 31-128x10^3 N/ m^3 during high tide and56-82x10^3 N/ m^3during low tide of Neap Tide period.

For the evaluation of the Zooplankton population in DPT OOT jetty area in Path Finder creek and SPM in Vadinar selected 2 sampling locations (1 in jetty area and one near SPM).

During spring tide sampling plankton sample were collected at Jetty area and near SPM during consecutive high tide period and low tide period. During Neap tide sampling Plankton samples were collected from jetty area and SPM during consecutive high tide period and low tide period.

The Zooplankton community of the sub surface water in the path finder creek during spring tide was represented by mainly Six groups Tintinnids, Copepods, Arrow worms, Urochordata, Mysids, Foraminiferans and 7larval forms. The Zooplankton community of the sub surface water in the path Finder creeks at Jetty region and SPM during neap tide was represented by mainly Fivegroups, Titinids, Copepods, Urochordata, Foraminifera, Nematodeand 9 larval forms.

Zooplankton of the sampling stations at sub surface layer in the DPT OOT Jetty area of path finder creek was 120 x10^3 N/ m^3 during high tide and 87x10^3 N/ m^3 during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPTSPM area of path finder creek was 70 x10^3 N/ m^3 during high tide and94x10^3 N/ m^3 during low tide of spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPT OOT jetty area in path finder creek was recorded 89 x10^3 N/ m^3during high tide and 120x10^3 N/ m^3 during consecutive low tide period of Neap tide. Zooplankton of the sampling stations at sub surface layer in the DPTSPM area in path finder creek was recorded 75x10^3 N/ m^3during high tide and 118 x10^3 N/ m^3 during consecutive low tide period of Neap Tide.

Species Richness Indices and Diversity Indices:

Margalef's diversity index (Species Richness)S

At the organismal level, the most widely used biodiversity measures are those based on the number of species present, perhaps adjusted for the number of individuals sampled, Here Margalef's Species richness index (d), or indices that describe the evenness of the distribution of the numbers of individuals among species, are derived.

Margalef's diversity index (Species Richness) S of Zooplankton communities in the stations Kandla creek region and nearby creeks was varying from 2.288- 3.852 with an average of 3.006during the sampling conducted in High tide period. Margalef's diversity index (Species Richness) S of Zooplankton communities varying from2.276- 4.085 with an average of2.875 during the sampling conducted in low tide period during Spring tide.

Margalef's diversity index (Species Richness) S of Zooplankton communities in the Kandla creek region and nearby creeks sampling stations was varying from2.621- 4.912 with an average of 3.840 during the sampling conducted in high tide and varying from2.496 - 3.726 with an average of 3.208 during the sampling conducted in low tide during Neap tide period.

Margalef's diversity index (Species Richness) S of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted inconsecutive High tide period and low tide of spring tide was recorded as 4.178 and 4.254 respectively. Margalef's diversity index (Species Richness) S of Zooplankton communities in the sampling

station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 4.237 and 4.611 respectively.

Margalef's diversity index (Species Richness) S of Zooplankton communities near Jetty at Path finder creek was varying from 4.01- 3.76 respectively during the sampling conducted in consecutive High tide period and Low tide period of Neap tide. While Margalef's diversity index (Species Richness) S of Zooplankton communities near SPM at Path finder creek was varying from 3.243 -2.725 respectively during the consecutive High tide and low tide period.

Shannon-Wiener's index:

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of0.789 -0.992 (H'(log10)) between selected sampling stations with an average value of0.877 H'(log10)) during high tide period of spring tide.

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.839-0.984(H'(log10)) between selected sampling stations with an average value of0.891 (H'(log10)) during consecutive low tide period.

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.881-1.119(H'(log10)) between selected sampling stations with an average value of 0.981(H'(log10)) during high tide period of Neap tide.

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range 0.786- 0.948 of (H'(log10)) between selected sampling stations with an average value of0.903(H'(log10)) during consecutive low tide period.

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 1.055-1.056 respectively. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.950-0.969 respectively

Shannon-Wiener's Index (H) of Zooplankton communities near jetty at Path finder creek was varying from 0.920-1.065 during the sampling conducted consecutive High tide period and Low tide period of Neap tide. While Shannon-Wiener's Index (H) of Zooplankton communities near SPM at Path finder creek was varying from1.006-0.997 during the consecutive High tide and low tide period.

Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon-Wiener's index increases as both the richness and the evenness of the community increase. This result indicates that diversity of Zooplankton of Kandla Harbour

region and nearby creeks stations is slightly high with very minimum diverse population but very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson's diversity index:

Simpson's index (D) is a measure of diversity, which takes into account both species richness, and an evenness of abundance among the species present. The Simpson index is one of the meaningful and robust biodiversity measures available. (Magurran, 2004).

Simpson diversity index (1-D) of Zooplankton communities was below 0.9most of sampling stations in the Kandla Harbour region and nearby creeks during high tide and low tide of spring tide period except few stations, which was varying from 0.792 -0.872 between selected sampling stations with an average of 0.827 during high tide period and was varying from 0.837 - 0.861 with an average value of 0.845 between selected sampling stations during low tide

Simpson diversity index (1-D) of Zooplankton communities was below0.9 at all sampling stations in the Kandla Harbour region and nearby creeks during high tide and low tide period of Neap tide except few, which was varying from 0.794 - 0.895 between selected sampling stations with an average of 0.849 during high tide period and was varying from 0.757 --0.865 with an average value of 0.831 between selected sampling stations during consecutive low tide .This species diversity suggests a relatively few successful species in this habitat during July 2022 sampling.

Simpson diversity index (1-D) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.880 and 0.882 respectively. Simpson diversity index (1-D) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.822 and 0.809 respectively.

Simpson diversity index (1-D) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of Neap tide was recorded as 0.829 - 0.901 respectively. Simpson diversity index (1-D) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.887 and 0.890 respectively.

TABLE # 51 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND NEAR BY CREEKS DURING SPRING TIDE IN JULY 2022

Tide	Sampling Station	Abundance In Nx10^3/ m^3	No of Species/ groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	107	19/28	67.86	3.852	0.9921	0.8718
	2	82	13/28	46.43	2.723	0.8614	0.807
	3	109	17/28	60.71	3.411	0.9008	0.8206
	4	146	13/28	46.43	2.408	0.8234	0.7922
	5	118	17/28	60.71	3.354	0.8944	0.8399
	6	33	9/28	32.14	2.288	0.7888	0.8277
LOW TIDE	1	82	19/28	67.86	4.085	0.9837	0.8612
	2	107	14/28	50.00	2.782	0.8873	0.8401
	3	69	12/28	42.86	2.598	0.8701	0.841
	4	65	12/28	42.86	2.635	0.8733	0.8447
	5	81	11/28	39.29	2.276	0.8389	0.8373

TABLE # 52 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREAAT KANDLA CREEK AND NEAR BY CREEKS DURING NEAP TIDE INJULY 2022

Tide	Sampling Station	Abundance In No x10^3/ m^3	No of Species/ groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	108	24/31	77.42	4.912	1.119	0.8946
	2	117	23/31	74.19	4.62	1.057	0.8638
	3	128	20/31	64.52	3.916	0.9808	0.8333
	4	93	17/31	54.84	3.53	0.9641	0.842
	5	105	17/31	54.84	3.438	0.8858	0.7936
	6	31	10/31	32.26	2.621	0.8806	0.8667
LOW TIDE	1	56	16/31	51.61	3.726	0.9456	0.8422
	2	62	16/31	51.61	3.634	0.9481	0.854
	3	72	15/31	48.39	3.274	0.9061	0.8365
	4	82	12/31	38.71	2.496	0.7861	0.7573
	5	62	13/31	41.94	2.908	0.9301	0.8646

Table # 53 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREAATKANDLA CREEK AND NEAR BY CREEKS DURING SPRING TIDE IN JULY 2022

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton x10^3 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinids	1-7	5/28	17.86
			Copepods	23-60	9/28	32.15
			Arrow worms	0	1/28	3.57
			Urochordata	0-1	1/28	3.57
			Ciliates	0-5	1/28	3.57
			Medusa	0-1	1/28	3.57
			Larval forms	8-80	8/28	28.57
			Foraminferans	0	1/28	3.57
			Nematode	0	1/28	3.57
			TOTAL ZOOPLANKTON N/M^3	**33-146**	**28**	
LOW TIDE	Sub surface	5	Tintinids	0-6	5/28	17.86
			Copepods	33-51	9/28	32.15
			Arrow worms	0-1	1/28	3.57
			Urochordata	0	1/28	3.57
			Ciliates	1-3	1/28	3.57
			Medusa	0	1/28	3.57
			Larval forms	22-49	8/28	28.57
			Foraminferans	0-1	1/28	3.57
			Nematode	0-1	1/28	3.57
			TOTAL ZOOPLANKTON N/M^3	**65-107**	**28**	

TABLE # 54 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA IN KANDLA CREEK AND, NEAR BY CREEKS DURING NEAP TIDE IN JULY 2022

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton x10^3 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinids	1-11	7/31	22.57
			Copepods	11-56	12/31	38.71
			Rotifers	0-10	1/31	3.23
			Arrow worms	0-2	1/31	3.23
			Ciliates	0-2	1/31	3.23
			Larval forms	18-64	8/31	25.80
			Nematode	0-1	1/31	3.23
			TOTAL ZOOPLANKTON N/M^3	**31-128**	**31**	
LOW TIDE	Sub surface	5	Tintinids	2-3	7/31	22.57
			Copepods	20-40	12/31	38.71
			Rotifers	0-2	1/31	3.23
			Arrow worms	0	1/31	3.23
			Ciliates	0-2	1/31	3.23
			Larval forms	23-48	8/31	25.80
			Nematode	0-1	1/31	3.23
			TOTAL ZOOPLANKTON N/M^3	**56-82**	**31**	

Table # 55 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING SPRING TIDE IN JULY 2022

Tide	Sampling Station	Abundance In $x10^3$N / m^3	No of Species/ groups observed /total species/ group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	120	21/33	63.64	4.178	1.055	0.8804
	SPM	70	19/33	57.58	4.237	0.9497	0.8215
LOW TIDE	Jetty	87	20/33	60.61	4.254	1.056	0.8818
	SPM	95	22/33	66.67	4.611	0.9685	0.8087

TABLE # 56 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURINGNEAP TIDEIN JULY 2022

Tide	Sampling Station	Abundance In Nx10^3/ m^3	No of Species/ groups observed /total species/ group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	89	19/29	65.52	4.01	0.9196	0.8294
	SPM	75	15/29	51.72	3.243	1.006	0.8868
LOW TIDE	Jetty	120	19/29	65.52	3.76	1.065	0.901
	SPM	118	14/29	48.28	2.725	0.9966	0.8898

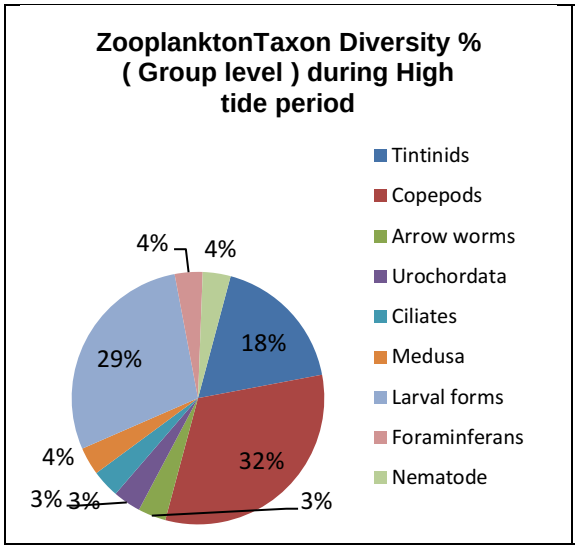
Table # 57 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT OOT AREAATPATH FINDER CREEK AND NEAR BY SPM DURING SPRING TIDE IN JULY 2022

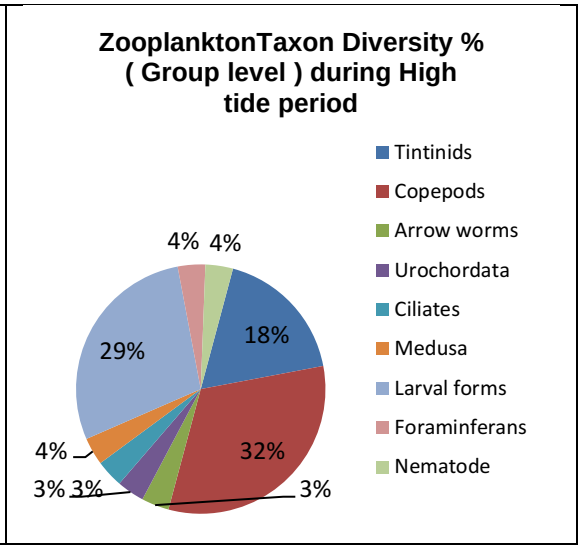
Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton x10^3 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	Tintinids	14-29	6/33	18.19
			Copepods	23-47	14/33	42.42
			Arrow worms	0	1/33	3.03
			Mysids	1-2	2/33	6.06
			Urochordata	1	2/33	6.06
			Larval forms	30-42	7/33	21.21
			Foraminferans	0	1/33	3.03
			TOTAL ZOOPLANKTON NO/L	**70-120**	**33**	
LOW TIDE	Sub surface	2	Tintinids	17-21	6/33	18.19
			Copepods	27-42	14/33	42.42
			Arrow worms	0-1	1/33	3.03
			Mysids	0-2	2/33	6.06
			Urochordata	0-1	2/33	6.06
			Larval forms	27-43	7/33	21.21
			Foraminferans	0-1	1/33	3.03
			TOTAL ZOOPLANKTON NO/L	**87-94**	**33**	

TABLE # 58 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING NEAP TIDE IN JULY 2022

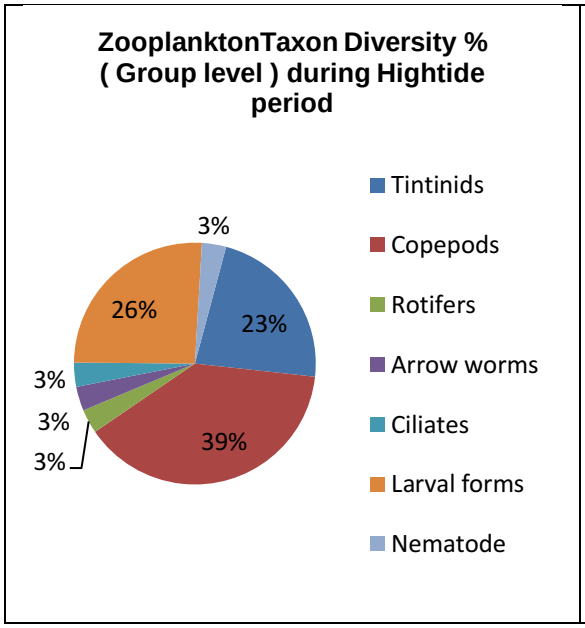
Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton x10^3 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	Tintinids	21-32	6/29	20.69
			Copepods	19-25	10/29	34.48
			Urochordata	1-2	2/29	6.90
			Larval forms	27-35	9/29	31.03
			Foraminifera	0-1	1/29	3.45
			Nematode	0-1	1/29	3.45
			TOTAL ZOOPLANKTON	**75-89**	**29**	
LOW TIDE	Sub surface	2	Tintinids	29-33	6/29	20.69
			Copepods	27-33	10/29	34.48
			Urochordata	0	2/29	6.90
			Larval forms	54-61	9/29	31.03
			Foraminifera	0	1/29	3.45
			Nematode	0-1	1/29	3.45
			TOTAL ZOOPLANKTON	**118-120**	**29**	

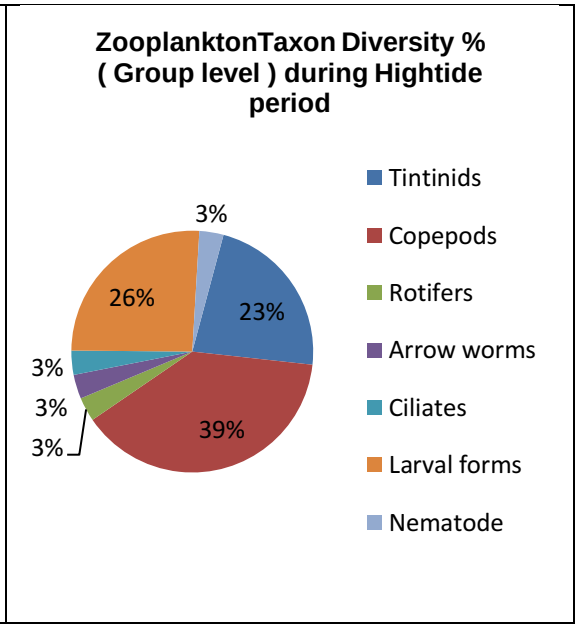
Taxon Diversity % of Zooplankton during High tide and Low tide period of Spring tide In Kandla Creek and nearby Creeks



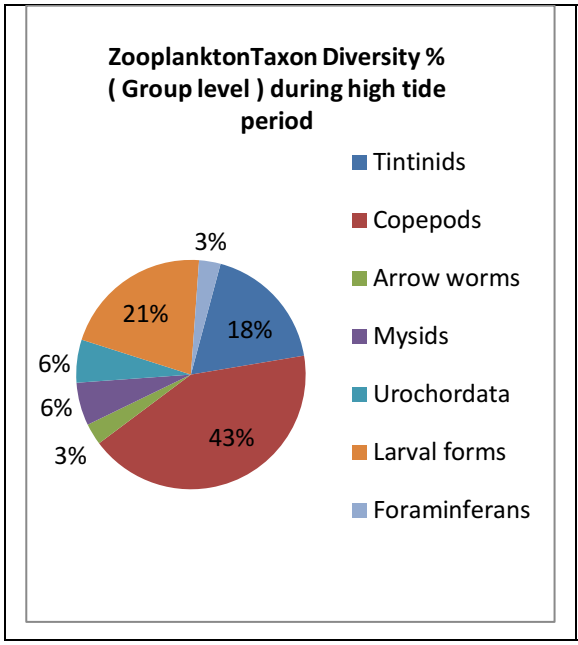


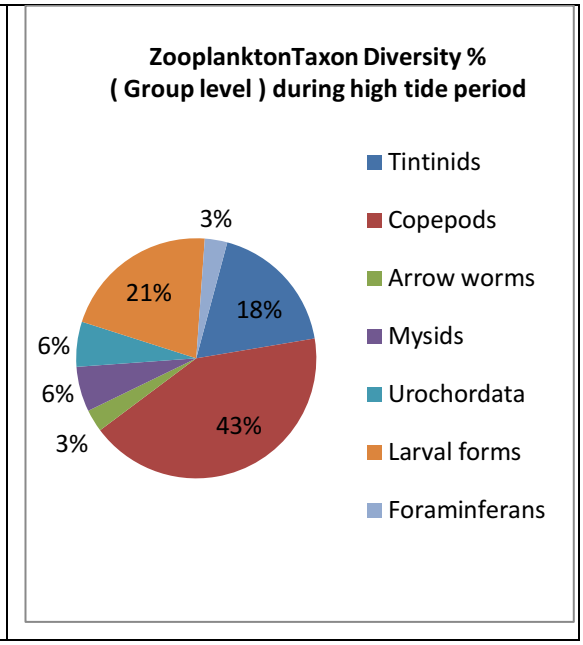
Taxon Diversity % of Zooplankton during High tide and Low tide period of Neap tide In Kandla Creek and nearby Creeks



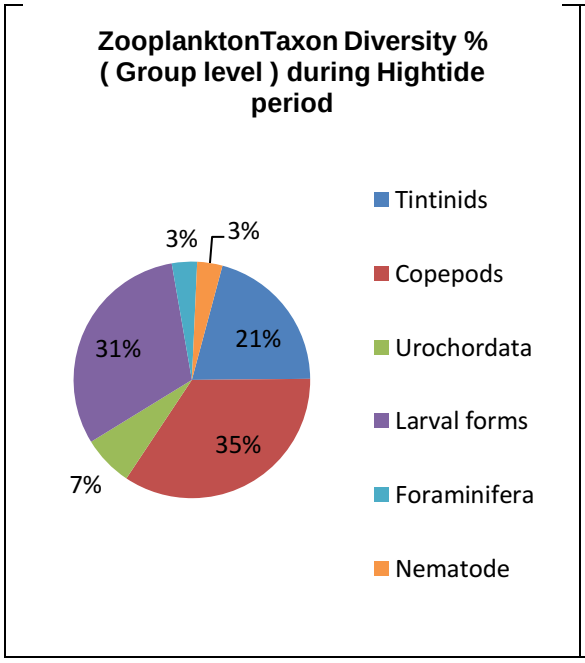


Taxon Diversity % of Zooplankton during High tide and Low tide period of Spring tide In Path Finder Creek and near Jetty





Taxon Diversity % of Zooplankton during High tide and Low tide period of Neap tide In Path Finder Creek near jetty and nearby SPM



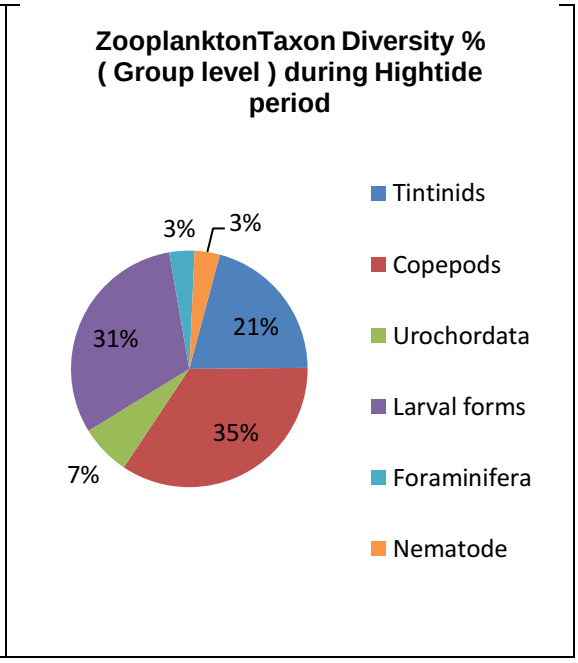


TABLE # 59 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS OF DPT HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURINGSPRING TIDE OF JULY 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAE	Cyanophyta	Cyanophyceae	Nostocales	Oscillatoriaceae	*Arthrospira sp.*	B1	Sparse
					Lyngbya sp.	B2	Very sparse
					Oscillatoria sp.	B3	Sparse
					Trichodesmium sp.	B4	Very sparse
			Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B5	Very sparse
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D1	Scattered
			Biddulphiales	Biddulphiaceae	Biddulphia sp.	D2	Dominant
			Hemiaulales	Bellerocheaceae	*Bellerochea*sp	D3	Very sparse
				Hemiaulaceae	Cerataulina sp.	D4	Very sparse
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros*sp	D5	Very sparse
			Lithodesmiales	Lithodesmiaceae	*Ditylumsp*	D6	Abundant
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D7	Very sparse
			Thalassiosirales	Thalassiosiraceae	*Thalassiosirasp*	D8	Very sparse

			Triceratiales	Triceratiaceae	Odontella sp.	D9	Sparse
					*Triceratium*sp.	D10	Very sparse
		Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria*sp.	D11	Very sparse
					Nitzschiasp	D12	Very sparse
			Naviculales	Pleurosigmataceae	*Pleurosigma* sp	D13	Very sparse
				Pinnulariaceae	*Pinnulariasp*	D14	Very sparse
			Surirellales	Surirellaceae	*Surirella*sp	D15	Very sparse
		Fragilariophyceae	Fragilariales	Fragilariaceae	Fragilariasp	D16	Very sparse
					Synedrasp	D17	Sparse
			Thalassionematales	Thalassionemataceae	*Thalassionema sp.*	D18	Sparse
					Thalassiothrix sp.	D19	Scattered
DINO FLAGELLATES	Dinoflagellata / Dinozoa	Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Very sparse
			Dinophysales	Dinophysaceae	*Dinophysis sp.*	DF2	Very sparse
			Gonyaulacales	Ceratiaceae	*Ceratiumfurca*	DF3	Very sparse
					Ceratium tripos	DF4	Very sparse

TABLE # 60 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPT HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING AND NEAP TIDE OF JULY 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAE	Cyanophyta	Cyanophyceae	Nostocales	Oscillatoriaceae	*Arthrospira sp.*	B1	Very sparse
					Lyngbya sp.	B2	Very sparse
					Oscillatoria sp.	B3	Sparse
			Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B4	Very sparse
			Stigonematales	Stigonemataceae	*Stigonema sp.*	B5	Very sparse
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D1	Scattered
			Biddulphiales	Biddulphiaceae	Biddulphiasp	D2	Dominant
			Hemiaulales	Bellerocheaceae	*Bellerochea*sp	D3	Very sparse
				Hemiaulaceae	Cerataulina sp.	D4	Very sparse
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D5	Very sparse
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros*sp.	D6	Sparse
			Lithodesmiales	Lithodesmiaceae	*Ditylumsp*	D7	Abundant

			Melosirales	Melosiraceae	*Melosirasp*	D8	Very sparse
			Thalassiosirales	Thalassiosiraceae	Planktoniellasp	D9	Very sparse
				Lauderiaceae	*Lauderia*sp	D10	Very sparse
				Skeletonemataceae	*Skeletonema*sp	D11	Very sparse
			Triceratiales	Triceratiaceae	Odontella sp.	D12	Sparse
					*Triceratium*sp.	D13	Very sparse
		Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria*sp.	D14	Very sparse
					Nitzschiasp	D15	Very sparse
					Pseudo-nitzschia sp.	D16	Very sparse
			Naviculales	Naviculaceae	*Navicula*sp	D17	Very sparse
				Pinnulariaceae	*Pinnulariasp*	D18	Very sparse
				Pleurosigmataceae	*Pleurosigma* sp.	D19	Very sparse
			Surirellales	Surirellaceae	*Campylo discus* sp	D20	Very sparse
					Surirella sp.	D21	Very sparse
		Fragilariophyceae	Fragilariales	Fragilariaceae	*Asterionellopsissp*	D22	Very sparse

					Fragilariasp	D23	Very sparse
					Synedrasp	D24	Sparse
			Thalassionematales	Thalassionemataceae	*Thalassionema sp.*	D25	Scattered
					Thalassiothrix sp.	D26	Abundant
DINO FLAGELLATES	Dinoflagellata / Dinozoa	Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Very sparse
			Gonyaulacales	Ceratiaceae	*Ceratiumfurca*	DF2	Very sparse
					Ceratium tripos	DF3	Very sparse

TABLE # 61 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPTOOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINARDURING SPRING TIDE OF JULY 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAE	Cyanophyta	Cyanophyceae	Nostocales	Oscillatoriaceae	*Oscillatoria sp.*	B1	Very sparse
			Stigonematales	Stigonemataceae	*Stigonema sp.*	B2	Very sparse
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D1	Abundant
			Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D2	Scattered
			Hemiaulales	Bellerocheaceae	*Bellerochea*sp	D3	Very sparse
				Hemiaulaceae	*Cerataulina sp.*	D4	Very sparse
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D5	Very sparse
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros*sp	D6	Sparse
			Lithodesmiales	Lithodesmiaceae	*Ditylumsp*	D7	Dominant
			Thalassiosirales	Skeletonemataceae	*Detonula sp.*	D8	Very sparse
				Lauderiaceae	*Lauderia*sp	D9	Sparse
			Triceratiales	Triceratiaceae	*Odontella* sp.	D10	Scattered
					*Triceratium*sp.	D11	Sparse

		Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria*sp.	D12	Very sparse
					*Nitzschia*sp	D13	Very sparse
			Naviculales	Naviculaceae	*Navicula*sp	D14	Very sparse
				Pleurosigmataceae	*Pleurosigma* sp	D15	Very sparse
				Pinnulariaceae	*Pinnulariasp*	D16	Very sparse
			Surirellales	Entomoneidaceae	*Entomoneis sp.*	D17	Very sparse
				Surirellaceae	*Surirella* sp.	D18	Very sparse
					*Campylodiscus*sp	D19	Very sparse
		Fragilariophyceae	Climacospheniales	Climacospheniaceae	*Climacosphenia sp.*	D20	Very sparse
			Fragilariales	Fragilariaceae	*Synedra sp.*	D21	Very sparse
			Striatellales	Striatellaceae	*Striatella sp.*	D22	Very sparse
			Thalassionematales	Thalassionemataceae	*Thalassionema sp.*	D23	Scattered
					Thalassiothrix sp.	D24	Scattered
DINOFLAGELLATES	Dinoflagellata / Dinozoa	Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Very sparse
			Dinophysales	Dinophysaceae	*Dinophysis sp.*	DF2	Very sparse
			Gonyaulacales	Ceratiaceae	*Ceratiumfurca*	DF3	Very sparse
					Ceratium tripos	DF4	Very sparse

TABLE # 62 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPTOOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING AND NEAP TIDE OF JULY 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAE	Cyanophyta	Cyanophyceae	Chroococcales	Chroococcaceae	*Merismopedia sp.*	B1	Very sparse
			Nostocales	Oscillatoriaceae	*Lyngbya sp.*	B2	Very sparse
					Oscillatoria sp.	B3	Very sparse
			Stigonematales	Stigonemataceae	*Stigonema sp.*	B4	Very sparse
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D1	Scattered
					Palmeria sp.	D2	Very sparse
			Biddulphiales	Biddulphiaceae	Biddulphiasp	D3	Scattered
			Hemiaulales	Bellerocheaceae	*Bellerochea*sp	D4	Very sparse
				Hemiaulaceae	Cerataulina sp.	D5	Very sparse
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D6	Very sparse
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros*sp	D7	Abundant
			Lithodesmiales	Lithodesmiaceae	*Ditylumsp*	D8	Dominant

			Melosirales	Melosiraceae	*Melosirasp*	D9	Very sparse
			Thalassiosirales	Lauderiaceae	*Lauderia*sp.	D10	Very sparse
				Thalassiosiraceae	Planktoniellasp	D11	Very sparse
			Triceratiales	Triceratiaceae	Odontellasp	D12	Sparse
					*Triceratium*sp	D13	Very sparse
		Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria*sp.	D14	Scattered
					Nitzschiasp	D15	Sparse
					Pseudonitzschiasp	D16	Very sparse
			Naviculales	Naviculaceae	*Navicula*sp	D17	Very sparse
				Pinnulariaceae	*Pinnulariasp*	D18	Very sparse
				Pleurosigmataceae	*Pleurosigma* sp	D19	Sparse
			Surirellales	Entomoneidaceae	*Entomoneis sp.*	D20	Very sparse
				Surirellaceae	*Campylodiscus*sp	D21	Very sparse
					Surirella sp.	D22	Very sparse
		Fragilariophyceae	Climacospheniales	Climacospheniaceae	*Climacosphenia sp.*	D23	Very sparse
			Fragilariales	Fragilariaceae	*Asterionellopsissp*	D24	Very sparse

					Synedra sp.	D25	Sparse
			Licmophorales	Licmophoraceae	*Licmophora sp.*	D26	Very sparse
			Thalassionematales	Thalassionemataceae	*Thalassionema sp.*	D27	Scattered
					Thalassiothrix sp.	D28	Scattered
DINO FLAGELLATES	Dinoflagellata / Dinozoa	Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Very sparse
				Ceratiaceae	*Ceratium tripos*	DF2	Very sparse

TABLE #63 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPT HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKSDURING SPRING TIDE OF JULY 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnussp.*	T1	Very sparse
				Codonellidae	*Tintinnopsisfailakkaensis*	T2	Very sparse
	CILIOPHORA				*Tintinnopsisgracilis*	T3	Very sparse
					Tintinnopsis radix	T4	Very sparse
				Xystonellidae	*Favella sp.*	T5	Very sparse
COPEPODS		Crustacea	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Scattered
					Parvocalanus sp.	C2	Very sparse
	ARTHROPODA	Subclass: Copepoda		Acartiidae	*Acartia sp.*	C3	Very sparse
				Clausocalanidae	*Clausocalanus sp.*	C4	Very sparse
				Centropagidae	*Centropages sp.*	C5	Very sparse
				Temoridae	*Temora sp.*	C6	Sparse
			Cyclopoida	Oithonidae	*Oithona sp.*	C7	Abundant
			Harpacticoida	Ectinosomatidae	*Microsetella*sp.	C8	Scattered

				Euterpinidae	*Euterpina sp.*	C9	Sparse
ARROW WORMS	CHAETOGNATHA	Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse
UROCHORDATA	CHORDATA SUB PHYLUM UROCHORDATA	Appendicularia		Oikopleuridae	*Oikopleura sp.*	U1	Very sparse
CILIATES	CILIOPHORA	Oligohymenophorea	Sessilida	Zoothamniidae	*Zoothamniumsp.*	CI1	Sparse
MEDUSA	PHYLUM CNIDARIA	Hydrozoa			Unidentified medusa	ME1	Very sparse
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of copepods	L1	Dominant
BRACHYURA LARVAE	ARTHROPODA (CRUSTACEA)	Malacostraca Decapoda			Brachyuran zoea larvae	L2	Very sparse
BARNACLE LARVAE	ATHROPODA CRUSTACEA	Maxillopoda Thecostraca			Cirripede larvae	L3	Very sparse
CYPHONAUTES LARVAE	BRYOZOA				Cyphonautes larvae	L4	Very sparse
ECHINODERMATA LARVAE	ECHINODERMATA				Ophiopluteus larvae	L5	Very sparse
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda			Opisthobranchia larvae	L6	Very sparse

TABLE # 64 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING OF DPT HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKSDURING NEAP TIDE OF JULY 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA	Spirotrichea	Tintinnida	Tintinnidiidae	*LeprotintinnusSp.*	T1	Very sparse
				Codonellidae	*Tintinnopsis acuminata*	T2	Very sparse
	CILIOPHORA				*Tintinnopsisfailakkaensis*	T3	Sparse
					Tintinnopsisgracilis	T4	Very sparse
					Tintinnopsis radix	T5	Very sparse
				Tintinnidae	*Eutintinnus*sp.	T6	Very sparse
				Xystonellidae	*Favella sp.*	T7	Very sparse
		Crustacea	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Sparse
					Parvocalanus sp.	C2	Very sparse
COPEPODS	ARTHROPODA	Subclass: Copepoda		Eucalanidae	*Subeucalanus sp.*	C3	Very sparse
				Acartiidae	*Acartia sp.*	C4	Very sparse
				Clausocalanidae	*Clausocalanus sp.*	C5	Very sparse
				Centropagidae	*Centropagessp.*	C6	Very sparse

				Temoridae	*Temora sp.*	C7	Sparse
				Tortanidae	*Tortanus sp.*	C8	Very sparse
			Cyclopoida	Oithonidae	*Oithona sp.*	C9	Abundant
			Harpacticoida	Clytemnestridae	*Clytemnestra sp.*	C10	Very sparse
				Ectinosomatidae	*Microsetella*sp.	C11	Scattered
				Euterpinidae	*Euterpina sp.*	C12	Very sparse
ROTIFERS	ROTIFERA	Rotifera	Superorder: Monogononta	Brachionidae	*Brachionusplicatilis*	R1	Sparse
		Subclass: Eurotatoria	Order:Ploimida				
ARROW WORMS	CHAETOGNATHA	Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse
CILIATES	CILIOPHORA	Oligohymenophorea	Sessilida	Zoothamniidae	*Zoothamnium*sp.	CI1	Very sparse
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of copepods	L1	Dominant
BRACHYURA LARVAE	ARTHROPODA (CRUSTACEA)	Malacostraca	Decapoda		Brachyuran zoea larvae	L2	Very sparse
BARNACLE LARVAE	ATHROPODA CRUSTACEA	Maxillopoda			Cirripede larvae	L3	Very sparse
		Thecostraca					

CYPHONAUTES LARVAE	BRYOZOA				Cyphonautes larvae	L4	Sparse
ECHINODERMATA LARVAE	ECHINODERMATA				Ophiopluteus larvae	L5	Very sparse

TABLE # 65 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPTOOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINARDURING SPRING TIDE OF JULY 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnussp.*	T1	Sparse
				Codonellidae	*Tintinnopsisfailakkaensis*	T2	Very sparse
					Tintinnopsisgracilis	T3	Sparse
					Tintinnopsismortensenii	T4	Very sparse
					Tintinnopsis radix	T5	Scattered
				Dictyocystidae	*Luminella sp.*	T6	Very sparse
COPEPODS	ARTHROPODA	Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Scattered
					Parvocalanus sp.	C2	Very sparse
				Acartiidae	*Acartia sp.*	C3	Very sparse
				Centropagidae	*Centropages sp.*	C4	Very sparse

				Eucalanidae	*Pareucalanus sp.*	C5	Very sparse
					Subeucalanus sp.	C6	Very sparse
				Temoridae	*Temora sp.*	C7	Very sparse
				Tortanidae	*Tortanus sp.*	C8	Very sparse
			Cyclopoida	Oithonidae	*Oithona sp.*	C9	Abundant
			Harpacticoida	Clytemnestridae	*Clytemnestra sp.*	C10	Very sparse
				Euterpinidae	*Euterpina sp.*	C11	Sparse
				Ectinosomatidae	*Microsetella*sp.	C12	Sparse
			Poicilostomatatoida	Corycaeidae	*Corycaeus sp.*	C13	Very sparse
				Oncaeidae	*Oncaea sp.*	C14	Very sparse
ARROW WORMS	CHAETOGNATHA	Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse
MYSIDS	ATHROPODA CRUSTACEA	Malacostraca	Mysida, Decapoda	Penaeidae	*Metapenaeussp.*	M1	Very sparse
				Solenoceridae	*Solenocerasp.*	M2	Very sparse
UROCHORDATA	CHORDATA SUB PHYLUM UROCHORDATA	Appendicularia		Fritillariidae	*Fritillaria sp.*	U1	Very sparse
				Oikopleuridae	*Oikopleura sp.*	U2	Very sparse
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of copepods	L1	Dominant

ASCIDIAN LARVAE	CHORDATA SUBPHYLUM: TUNICATA	Ascidiacea			Ascidian tadpole larvae	L2	Very sparse
BRACHYURA LARVAE	ARTHROPODA (CRUSTACEA)	Malacostraca Decapoda			Brachyuran zoea larvae	L3	Very sparse
BARNACLE LARVAE	ARTHROPODA CRUSTACEA	Maxillopoda Thecostraca			Cirripede larvae	L4	Very sparse
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L5	Very sparse
POLYCHAETE LARVAE	ANNELIDA	Polychaeta			Trochophore larvae	L6	Sparse
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of bivalves	L7	Sparse
FORAMINIFERA	FORAMINIFERA	Globothalamea	Rotaliida	Rotalliidae	*Rotalia* sp.	F1	Very sparse

TABLE # 66 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPTOOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING NEAP TIDE OF JULY 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnussp.*	T1	Scattered
				Codonellidae	*Tintinnopsisfailakkaensis*	T2	Very sparse
					Tintinnopsisgracilis	T3	Very sparse
					Tintinnopsismortensenii	T4	Very sparse
					Tintinnopsis radix	T5	Abundant
				Xystonellidae	*Favella* sp.	T6	Very sparse
COPEPODS	ARTHROPODA	Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Scattered
					Parvocalanus sp.	C2	Very sparse
				Clausocalanidae	*Clausocalanus sp.*	C3	Very sparse
				Temoridae	*Temora sp.*	C4	Very sparse
				Tortanidae	*Tortanus sp.*	C5	Very sparse
			Cyclopoida	Oithonidae	*Oithona sp.*	C6	Scattered
			Harpacticoida	Clytemnestridae	*Clytemnestra sp.*	C7	Very sparse
				Euterpinidae	*Euterpina sp.*	C8	Sparse

				Ectinosomatidae	*Microsetella*sp.	C9	Very sparse
			Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C10	Very sparse
UROCHORDATA	CHORDATA SUB PHYLUM UROCHORDATA	Appendicularia		Fritillariidae	*Fritillaria sp.*	U1	Very sparse
				Oikopleuridae	*Oikopleura sp.*	U2	Very sparse
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of copepods	L1	Dominant
ASCIDIAN LARVAE	CHORDATA SUBPHYLUM: TUNICATA	Ascidiacea			Ascidian tadpole larvae	L2	Very sparse
BRACHYURA LARVAE	ARTHROPODA (CRUSTACEA)	Malacostraca Decapoda			Brachyuran zoea larvae	L3	Very sparse
BARNACLE LARVAE	ARTHROPODA CRUSTACEA	Maxillopoda Thecostraca			Cirripede larvae	L4	Very sparse
CYPHONAUTES LARVAE	BRYOZOA				Cyphonautes larvae	L5	Very sparse
ECHINODERMATA LARVAE	ECHINODERMATA				Ophiopluteus larvae	L6	Very sparse

MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L7	Sparse
POLYCHAETE LARVAE	ANNELIDA	Polychaeta			Trochophore larvae	L8	Scattered
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of bivalves	L9	Sparse
FORAMINIFERA	FORAMINIFERA	Globothalamea	Rotaliida	Rotalliidae	*Rotalia* sp.	F1	Very sparse
NEMATODE	NEMATODA				Unidentified nematodes	N1	Very sparse

BENTHIC ORGANISMS:

Few Benthic organisms were observed in the collected sediments by using the Van-veen grabs during the sampling conducted during spring tide period and Neap tide period from DPT harbour region and nearby creek. The meio-benthic organisms during spring tide and Neap tide were represented by Polychaetes *Dasybranchus* sp., and *Prinispo*sp. Population of benthic fauna was varying from 30-50 N/m^2 during spring tide and 10-60 N/m^2 during spring tide

Table # 67 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPT HARBOUR AREA CREEKS DURING SPRING TIDE IN JULY 2022

REPRESENTATION BY GROUP	DPT HARBOUR			CREEKS		
Benthic fauna						
POLYCHAETES	KPT-1	KPT-2	KPT-3	KPT-4	KPT-5	KPT-6
Family:Capitellidae Dasybranchussp.	10	20	40	10	20	NS
Family Spionidae Prinisposp.	20	20	10	20	20	NS
Total polychaetes N/M^2	30	40	50	30	40	NS
TOTAL BenthicFauna NUMBER/ M^2	30	40	50	30	40	

NS: No sample

Table # 68 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPT HARBOUR AREA CREEKS DURING NEAP TIDE IN JULY 2022

ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS						
REPRESENTATION BY GROUP	DPT HARBOUR			CREEKS		
Benthic fauna						
POLYCHAETES	KPT-1	KPT-2	KPT-3	KPT-4	KPT-5	KPT-6
Family :Capit*ellidae Dasybranchussp.*	10	10	20	50	30	NS

Family Spionidae Prinisposp.	20	20	10	10	20	NS
Family :Nephtyidae Nephthys sp.	10	10	10	10	10	NS
Total Polychaetes N/M^2	40	40	40	70	60	
TOTAL Benthic Fauna NUMBER/ M^2	40	40	10	70	60	

Table # 69 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPT OOT JETTY AREA, VADINAR DURING SPRING TIDE IN JULY 2022

ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS		
REPRESENTATION BY GROUP	OOT Jetty Area	SPM area
POLYCHAETES		
Family :Capit*ellidae Notomastussp.*	40	0
Family :Capit*ellidae Heteromastussp.*	10	0
Total polychaetes N/M^2	50	0
TOTAL Benthic Fauna NUMBER/ M^2	50	0

12.0 Conclusive Summary and Remedial measures Suggested

- The AAQ monitoring at five locations of Deendayal Port Kandla indicates that the mean PM_{10} and $PM_{2.5}$ values for four locations viz. Marine Bhavan, Oil Jetty area, Estate Office and Coal storage area were found above the permissible limit (standards100 µg/m^3, 60 µg/m^3). The higher concentration of Particulate matter at Marine Bhavan due to vehicles emissions during loading-unloading of food grains and timbers; at Oil Jetty area due to industries activities and heavy vehicles transportation; at Estate office due to construction work, vehicles emission produced from trucks, heavy duty vehicles that pass through the road outside Kandla port and Oil jetty area; while at Coal Storage area lifting of coal with grab and other coal handling processes. Moreover, the traffic was also heavy around this place for transport of coal thus emissions produced from heavy vehicles. At Gopalpuri location, concentration of PM_{10} varied from 86-135 µg/m^3 and mean was 107 µg/m, concentration of $PM_{2.5}$ was ranges from 42-82 µg/m^3 and mean was 58 µg/m^3. Tuna port for PM_{10} and $PM_{2.5}$ were found within permissible limit.
- The AAQ monitoring Vadinar at Admin building, the concentration of monthly average PM_{10} value was found 103 µg/m^3 slightly higher at both sampling station (Standard Limit 100 µg/m^3) & concentration of $PM_{2.5}$ within the limit at both sampling station (Limit 60 µg/m^3).
- Drinking water at all the twenty locations was found potable and was within permissible limits of BIS standards (IS 10500-2012).
- Noise quality was also within the set permissible standards of an Industrial Area. The noise level observed during day time was >75 dB (A) and at night time was >70 dB (A) during the entire monitoring period.
- The treated sewage water of Kandla STP, Deendayal Port Colony (Gopalpuri) and Vadinar were in line with the standards set by the Gujarat Pollution Control Board.
- It was suggested to do treatment on regular basis to avoid flow of contamination / Pollutant water into the sea.
- The mean day time temperature for Deendayal Port was 25.6 °C. The day-time maximum temperature was 34.3°C. The mean night time temperature recorded was 28.4 °C. The Solar Radiation minimum was recorded 0.23 w/m^2 in 27th July and maximum 623.2 18th July. The mean Solar Radiation in July month was 115.72 w/m^2. The mean Relative humidity was 88.15 % for the month of July. Maximum Relative humidity was recorded 99.0 % and minimum Relative humidity was recorded 47 %. The average wind velocity for the entire month of July was 1.56 m/s. Maximum wind velocity was recorded 13.8 m/s. The wind direction was mostly North West.

Reasons for higher Values of PM_{10}

- The unloading of coal directly in the truck, using grabs cause coal to spread in air as well as coal dust to fall on ground. This settled coal dust again mixes with the air while trucks travel through it.
- Also, the coal loaded trucks were not always covered with tarpaulin sheets and these results in spillage of coal from trucks/dumpers during its transit from vessel to yard or storage site. This also increased PM values around marine Bhavan & Coal storage area.

Remedial Measures

The values of PM_{10} & $PM_{2.5}$ during the month of July, 2022 were beyond the permissible limit at all locations mentioned above Except Tuna Port for PM_{10}. Given below are the remedial measures suggest to minimize the Air pollution.

- During July, 2022 overall ambient air quality of the DPA was within GPCB permissible limits except TSPM, PM_{10}, $PM_{2.5}$ at Coal storage area, Marine Bhavan, Estate Office and Oil Jetty area. To improve air quality the port was using number of precautionary measures, such as maintained a wide expanse of Green zone, initiated Inter-Terminal Transfer (ITT) of tractor-trailers, Centralized Parking Plaza, providing shore power supply to tugs and port crafts, the use of LED lights at DPA area helps in lower energy consumption and decreases the carbon foot prints in the environment, time to time cleaning of paved and un paved roads, use of tarpaulin sheets to cover dumpers at project sites etc. are helping to achieve the cleaner and green future at port.

Solution towards the Green port:

- The vehicles should be covered during transportation and the vehicle carrying the coal should not be overloaded by raising the height of carriage.
- The water sprinklers should be use during transportation of loaded heavy vehicles on raw road.
- Practice should be initiated for using mask as preventative measure, to avoid Inhalation of dust particle- Mask advised in sensitive areas.
- Use of renewable energy like solar energy should be optimal and ensure to work continuously.
- Create awareness towards public.
- Technology like Electric cart, Inter-Terminal Transfer (ITT) are worthy selection to reduce Port operation efficiency and fuel cost.
- Limit the Activity and time of Exposure in Sensitive Area.
- Conventional RTGCs should be altered as E-RTGCs counting inside the port completely.
- New scanning technology and new high power Tugs are reducing operation timing and CO_2 Emission are good creativity.
- Initiate Natural Gas (CNG) as fuel by all buses and trucks.

ENVIRONMENTAL MONITORING REPORT FOR DEENDAYAL PORT AUTHORITY

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Mont	:	August
Issue	:	01
Revision	:	00
Prepare	:	DETOX CORPORATION PVT. LTD., SURAT

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ENVIRONMENTAL MONITORING PLAN FOR DEENDAYAL PORT ENVIRONMENTALMONITORING REPORT- AUGUS, 2022

1. EXECUTIVE SUMMARY

Monitoring of various environmental aspects of the Deendayal port by M/s Detox Corporation Pvt. Ltd. has been carried out through collection of samples, analysis of the same, comparing results with respect to the national standards and any other relevant standards by GBCB/CPCB/MoEF & CC to understand status of various parameters in the Environment of the Deendayal Port. The results shall address the identified impacts and suggest measures to minimize the environmental impact due to various operations at Deendayal Port.

A) Ambient Air

The monitoring of Ambient Air quality at 6-locations at Deendayal Port Authority Kandla and 2- location at Vadinar Port on 24 hourly basis for TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2, NH_3, CO_2, CO, C_6H_6 and NMHC in twice a week 24 hourly at uniform intervals (as per NAAQS) at Gopalpuri, Tuna Port, Marine Bhavan building, Coal storage area, Estate building, Oil jetty and at Vadinar port, Vadinar Jetty and Vadinar colony area using respirable dust sampler, Fine particulate sampler and gaseous sampler.

The TSPM values in month of August 2022 were found 562 µg/m^3 maximum at Coal Storage area on 08.08.2022 and minimum 102 µg/m^3 at Tuna Port on 16.08. 2022. The PM_{10} values were found from 412 µg/m^3 maximum at Coal Storage area on 08.08.2022 and minimum 61 µg/m^3 at Tuna Port on 26.08. 2022. The $PM_{2.5}$ values were found from 146 µg/m^3 maximum at Coal Storage area on 08.08. 2022 and minimum 27 µg/m^{3}at Tuna Port on 04.08 2022. The PM_{10} and $PM_{2.5}$ values were found for four locations (Marine Bhavan Building, Coal Storage Area, Estate Building, and Oil Jetty) to exceed the permissible limit.

At Gopalpuri location concentration of PM_{10} was found mostly within the permissible limit, the concentration of $PM_{2.5}$ was within the permissible limit. Only at Tuna port, all parameters of ambient air quality were found within the limit.

The AAQ monitoring Vadinar at Admin building and signal building the concentration of $PM_{2.5}$ had shown very slight increase and the PM_{10} concentrations had shown the increasing trend.

The overall values of August for Gaseous SO_2, NO_2, NH_3, CO_2, CO, C_6H_6 concentration were within the permissible limit at all location and NMHC were found BQL (Below Quantification Limit).

B) Weather

The mean day time temperature at Deendayal Port was 29.81 °C. The day-time maximum temperature was 35.4°C and minimum was 25.7 °C. The mean night time temperature recorded was 27.57 °C. The mean Solar Radiation in August month was 109.08 w/m^2. The maximum solar radiation was recorded 663.7 w/m^2 in 6th August, 2022 and the minimum solar radiation was recorded 0.23 w/m^2 in 5th August, 2022. The mean Relative humidity was 88.15 % for the month of August. Maximum Relative humidity was recorded 99.55 % and minimum Relative humidity was recorded 58 %. The average wind velocity for the entire month of August was 0.55 m/s. Maximum wind velocity was recorded 9.2 m/s. The wind direction was mostly West-South.

C) Marine Ecology (Flora and Fauna) / Marine Water / Sediments:

The results obtained from the study for the month of August 2022 for biological and ecological parameters in marine water for Arabian Sea at surrounding area of Deendayal Port Authority (DPA) was not affected by Port activities.

D) Drinking Water Quality

The drinking water being supplied to Deendayal Port was safe for drinking purpose. At all drinking water monitoring stations around port area were in line with the standard limit as per the drinking water specifications given in IS 10500:2012 as per tested parameters only.

The average results for 20 locations were as: pH were found Min 7.20 and maximum 7.60, TDS were found min 374.0 mg/l and Max found 490.0 mg/l, Chloride were found Min 150.33 mg/l and Max 215.48 mg/l, Total Hardness were found Min 370.0 mg/l and Max 500.0 mg/l and Calcium were found Min 40.08 mg/l and Max 72.14 mg/l, color found colorless and odor were odorless. In all water samples BOD, Heavy metal like manganese, Hexavalent chromium, Copper, Cadmium, Arsenic, Mercury, Lead, zinc all are found BQL (Below Quantification Limit). The bacterial count (E-coli & Coliform) is absent in all drinking water samples.

E) Monitoring Performance of Sewage Treatment Plant

It was seen that the performance of STP at Deendayal Township, DPA STP Plant and Vadinar STP plant was satisfactory by overall. The treatment plant was well maintained during [August 2022] with considerable removal efficiency achieving the standards prescribed for final disposal. At Gopalpuri STP, the pollutant removal efficiency for TSS, BOD and COD was ranged from 33-68%, 18-69% and 42-67% respectively. At Kandla STP, removal efficiency for TSS, BOD and COD was ranged from 43-61%, 14-66% and 41-63% respectively & at Vadinar STP removal efficiency for TSS, BOD and COD was ranged from

34-57%, 12-66% and 40-70% respectively. At all STP location the pH were ranged from 7.21-7.45,Total Suspended Solids were found 34.4-57.7 mg/l , Residual Chlorine were below Detection Limit (Less Than 0.5) , COD were found 30-70 mg/l and 3day BOD @ 27 °C were found 6 to 22 mg/l.

F) Noise

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. The Day Time Noise Level (SPL) in all 10 locations at Deendayal Port ranged from 67.1 dB(A) to 74.8 dB(A) while at Vadinar port 3 location ranged from 58.0 dB(A) to 64.9 dB(A) which was within the permissible limits of 75 dB(A) for the industrial area for the daytime. The Night Time Average Noise Level (SPL) in all locations of Deendayal Port ranged from 62.3 dB to 69.5 dB(A) while at Vadinar port which was within the permissible limits of 70 dB(A) for the industrial area for the night time.

1.0 Introduction

About Deendayal Port

The Deendayal Port is situated in the Kandla Creek and is 90 Kms. From the mouth of Gulf of Kachchh. Latitude: 23° 01" N Longitude: 70° 13"E. Deendayal Port's journey began in 1931 with construction of RCC Jetty by Maharao Khengarji. After partition, Deendayal Port's success story has continued and it rise to the No. 1 Port in India in the year 2007-08 and since then retained the position for the 15 consecutive year. On 31.03.2016, Deendayal Port created history by handling 100 MMT cargoes in a year, the first Major Port to achieve the milestone. Kandla, also known as the Deendayal Port Authority is a seaport in Kutch District of Gujarat state in western India, near the city of Gandhidham. Located on the Gulf of Kutch, it is one of major ports on west coast. Kandla was constructed in the 1950s as the chief seaport serving western India, after the partition of India from Pakistan left the port of Karachi in Pakistan. The Port of Deendayal is located on the Gulf of Kutch on the northwestern coast of India some 256 nautical miles North West of the Port of Karachi in Pakistan and over 430 nautical miles north-northwest of the Port of Mumbai (Bombay). It is the largest port of India by volume of cargo handled. Kandla history Deendayal Port Authority, India's busiest major port in recent years, is gearing to add substantial cargo handling capacity with private sector participation. Deendayal port Authority creates a new record by handling 127.10 million metric tons of cargo during the FY 2021-22, as against 117.566 million metric tons in FY 2020-21. Showing a growth of 8.11 %. Incidentally, DPA is the only major Indian port of handle more than 127 MMT cargo throughout and it has also registered the highest cargo throughput in its history. While the port has flagged off several projects related to infrastructure creation, DPA has successfully awarded the work of augmentation of liquid cargo handling capacity by revamping the existing pipeline network at the oil jetty area in Sept. 2021. Even as much of this growth has come from handling of crude oil imports, mainly for Essar Oil's Vadinar refinery in Gujarat, the port is also taking measures to boost non-POL cargo. Last fiscal, POL traffic accounted for 63 per cent of the total cargo handled at Deendayal Port, as against 59% in 2007-08. The Deendayal Port Authority had commissioned the Off-shore Oil Terminal facilities at Vadinar in the year 1978, for which M/s. Indian Oil Corporation Limited (IOCL) provided Single Bouy Mooring (SBM) system, having a capacity of 54 MMTPA, which was first of its kind in India. Further, significant. Quantum of infrastructural up-gradation has been affected & excellent maritime infrastructure been created at Vadinar for the 32MMTPA Essar Oil Refinery in Jamnagar District. Monitoring of various environmental aspects of the Deendayal port by M/s Detox Corporation Pvt. Ltd. has been carried out through collection of samples, analysis of the same, comparing results with respect to the prescribed standards by GPCB/CPCB/MoEF& CC. The results shall address the identified impacts and suggest measures to minimize the environmental impact due to various operations at Deendayal Port. The environmental monitoring is carried out as per the Environment Management and Monitoring Plan submitted by Detox Corporation Pvt. Ltd.

2. Introduction

Air pollutants are added in the atmosphere from variety of sources that change the composition of atmosphere and affect the biotic environment. The concentration of air pollutants depend not only on the quantities that are emitted from air pollution sources but also on the ability of the atmosphere to either absorb or disperse these emissions. The air pollution concentration vary spatially and temporarily causing the air pollution pattern to change with different locations and time due to changes in meteorological and topographical condition. Air pollution occurs when harmful substances including particulates and biological molecules are introduced into earth's atmosphere. It may cause diseases, allergies or death of humans; it may also cause harm to other living organisms such as animals and food crops, and may damage the natural or built environment. Human activity and natural processes can both generate air pollution. A physical, biological or chemical alteration to the air in the atmosphere can be termed as pollution. It occurs when any harmful gases, dust, smoke enters into the atmosphere and makes it difficult for plants, animals and humans to survive as the air becomes dirty. The consequences of industrialization and the demand for improved quality of life has been increased exposure to air pollution (Vallero, 2014). An air pollutant is a substance in the air that can have adverse effects on humans and the ecosystem. The substance can be solid particles, liquid droplets, or gases. A pollutant can be of natural origin or man-made. Pollutants are classified as primary or secondary. Any gas could qualify as pollution if it reached a high enough concentration to do harm. Theoretically, that means there are dozens of different pollution gases. In practice, about ten different substances cause most concern. Heavy metals represent a class of omnipresent pollutants, with toxic potential, in some cases even at low exposure levels. They concentrate in each tropic level because of their weak mobility, so the concentration in plants is higher than in soil, in herbivore animals higher than in plants, in carnivores' tissues higher than in herbivore, the highest concentration being reached at the end of the tropic chain, at big predacious and human bodies.

Globally, one of the main contributors to emissions of atmospheric pollutants and a significant user of energy is the industrial sector (Conti et al. 2015).

The concentration of air pollutants depends not only on the quantities that are emitted from the polluting sources, but also on the ability of the atmosphere to either absorb or disperse such emissions (USEPA, 2008).

Nowadays, the shipping sector provides low-cost and reliable delivery services in the economic field (Arunachalam et al. 2015). Nevertheless, shipping-related activities have a

considerable impact on air pollution, especially in coastal areas but also globally (Buccolieri et al. 2016). The primary air pollutants are PM, VOCs, NOx, O3, SO2, and CO (Bailey and Solomon 2004). As a consequence, a wide range of options toward "greener" seaports is needed (Bailey and Solomon 2004). Some of these measures are easy to adopt such as the regulation of fuel quality (by using low-sulfur alternative fuels), the speed reduction (Lack et al. 2011), and the use of alternative transportation equipment (Lai et al. 2011).

Clean air is the basic requirement of all living organisms. In recent times, due to population growth, urban sprawl, industrial development, and vehicular boom, the quality of air is deteriorating and being polluted. Pollutants of major public health concerns include particulate matter, carbon monoxide, ozone, nitrogen dioxide, and sulfur dioxide, which pose serious threats to human health and hygiene. In the present study, prime particulate pollutants (PM_{10}, $PM_{2.5}$), and gaseous pollutants (SO_2, and NO_2) were estimated at seven stations in and around Dahej Port, Gujarat, India (Soni and Jagruti Patel, 2017).

Among particulate pollutants, particulate matter (PM) is a ubiquitous entity, and is especially a grave problem due to its higher suspension rate into the atmosphere, and adverse health effects on plants, animals, humans, and materials in the form of visibility reduction, soiling of buildings, etc. (Horaginamani and Ravichandran, 2010; Chaurasia *et al*., 2013).

The sources of air pollutants include vehicles, industries, domestic sources and natural sources. Because of the presence of high amount of air pollutants in the ambient air, the health of the population and property is getting adversely affected. In order to arrest the deterioration in air quality, Govt. of India has enacted Air (Prevention and Control of Pollution) Act in 1981. The responsibility has been further emphasized under Environment (Protection) Act, 1986. It is necessary to assess the present and anticipated air pollution through continuous air quality survey/monitoring programs. Therefore, Central Pollution Control Board had started National Ambient Air Quality Monitoring (NAAQM) Network during 1984 - 85 at national level. The programme was later renamed as National Air Quality Monitoring Programme (NAMP).

2.1 Ambient Air Quality Monitoring

As per the Environmental Monitoring Plan of Deendayal Port Authority, Air monitoring was carried out at six identified locations at Deendayal Port and two locations at Vadinar Port.

Table: 1. Ambient Air Sampling Location

Sr. No.	Name of Location	Location Code	Latitude	Longitude	Remarks
1.	Marine Bhavan	AL-1	23° 0' 26.524"N	70° 13' 22.414"E	**DPA-Kandla**
2.	Oil Jetty	AL-2	23° 1' 45.613"N	70° 13' 11.052"E	
3.	Estate Office	AL-3	23° 1' 11.273"N	70° 12' 48.657"E	
4.	Gopalpuri Hospital	AL-4	23° 4' 53.551"N	70° 8' 7.047"E	
5.	Coal Storage Area	AL-5	22° 59' 31.812"N	70° 13' 9.979"E	
6.	Tuna Port	AL-6	22° 59' 15.291"N	70° 58' 57.018"E	
7.	Signal Building	AL-7	22° 26' 26.750"N	69° 40' 22.127"E	**DPA-Vadinar**
8.	Admin Building	AL-8	22° 26' 25.223"N	69° 40' 19.358"E	

- **Air Quality Monitoring Methodology**

Air quality is measured in all the stations, for 24 hour for Total Suspended Particulate Matter (TSPM), PM_{10}, $PM_{2.5}$, SO_2, NO_2, NH_3 & Benzene and Grab-sampling for CO & CO_2 measurements. The Air samplers are operated for a period of 24 hours and after a continuous operation of 8 hours for gaseous parameters. The absorbing reagents for $SO_{2:-}$ Absorbing Reagent TCM (Potassium Tetrachloromercurate 0.04M): Mercuric Chloride, Potassium Chloride and EDTA used. For $NO_{2:-}$ Absorbing Reagent Sodium Hydroxide (NAOH): Sodium Hydroxide and Sodium Arsenite used. For NH_3 need Conc. Sulphuric Acid and Distilled water was used. By replacing 3 times the reagents per day for each parameter namely, SO_2, NO_2, NH_3. The GFA filter paper and PTFE Membrane bound filter paper are used for a period of 24 hours to obtain one sample each of TSPM, PM_{10} & $PM_{2.5}$. The AAQ samples are collected two consecutive days a week as per CPCB guidelines, from all the eight locations as mentioned in the EMP.

2.2 Results

The ambient air quality monitoring data for six stations, viz. Marine Bhavan, Oil Jetty, Port Colony, Gopalpuri Hospital, Tuna Port and Nr. Coal Storage Area for the month of August 2022 are given in Tables 2 to 7. The ambient air quality monitoring data for two stations at Vadinar (Nr. Admin Building &Nr. Signal Building) are given in Tables 8 to 9.

The Movement of heavy transport with uncovered coal transportation, raw road around ambient location may be causes fugitive dust emission from dry conditions. Particulate Matter then enters the atmosphere through the action of wind, vehicular movement, or other activities. The dust produces tends to float in air and spread all around the vicinity. Direction and speed of wind affect the dispersion of the dust particulate matter. Humidity of air also has strong effect on the spreading of particulate matter. With increasing humidity, moisture particles eventually grow in size to a point where ‘dry deposition’ occurs, reducing PM_{10} concentrations in the atmosphere.

Location 1: Marine Bhavan (AL1)

Table 2 : Results of Air Pollutant Concentration at Marine Bhavan										
Sampling Period	**Date**	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
		24hr	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL1 – 1	01.08.2022	311	204	97	6.04	5.14	18.47	16.54	3.34	5.79
					4.23		14.43		6.79	
					5.14		16.74		7.25	
AL1 – 2	04.08.2022	364	248	112	5.14	5.24	13.27	18.28	6.22	6.37
					6.65		14.43		7.83	
					3.93		27.12		5.06	
AL1 – 3	08.08.2022	414	260	125	3.17	3.75	27.12	24.62	5.41	5.18
					5.19		28.86		5.87	
					2.88		17.89		4.26	
AL1 – 4	12.08.2022	366	245	115	3.02	4.33	16.74	15.58	6.56	7.07
					5.74		14.43		7.98	
					4.23		15.58		6.68	
AL1 – 5	16.08.2022	289	195	84	5.44	4.23	17.89	19.43	2.42	4.34
					4.23		18.47		5.41	
					3.02		21.93		5.18	
AL1 - 6	20.08.2022	315	201	98	3.93	4.84	16.16	15.00	4.72	2.76
					4.84		19.62		2.42	
					5.74		9.23		1.15	
AL1 - 7	23.08.2022	365	254	109	4.84	4.33	12.12	16.35	6.68	5.22
					3.63		20.20		4.72	
					4.53		16.74		4.26	
AL1 – 8	26.08.2022	329	217	101	5.14	4.03	24.82	23.85	4.95	3.53
					3.02		27.70		2.53	
					3.93		19.04		3.11	
AL1 – 9	29.08.2022	170	106	59	3.93	4.73	19.04	19.04	7.94	6.91
					4.84		16.74		5.99	
					5.44		21.35		6.79	
Monthly Average		325	214	100		4.49		18.71		5.03
Standard Deviation		69	48	20		0.53		3.70		1.44

Table 2 : Results of Air Pollutant Concentration at Marine Bhavan					
Parameter	**Date**	**C_6H_6 [µg/m3]**	***NMHC**	**CO [mg/m3]**	**CO_2 [ppm]**
Sampling Period		**8 hr**		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**	**ppm**	**4.0 mg/m3**	**-**
AL1 – 1	01.08.2022	1.03	BQL	2.09	388
AL1 – 2	04.08.2022	1.18	BQL	1.35	1099
AL1 – 3	08.08.2022	1.02	BQL	1.6	2350
AL1 – 4	12.08.2022	1.23	BQL	1.62	1126
AL1 – 5	16.08.2022	1.02	BQL	1.63	1921
AL1 - 6	20.08.2022	1.14	BQL	1.95	383
AL1 - 7	23.08.2022	1.13	BQL	2.14	1621
AL1 - 8	26.08.2022	1.03	BQL	1.41	1036
AL1 - 9	29.08.2022	1.05	BQL	2.02	958
Monthly Average		**1.10**	**-**	**1.72**	**1241**
Standard Deviation		**0.08**	**-**	**0.30**	**694**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

At Marine Bhavan, the overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 is attributed mainly by motor vehicle emission produced from various types of automobiles (both diesel and petrol driven). Moreover, the loading and unloading of Food Grains and Timber at Jetty no. 1 and 2 also contributes to the high levels of TSPM and PM_{10}. The mean TSPM value at Marine Bhavan was 325 µg/m^3, the mean PM_{10} value was 214 µg/m^3, and PM2.5 value was 100 µg/m^3 which is above the permissible limit prescribed by NAAQS. The average values of SO_2, NO_2 and NH_3 were within the permissible limit. The average values of SO_2, NO_2 and NH_3 were 4.49 µg/ m^3, 18.71 µg/ m^3 & 5.01µg/ m^3 respectively; these values were within the permissible limit prescribed by NAAQS.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Marine Bhavan. The mean Benzene concentration was 1.12 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.80 mg/m^3, well below the permissible limit of 4.0 mg/m^3 prescribed by NAAQS.

Location 2: Oil Jetty (AL2)

Table 3 : Results of Air Pollutant Concentration at Oil Jetty										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL2 -1	01.08.2022	200	121	72	5.44	4.23	13.85	13.47	6.10	6.52
					4.23		10.97		7.83	
					3.02		15.58		5.64	
AL2 -2	04.08.2022	202	121	70	3.63	3.73	10.97	11.16	3.34	4.72
					4.23		9.81		5.29	
					3.32		12.70		5.53	
AL2 -3	08.08.2022	220	138	72	2.88	2.98	30.59	23.28	1.84	3.11
					3.46		17.31		3.11	
					2.59		21.93		4.37	
AL2 -4	12.08.2022	221	142	70	3.32	3.93	16.16	14.81	3.22	4.11
					3.93		14.43		4.83	
					4.53		13.85		4.26	
AL2 – 5	16.08.2022	206	138	67	3.32	4.03	15.58	16.93	4.37	3.53
					5.14		23.66		2.42	
					3.63		11.54		3.80	
AL2 – 6	20.08.2022	257	165	85	4.53	4.03	20.78	14.43	2.42	3.61
					3.32		8.08		3.80	
					4.23		14.43		4.60	
AL2 – 7	23.08.2022	256	163	87	2.42	2.01	21.93	18.85	4.49	4.68
					1.51		14.43		5.76	
					2.12		20.20		3.80	
AL2 -8	26.08.2022	186	126	53	2.42	2.92	14.43	16.16	2.65	3.84
					1.81		21.93		4.14	
					4.53		12.12		4.72	
AL1 – 9	29.08.2022	225	148	67	2.72	3.63	19.62	17.89	6.79	5.53
					4.53		17.31		4.49	
					3.63		16.74		5.29	
Monthly Average		219	140	71		3.48		16.13		4.26
Standard Deviation		24	16	10		0.77		3.70		1.07

Table 3 : Results of Air Pollutant Concentration at Oil Jetty

Sampling Period	Date	C_6H_6 [µg/m3]	*NMHC	CO [mg/m3]	CO_2 [ppm]
		8 hr		Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m3		4.0 mg/m3	-
AL2 -1	01.08.2022	1.1	BQL	1.88	420
AL2 -2	04.08.2022	1.09	BQL	1.35	1181
AL2 -3	08.08.2022	1	BQL	1.19	1156
AL2 -4	12.08.2022	1.04	BQL	1.19	1160
AL2 – 5	16.08.2022	1.14	BQL	1.52	2302
AL2 – 6	20.08.2022	1.01	BQL	1.99	492
AL2 -7	23.08.2022	1.03	BQL	2.17	987
AL2 -8	26.08.2022	1.11	BQL	1.28	1076
AL2 -8	29.08.2022	1.11	BQL	1.93	1261
Monthly Average		**1.07**	**-**	**1.57**	**1097**
Standard Deviation		**0.05**	**-**	**0.39**	**574**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

Oil Jetty Area, the overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 was mainly by motor vehicle emission produced from various types of vehicles at Oil Jetty Area. The mean TSPM value at Oil Jetty was 219 µg/m^3. The mean PM_{10} value was 140 µg/m^3, $PM_{2.5}$ value was 71 µg/m^3 which is above the permissible limit. The average values of SO_2, NO_2 and NH_3 were within the permissible limit prescribed by NAAQS. The mean concentration of SO_2, NO_2 and NH_3 were 3.48 µg/m^3, 16.13 µg/m^3 and 4.26 µg/m^3 respectively.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Oil Jetty. The mean Benzene concentration was 1.07 µg/m^3 which was well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.57 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 3: Kandla Colony – Estate Office (AL-3)

Table 4 : Results of Air Pollutant Concentration at Estate Office

Sampling Period	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit			100 µg/m3	60 µg/m3		80 µg/m3		80 µg/m3		400 µg/m3
AL3 – 1	01.08.2022	166	100	65	6.95	5.54	18.47	15.58	6.33	7.52
					5.74		16.74		7.83	
					3.93		11.54		8.40	
AL3 – 2	04.08.2022	181	113	66	3.02	4.03	11.54	11.93	6.45	4.18
					5.74		9.81		3.22	
					3.32		14.43		2.88	
AL3 – 3	08.08.2022	182	110	61	3.75	3.65	19.62	22.12	3.80	2.92
					4.32		26.55		3.22	
					2.88		20.20		1.73	
AL3 – 4	12.08.2022	205	128	62	3.02	4.33	19.04	16.74	5.76	4.34
					4.84		14.43		4.37	
					5.14		16.74		2.88	
AL3 – 5	16.08.2022	209	122	69	1.51	2.42	21.93	22.51	4.37	17.23
					3.02		31.16		4.72	
					2.72		14.43		42.59	
AL3 – 6	20.08.2022	227	144	77	4.23	3.53	19.04	19.04	4.60	3.72
					2.72		14.43		4.26	
					3.63		23.66		2.30	
AL3 – 7	23.08.2022	317	212	97	3.63	3.53	20.20	17.31	5.41	5.26
					3.02		16.16		5.41	
					3.93		15.58		4.95	
AL3 – 8	26.08.2022	259	159	90	3.32	3.32	15.00	15.97	5.18	3.95
					3.93		15.58		4.26	
					2.72		17.31		2.42	
AL1 – 9	29.08.2022	228	150	75	2.72	2.72	16.74	19.62	4.72	5.41
					3.32		19.04		5.41	
					2.12		23.08		6.10	
Monthly Average		219	137	74		3.79		17.65		6.14
Standard Deviation		47	34	12		0.90		3.51		4.69

Table 4 : Results of Air Pollutant Concentration at Estate Office					
Sampling Period	**Date**	**C_6H_6 [µg/m3]**	***MNHC**	**CO [mg/m3]**	**CO_2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL3 -1	01.08.2022	1.24	BQL	2.2	418
AL3 -2	04.08.2022	1.01	BQL	1.65	1758
AL3 -3	08.08.2022	1.14	BQL	1.24	2059
AL3 -4	12.08.2022	1.18	BQL	1.87	1755
AL3 – 5	16.08.2022	1.08	BQL	2.07	2277
AL3 – 6	20.08.2022	1.01	BQL	1.75	1066
AL3 – 7	23.08.2022	1.04	BQL	1.85	1802
AL3 – 8	26.08.2022	1.06	BQL	1.42	940
AL3 – 9	29.08.2022	1.17	BQL	1.75	776
Monthly Average		**1.10**	**-**	**1.76**	**1509**
Standard Deviation		**0.08**	**-**	**0.32**	**634**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, $NO_2$and NH_3 at Kandla Port Colony (Estate Office) was attributed by vehicle emission produced from trucks and heavy duty vehicles that pass through the road outside Kandla Port Colony. The mean TSPM values at Kandla port Colony were 219 µg/m^3, the mean PM_{10} value was 137 µg/m^3, and PM2.5 value was 74 µg/m^3 which is above the permissible limit prescribed by NAAQS. The average values of SO_2, NO_2 and NH_3 were 3.79 µg/m^3, 17.05 µg/m^3 and 6.14 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Kandla Port Colony. The mean Benzene concentration was 1.10 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide was 1.76 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 4: Gopalpuri Hospital (AL-4)

Table 5 : Results of Air Pollutant Concentration at Gopalpuri Hospital										
Sampling Period	**Date**	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
		24hr	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL4 -1	01.08.2022	145	97	45	5.14	4.53	10.39	8.27	4.37	3.57
					3.02		7.50		3.45	
					5.44		6.93		2.88	
AL4 -2	04.08.2022	176	119	55	4.84	4.03	5.77	9.23	2.42	3.53
					3.02		10.39		3.68	
					4.23		11.54		4.49	
AL4 -3	08.08.2022	169	104	52	4.61	3.36	6.93	8.46	1.96	2.19
					2.88		10.97		2.42	
					2.59		7.50		2.19	
AL4 -4	12.08.2022	151	99	50	1.21	1.71	9.23	9.04	3.22	2.53
					2.12		11.54		1.84	
					1.81		6.35		2.53	
AL4 – 5	16.08.2022	151	94	49	2.42	2.42	14.43	13.27	2.42	3.11
					1.81		8.08		4.03	
					3.02		17.31		2.88	
AL4 – 6	20.08.2022	175	101	59	1.51	1.81	12.70	11.73	2.42	4.07
					2.12		8.08		4.37	
					1.81		14.43		5.41	
AL4 – 7	23.08.2022	146	99	44	1.51	2.22	17.31	15.58	3.11	3.03
					2.42		13.27		3.80	
					2.72		16.16		2.19	
AL4 – 8	26.08.2022	140	89	49	1.81	2.52	10.97	10.97	3.57	4.03
					3.32		11.54		4.14	
					2.42		10.39		4.37	
AL1 – 9	29.08.2022	170	106	59	3.02	2.32	8.66	9.43	3.22	4.53
					2.12		12.12		4.72	
					1.81		7.50		5.64	
Monthly Average		158	101	51		2.83		10.82		3.26
Standard Deviation		14	8	6		1.04		2.60		0.67

Table 5 : Results of Air Pollutant Concentration at Gopalpuri Hospital					
Sampling Period	**Date**	**C_6H_6 [µg/m3]**	***NMHC**	**CO [mg/m3]**	**CO_2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL4 -1	01.08.2022	1.2	BQL	1.99	403
AL4 -2	04.08.2022	1.11	BQL	1.26	1375
AL4 -3	08.08.2022	1.06	BQL	1.23	1531
AL4 -4	12.08.2022	1.16	BQL	1.84	2314
AL4 – 5	16.08.2022	1.05	BQL	1.58	1383
AL4 – 6	20.08.2022	1	BQL	2.12	623
AL4 – 7	23.08.2022	1.1	BQL	1.61	910
AL4 – 8	26.08.2022	1.01	BQL	1.64	1324
AL4 – 9	29.08.2022	1.03	BQL	1.92	1149
Monthly Average		**1.09**	**-**	**1.66**	**1233**
Standard Deviation		**0.07**	**-**	**0.32**	**594**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 at Gopalpuri Hospital was attributed by vehicle emission produced from light motor vehicles of the colony residents. The mean TSPM values at Gopalpuri Hospital were 158 µg/m^3, the PM_{10} value was found mostly within the permissible limit but mean value was 101 µg/m^3 which is slightly exceed the permissible limit, $PM_{2.5}$ value was 51 µg/m^3 which is within the permissible limit. The average values of SO_2, NO_2 and NH_3 were 2.88 µg/m^3, 10.82 µg/m^3 and 3.26 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Gopalpuri Hospital. The mean Benzene concentration was 1.09 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon monoxide concentration was 1.66 mg/m^3 which is well below the permissible limit of 4.0 mg/m^3.

Location 5: Coal Storage Area (AL-5)

Table 6 : Results of Air Pollutant Concentration at Coal Storage Area

Sampling Period	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL6 – 1	01.08.2022	455	325	130	7.25	6.04	21.93	21.93	4.95	6.56
					6.04		23.08		6.91	
					4.84		20.78		7.83	
AL6 – 2	04.08.2022	508	352	142	6.95	5.34	19.04	18.28	7.48	7.67
					5.14		22.51		8.06	
					3.93		13.27		7.48	
AL6 – 3	08.08.2022	562	412	146	5.77	4.52	21.93	25.20	3.80	3.49
					4.32		23.08		3.22	
					3.46		30.59		3.45	
AL6 – 4	12.08.2022	529	379	136	6.04	6.04	16.16	15.97	5.87	5.76
					7.55		12.70		4.03	
					4.53		19.04		7.37	
AL6 – 5	16.08.2022	480	331	127	6.35	4.94	19.62	20.01	7.71	6.56
					4.84		17.31		6.33	
					3.63		23.08		5.64	
AL6 – 6	20.08.2022	491	354	131	6.04	4.63	15.00	16.35	7.60	7.06
					3.32		13.85		7.37	
					4.53		20.20		6.22	
AL6 – 7	23.08.2022	555	399	145	6.95	5.24	12.70	15.58	8.17	5.99
					5.14		17.89		4.37	
					3.63		16.16		5.41	
AL6 – 8	26.08.2022	439	303	122	4.23	5.24	23.08	20.97	5.18	6.06
					6.35		17.89		6.33	
					5.14		21.93		6.68	
AL1 – 9	29.08.2022	554	408	133	5.74	5.04	26.55	22.12	8.06	8.25
					6.35		23.08		7.48	
					3.02		16.74		9.21	
Monthly Average		508	363	135		5.25		19.29		6.14
Standard Deviation		45	39	8		0.57		3.37		1.24

Table 6 : Results of Air Pollutant Concentration at Coal Storage Area

Sampling Period	Date	C_6H_6 [µg/m3]	*NMHC	CO [mg/m3]	CO_2 [ppm]
		8 hr		Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m3		4.0 mg/m3	-
AL5 – 1	01.08.2022	1.03	BQL	2.08	524
AL5 – 2	04.08.2022	1.04	BQL	1.58	1040
AL5 – 3	08.08.2022	1.18	BQL	1.28	2322
AL5 – 4	12.08.2022	1.03	BQL	1.37	962
AL5 – 5	16.08.2022	1.06	BQL	1.75	1074
AL5 – 6	20.08.2022	1.14	BQL	1.66	590
AL5 – 7	23.08.2022	1.18	BQL	1.61	920
AL5 – 8	26.08.2022	1.20	BQL	1.53	854
AL5 – 9	29.08.2022	1.11	BQL	1.29	580
Monthly Average		**1.11**	**-**	**1.61**	**1036**
Standard Deviation		**0.07**	**-**	**0.24**	**557**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 at Coal Storage Area was comparatively highest among all the locations of Air Quality monitoring in Kandla Port. High values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 at this location was due to lifting of coal with grab and other coal handling processes near Berth no. 6 & 7. Moreover, the traffic was also heavy around this place for transport of coal thus emissions produced from heavy vehicles. The mean TSPM values at Coal storage were 508 µg/m^3, the mean PM_{10} value was 363 µg/m^3, the $PM_{2.5}$ value was 135 µg/m^3 which was well above the permissible limit prescribed by NAAQS. The average values of SO_2, NO_2 and NH_3 were 5.25 µg/m^3, 19.29 µg/m^3 and 6.14 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Coal Storage Area. The mean Benzene concentration was1.11 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.61 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 6: Tuna Port (AL-6)

Table 7 : Results of Air Pollutant Concentration at Tuna Port										
Sampling Period	**Date**	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
		24hr	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL5 -1	01.08.2022	104	69	34	4.53	3.42	11.54	9.62	4.49	3.57
					3.02		9.81		3.91	
					2.72		7.50		2.30	
AL5 – 2	04.08.2022	106	69	27	2.42	1.91	7.50	8.27	2.65	3.61
					1.81		9.23		3.45	
					1.51		8.08		4.72	
AL5 – 3	08.08.2022	107	64	36	2.59	2.11	6.35	10.39	3.11	2.92
					1.73		11.54		2.07	
					2.02		13.27		3.57	
AL5 – 4	12.08.2022	127	76	41	1.21	1.31	8.66	10.97	2.42	2.95
					0.91		11.54		3.57	
					1.81		12.70		2.88	
AL5 – 5	16.08.2022	102	68	32	1.81	2.82	13.27	11.73	5.76	5.45
					3.63		11.54		5.53	
					3.02		10.39		5.06	
AL5 – 6	20.08.2022	136	81	46	3.02	2.42	30.01	25.97	4.72	11.02
					2.72		20.78		15.57	
					1.51		27.12		12.76	
AL5 – 7	23.08.2022	119	71	39	3.02	2.52	14.43	12.31	4.49	4.60
					1.81		10.39		4.26	
					2.72		12.12		5.06	
AL5 – 8	26.08.2022	119	61	39	3.63	2.52	15.58	14.81	4.72	4.49
					2.12		10.97		3.80	
					1.81		17.89		4.95	
AL1 – 9	29.08.2022	143	98	39	2.42	2.22	10.39	11.16	4.49	3.41
					3.02		12.12		3.34	
					1.21		10.97		2.42	
Monthly Average		118	73	37		2.38		13.01		4.83
Standard Deviation		15	11	6		0.63		5.58		2.65

Table 7 : Results of Air Pollutant Concentration at Tuna Port					
		C_6H_6 [µg/m3]		CO [mg/m3]	CO_2 [ppm]
Sampling Period	**Date**	**8 hr**	***NMHC**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL6 -1	01.08.2022	1.19	BQL	2.24	947
AL6 – 2	04.08.2022	1	BQL	1.85	751
AL6 – 3	08.08.2022	1.09	BQL	1.18	1331
AL6 – 4	12.08.2022	1.13	BQL	2.08	777
AL6 – 5	16.08.2022	1	BQL	1.83	962
AL6 – 6	20.08.2022	1.11	BQL	1.68	1336
AL6 – 7	23.08.2022	1.19	BQL	2.05	761
AL6 – 8	26.08.2022	1.07	BQL	1.86	556
Monthly Average		**1.10**	**-**	**1.85**	**928**
Standard Deviation		**0.07**	**-**	**0.32**	**281**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The mean TSPM values at Tuna Port was 118 µg/m^3, the mean PM_{10} value was 73 µg/m^3, the mean $PM_{2.5}$ value was 37 µg/m^3 which is within the permissible limit prescribed by NAAQS. The average values of SO_2, NO_2 and NH_3 were 2.38 µg/m^3, 13.01 µg/m^3 and 4.83 µg/m^3 respectively and were all within the permissible limit prescribed by NAAQS.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Tuna Port. The mean Benzene concentration was 1.10 µg/m3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.85 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 7: Admin Building (Vadinar) (AL-7)

Table 8 : Results of Air Pollutant Concentration at Admin Building

Sampling Period	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit			100 µg/m3	60 µg/m3		80 µg/m3		80 µg/m3		400 µg/m3
AL7 -1	02.08.2022	180	111	59	3.02	5.14	10.39	16.54	6.45	5.79
					5.44		14.43		4.83	
					2.72		11.54		8.17	
AL7 -2	05.08.2022	205	127	69	3.93	5.24	13.27	18.28	9.44	6.37
					4.84		10.97		7.94	
					3.02		15.00		7.02	
AL7 -3	09.08.2022	188	120	65	4.53	3.75	16.16	24.62	6.79	5.18
					3.32		18.47		7.60	
					2.72		13.27		5.99	
AL7 -4	12.08.2022	204	123	68	5.14	4.33	10.97	15.58	8.52	7.07
					6.65		10.39		7.94	
					3.93		7.50		8.06	
AL7 -5	16.08.2022	177	119	54	3.32	4.23	11.54	19.43	6.79	4.34
					3.63		15.00		7.25	
					4.84		9.81		6.10	
AL7 -6	19.08.2022	205	130	69	3.02	4.84	10.97	15.00	9.32	2.76
					2.72		13.85		8.75	
					4.53		9.23		9.67	
AL1 -7	23.08.2022	200	125	65	3.63	4.33	8.66	16.35	5.87	5.22
					5.14		10.97		7.25	
					3.93		7.50		6.33	
AL1-8	26.08.2022	207	132	70	4.23	4.03	12.12	23.85	8.29	3.53
					2.72		14.43		6.91	
					5.44		16.16		5.99	
AL1-9	29.08.2022	194	127	65	3.32	4.73	11.54	19.04	8.63	6.91
					4.84		10.39		7.94	
					6.04		7.50		7.14	
Monthly Average		195	124	65		4.51		18.75		5.24
Standard Deviation		11	6	5		0.50		3.46		1.48

Table 8 : Results of Air Pollutant Concentration at Admin Building Vadinar					
Sampling Period	**Date**	**C_6H_6 [µg/m3]**	***NMHC**	**CO [mg/m3]**	**CO_2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL7 -1	02.08.2022	1.1	BQL	1.94	387
AL7 -2	05.08.2022	1.06	BQL	1.71	420
AL7 -3	09.08.2022	1.04	1.81	1.81	411
AL7 -4	12.08.2022	1.15	BQL	1.65	529
AL7 -5	16.08.2022	1.15	BQL	1.6	533
AL7 -6	19.08.2022	1.04	BQL	1.95	352
AL7 -7	23.08.2022	1.07	BQL	1.9	384
AL7 -8	26.08.2022	1.15	BQL	1.69	432
AL7 -9	29.08.2022	1.05	BQL	1.36	390
Monthly Average		**1.09**	**-**	**1.73**	**426**
Standard Deviation		**0.05**	**-**	**0.19**	**64**

*NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

At Admin Building, Vadinar the mean TSPM value was 195 µg/m^3, the mean PM_{10} value was 124 µg/m^3 which was exceed the permissible limit, the mean $PM_{2.5}$ value was 65 µg/m^3 which was also slightly exceed from the permissible limit. The average values of SO_2, NO_2 and NH_3 concentrations were 4.51 µg/m^3, 18.75 µg/m^3 and 5.24 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Vadinar Port. The mean Benzene concentration was 1.09 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.73 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 8: Signal Building (Vadinar) (AL-8)

Table 9 : Results of Air Pollutant Concentration at Signal Building Vadinar										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL8 -1	02.08.2022	153	98	48	3.93	5.64	14.43	14.81	5.29	7.10
					3.32		17.31		7.14	
					1.81		12.70		4.49	
AL8 -2	05.08.2022	179	114	63	2.42	4.10	10.97	27.70	5.76	5.45
					3.02		15.00		4.95	
					3.63		13.27		6.45	
AL8 -3	09.08.2022	170	111	58	4.23	3.88	15.00	16.35	8.29	6.27
					3.32		11.54		6.33	
					4.84		13.85		5.64	
AL8 -4	12.08.2022	164	106	54	2.72	4.63	9.81	17.31	5.06	4.83
					3.93		11.54		6.10	
					5.14		13.27		7.94	
AL8 -5	16.08.2022	161	107	49	3.63	3.93	16.16	19.24	4.14	4.11
					5.44		11.54		5.29	
					6.04		9.23		6.56	
AL8 -6	19.08.2022	176	116	58	3.02	4.73	12.12	13.85	8.98	4.18
					2.72		15.58		7.14	
					4.84		17.31		8.17	
AL8 -7	23.08.2022	178	115	58	6.04	4.23	15.00	23.08	6.79	3.91
					5.44		12.70		7.60	
					3.93		10.39		7.02	
AL8-8	26.08.2022	187	121	59	5.14	4.23	9.23	18.28	6.22	5.68
					3.93		11.54		7.14	
					3.02		12.12		8.06	
AL8-9	29.08.2022	218	137	76	4.23	5.44	11.54	21.35	6.79	6.79
					5.14		13.27		8.17	
					6.35		10.97		6.33	
Monthly Average		176	114	58		4.54		19.11		5.37
Standard Deviation		19	11	8		0.64		4.36		1.19

Table 9 : Results of Air Pollutant Concentration at Signal Building Vadinar					
	Date	C_6H_6 [µg/m3]	*NMHC	CO [mg/m3]	CO_2 [ppm]
Sampling Period		8 hr		Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m3		4.0 mg/m3	-
AL8 -1	02.08.2022	1.19	BQL	2.21	425
AL8 -2	05.08.2022	1.11	BQL	2.13	422
AL8 -3	09.08.2022	1.02	BQL	1.59	464
AL8 -4	12.08.2022	1.16	BQL	1.74	509
AL8 -5	16.08.2022	1.07	BQL	2.06	485
AL8 -6	19.08.2022	1.19	BQL	1.42	342
AL8 -7	23.08.2022	1.03	BQL	1.6	590
AL8 -8	26.08.2022	1.14	BQL	1.43	270
AL8 -9	29.08.2022	1.17	BQL	2.02	528
Monthly Average		1.12	-	1.80	448
Standard Deviation		0.07	-	0.31	97

* NMHC- Non- Methane Hydrocarbon
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The mean TSPM value at Signal Building Vadinar was 176 µg/m^3. The mean PM_{10} values were 114 µg/m^3 which was slightly exceed from the permissible limit, $PM_{2.5}$ value was 58 µg/m^3 which was within the permissible limit. The average values of SO2, NO_2 and NH_3 were 4.54 µg/m^3, 19.11 µg/m^3 and 5.37 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Admin Building, Vadinar Port. The mean Benzene concentration was 1.12 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.80 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Fig. No:-1 Average Ambient Air Qulaity (PM) at DPA and Vadinar Sampling Station

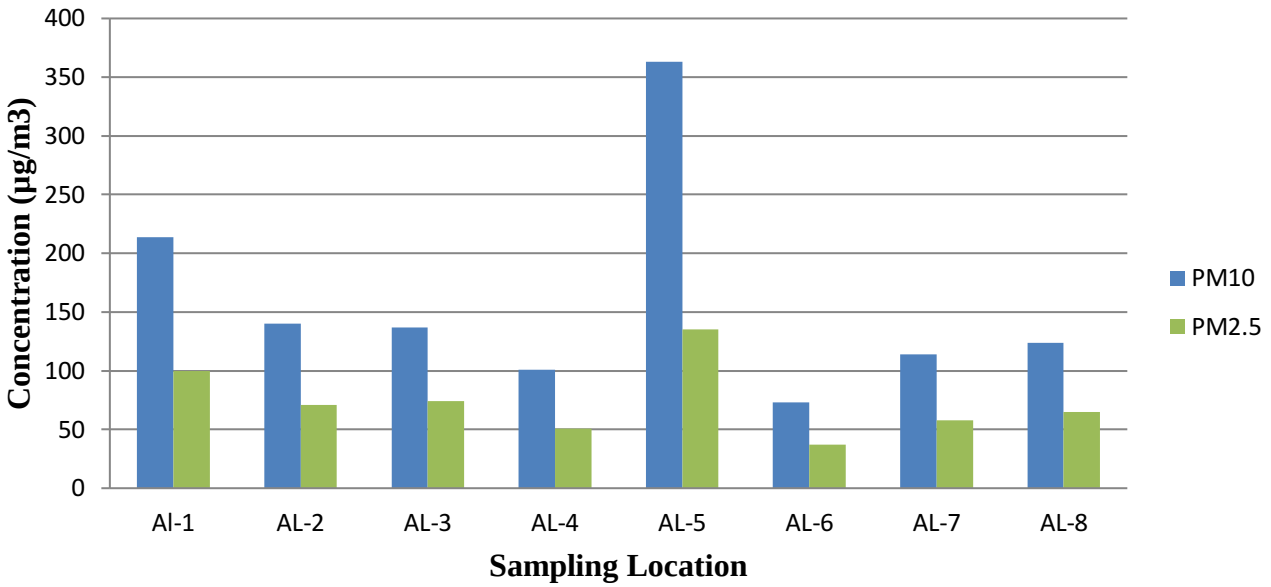


Fig. No:-2. Average ambient air qulaity (Gaseous) month of August-2022 at DPA and Vadinar sampling location

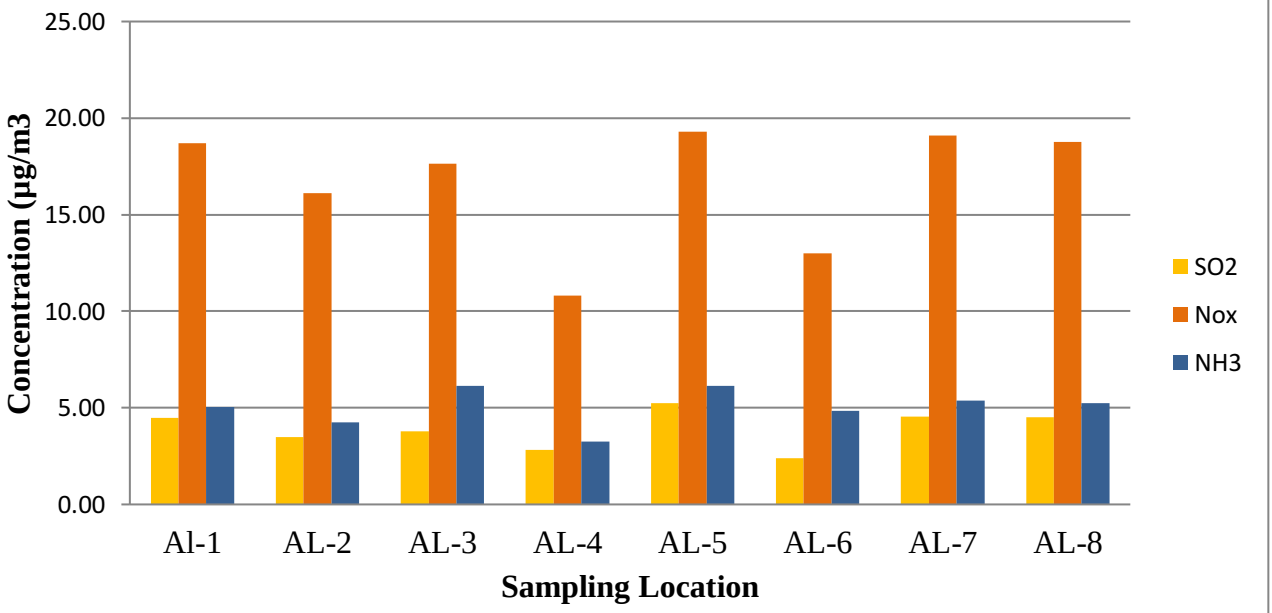


Fig. No:-3. Average ambient air qulaity (Gaseous) month of August-2022 at DPA and Vadinar sampling location

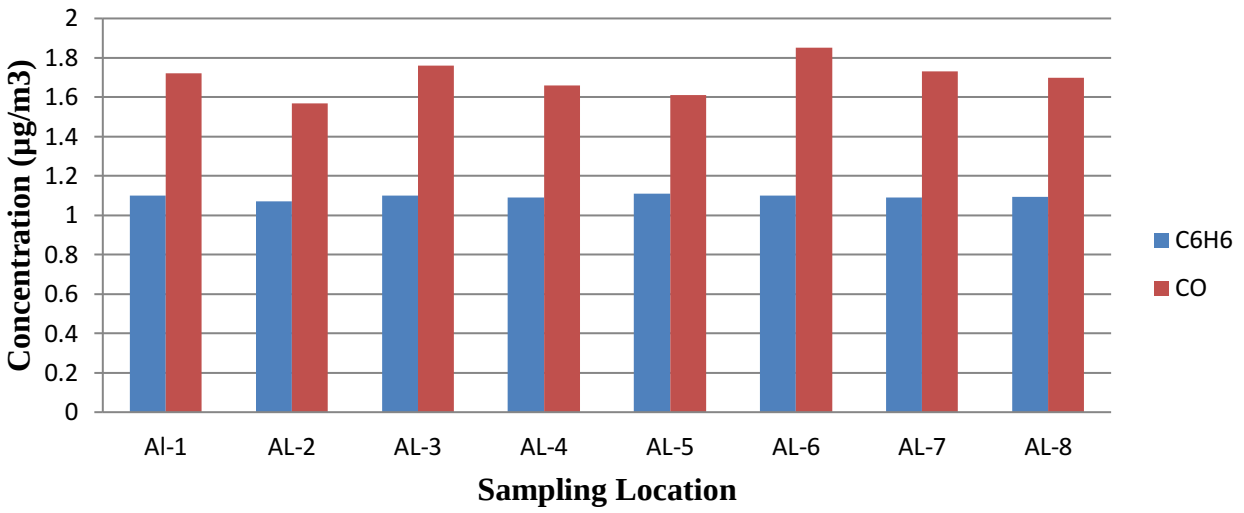
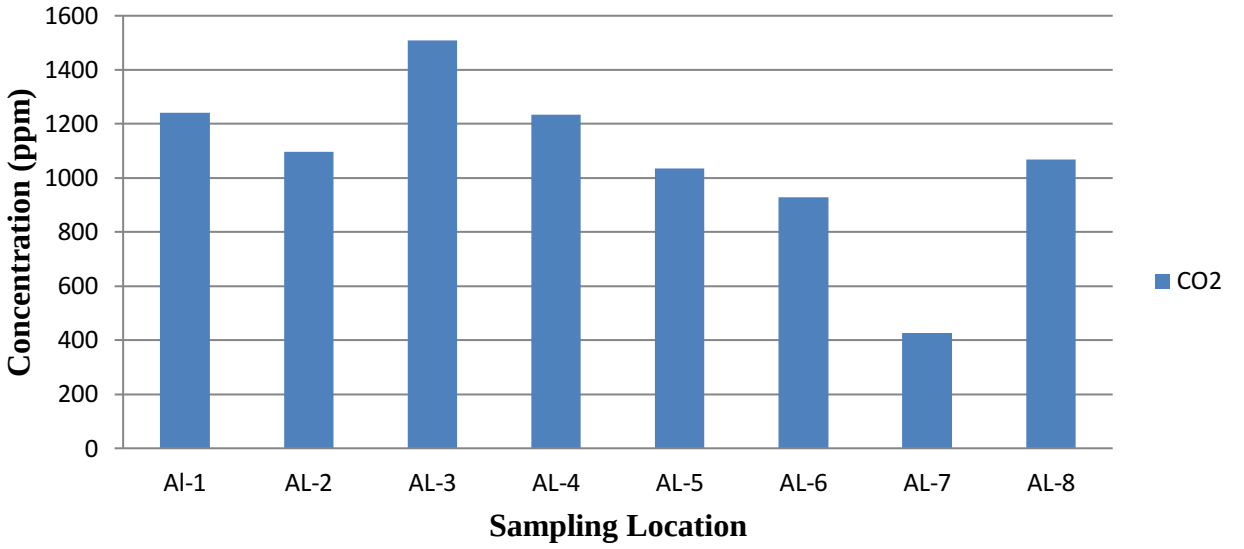


Fig. No:-4. Average ambient air qulaity (Gaseous) month of August-2022 at DPA and Vadinar sampling location



2.3 Observations and Conclusion

During the monitoring period, the overall Ambient Air Quality of the port area was found within permissible levels for various gaseous pollutants. However, Total Suspended Particulate matter as TSPM, Particulate matter as PM_{10} and $PM_{2.5}$ was found to exceed the limits at locations like Near Coal storage area, Marine Bhavan, Estate Office and Oil Jetty.

The concentration of PM_{10} was slightly exceeded at Admin building Vadinar & Signal building Vadinar while the mean concentration of $PM_{2.5}$ was found 58 µg/m3 within permissible limit at Signal Building. At Gopalpuri location concentration of PM_{10} was found mostly within the permissible limit but mean value was 101 µg/m3 which is very close the permissible limit, the average value of $PM_{2.5}$ was 51 µg/m3 which is within the permissible limit. Only at Tuna port, all parameters of ambient air quality were found within the limit.

4.1 Meteorological Data

Automatic Weather station (ID KAZPHOEN424) have been installed in Seva Sadan-3 at the Deendayal Port which records the data on Temperature (°C), Relative Humidity (%),Wind speed (kmph),Wind Direction (°), Solar radiation (w/m^2) and Rainfall mm.

Meteorological factors play an important role in environmental pollution studies particularly in pollutant transport irrespective of their entry into the environment. The wind speed and direction play a major role in dispersion of environment pollutants. Effects of pollution on receptors animate and inanimate depends on atmospheric condition.

Temperature

At Deendayal Port, the day time temperature was found range 25.7-35.4^{0}C. The average day time temperature was 29.81°C. The night time temperature was range from 25.4-32.8^{0}C. The mean night time temperature recorded was 27.57 °C.

Solar Radiation

The mean Solar Radiation in August month was 109.08 w/m^2. The maximum solar radiation was recorded 663.7 w/m^2 in 6th August, 2022 and the minimum solar radiation was recorded 0.23 w/m^2 in 5th August, 2022.

Rainfall

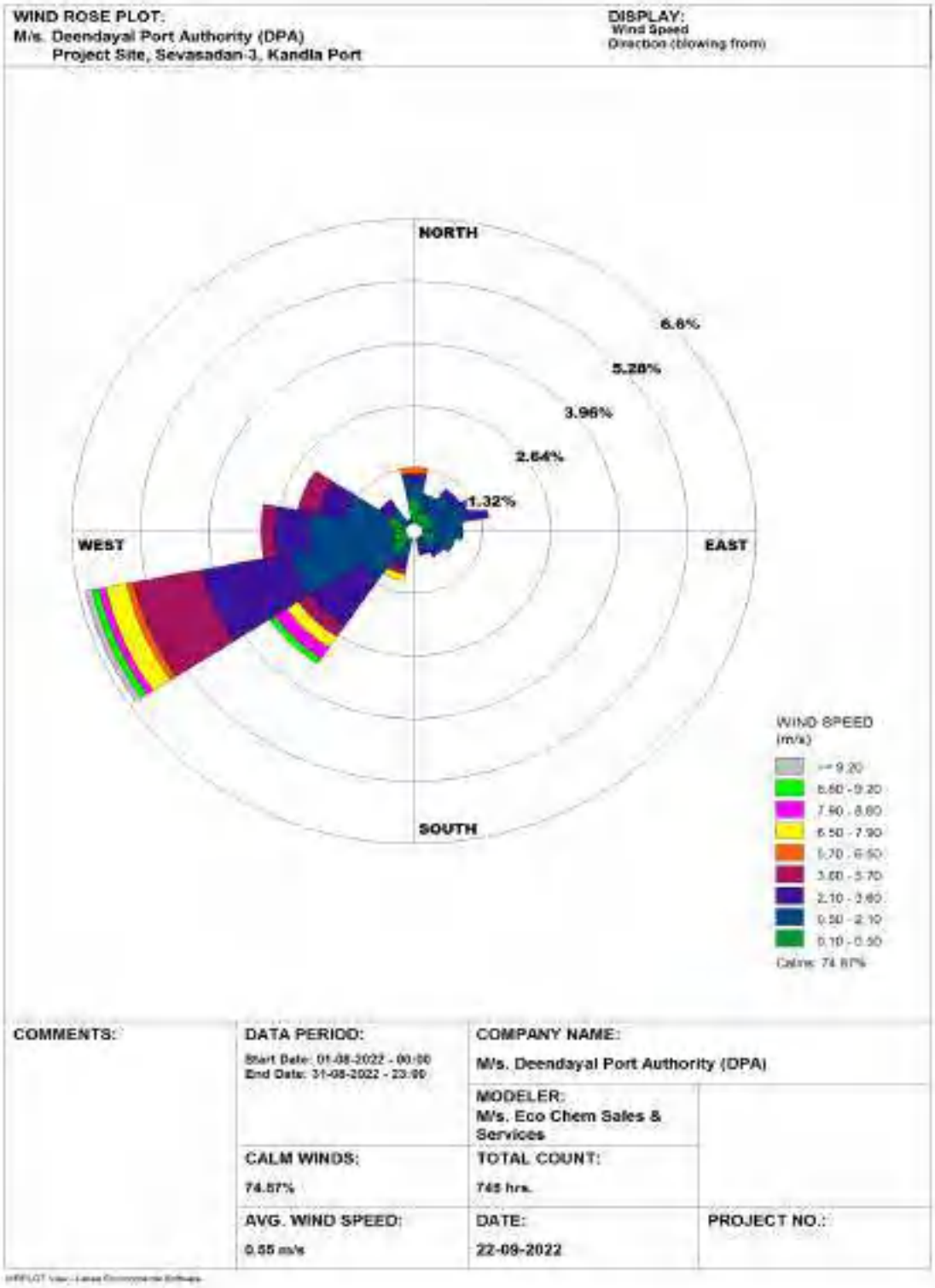
August falls in rainy season with an average rainfall was recorded 79.55 mm.

Relative Humidity

The mean Relative humidity was 85.55 % for the month of August. Maximum Relative humidity was recorded 99.0 % and minimum Relative humidity was recorded 58 %.

Wind Velocity and Wind Direction

Velocity and direction of wind have a significant role in the dispersion of air borne materials and therefore determines the air quality of the area. The average wind velocity for the entire month of August was 0.55 m/s. Maximum wind velocity was recorded 9.2 m/s. The wind direction was mostly West-South.


WIND ROSE PLOT:
M/s. Deendayal Port Authority (DPA)
Project Site, Sevasadan-3, Kandla Port
DISPLAY:
Wind Speed
Direction (blowing from)
NORTH
SOUTH
WEST
EAST
6.6%
5.28%
3.96%
2.64%
1.32%
WIND SPEED (m/s)
>= 9.20
8.60 - 9.20
7.90 - 8.60
6.50 - 7.90
5.70 - 6.50
3.60 - 5.70
2.10 - 3.60
0.50 - 2.10
0.10 - 0.50
Calms: 74.57%
COMMENTS:
DATA PERIOD:
Start Date: 01-08-2022 - 00:00
End Date: 31-08-2022 - 23:00
COMPANY NAME:
M/s. Deendayal Port Authority (DPA)
MODELER:
M/s. Eco Chem Sales & Services
CALM WINDS:
74.57%
TOTAL COUNT:
745 hrs.
AVG. WIND SPEED:
0.55 m/s
DATE:
22-09-2022
PROJECT NO.:

4.0 Drinking Water Quality Monitoring

Drinking Water Quality Monitoring was carried out at twenty stations at Kandla, Vadinar & Township Area of Deendayal Port.

Table No:-10. Drinking Water Sampling Location

Sr. No.	Name of Location	Location Code	Latitude	Longitude
1.	Nirman Building	DL-1	23° 0' 27"N	70° 13' 21"E
2.	P & C Building	DL-2	23° 0' 33"N	70° 13' 20"E
3.	North Gate	DL-3	23° 0' 26.97"N	70° 13' 21.87"E
4.	KPT-Canteen	DL-4	23° 2' 17.2674"N	70° 13'18.2814"E
5.	West Gate	DL-5	23° 59' 40.48"N	70° 12' 50.96"E
6.	Wharf Area	DL-6	22° 59' 52.2"N	70° 13' 22.95"E
7.	Sevasadan-3	DL-7	23° 0' 22.55"N	70° 13' 15.34"E
8.	Workshop	DL-8	23° 0' 33.74"N	70° 13' 20.05"E
9.	Custom Building	DL-9	23° 1' 8.70"N	70° 12' 52.0"E
10.	Kandla Colony	DL-10	23° 11' 14.9"N	70° 12' 48.4"E
11.	KPT Hospital	DL-11	23° 1' 5.02"N	70° 12' 44.38"E
12.	A.O. Building	DL-12	23° 3' 42.89"N	70° 8' 41.5"E
13.	Gopalpuri School	DL-13	23° 5' 1.03"N	70° 7' 55.42"E
14	Gopalpuri Guest House	DL-14	23° 4' 43.14"N	70° 7' 51.92"E
15.	E-Type Quarters	DL-15	23° 4' 59.90"N	70° 7' 56.72"E
16.	F-Type Quarters	DL-16	23° 4' 38.45"N	70° 8' 8.63"E
17.	Gopalpuri Hospital	DL-17	23° 4' 54.09"N	70° 8' 7.5"E
18.	Tuna Port	DL-18	23° 58' 23.06"N	70° 5' 35.6"E
19.	Vadinar Jetty	DL-19	22° 25' 51.73"N	69° 41' 36.62"E
20.	Vadinar Colony	DL-20	22° 30' 26.25"N	69° 39' 45.03"E

4.1 Drinking Water Monitoring Methodology

Samples for physico-chemical analysis were collected in 2 Carboys and samples for microbiological parameters were collected in sterilized bottles. These samples were then analyzed in laboratory for various drinking water parameters at Kandla Lab/Surat.

The Sampling was done as per IS: 3025 Part-1, analysis was done as per IS: 3025/APHA standard methods and, the analysis results compare with IS 10500:2012. The water samples were analyzed for various parameters, viz. Color , Odor, Turbidity , Conductivity , pH , Chlorides , TDS, Total Hardness, Iron , Sulphate, Salinity , DO, BOD, Na, K, Ca, Mg, F, NO_3, NO_2, Mn, Cr-6, Cu, Cd, As, Hg, Pb, Zn, Bacterial Count (CFU) .

4.2 Results

The Drinking Water Quality monitoring data for 20 stations are given in below from table No. 11 to Table No. 17

Table 11: Drinking Water Quality Monitoring Parameters for Nirman Building, P & C Building and Main Gate (North) at Kandla.

Sr. No.	Parameter	Unit	Nirman Building 1	P & C Building	Main Gate North	Acceptable Limits as per IS 10500 :2012	Permissible Limits in the absence of Alternate Source as
1	pH	-	7.3	7.4	7.5	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved	mg/l	445	456	449	500	2000
3	Turbidity	NTU	1	0	1	1	5
4	Odor	-				Agreeable	Agreeable
5	Color	-				5	15
6	Conductivity	µs/cm	941	908	892	NS*	NS*
7	BOD	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	185.41	190.42	210.47	250	1000
9	Total Hardness	mg/l	390	420	460	200	600
10	Calcium	mg/l	48.10	52.10	48.90	75	200
11	Salinity	‰	0.33	0.34	0.38	NS*	NS*
12	Mg as Mg	mg/l	65.61	70.47	82.134	30	100
13	Fluorides as F	mg/l	0.25	0.39	0.31	1	1.5
14	Sulphate as SO_4	mg/l	25.18	22.87	18.94	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	2.08	1.21	6.04	45	No Relaxation
17	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
18	Sodium as Na	mg/l	107.82	107.29	110.44	NS*	NS*
19	Potassium as K	mg/l	3.61	3.55	3.47	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe- 0.009 mg/l, Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu- 0.004 mg/l, Cd- 0.003 mg/l, As- 0.003mg/l, Hg- 0.001 mg/l, Pb- 0.006mg/l, Zinc- 0.021 mg/l).

Table 12: Drinking Water Quality Monitoring Parameters for Canteen, West Gate – I & Wharf Area at Kandla

Sr. No.	Parameter	Unit	Canteen	West Gate – I	Wharf Area	Acceptable Limits as per IS	Permissible Limits in the absence of Alternate Source as
1	pH	-	7.3	7.4	7.2	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	470	452	466	500	2000
3	Turbidity	NTU	1	0	1	1	5
4	Odor	-				Agreeable	Agreeable
5	Color	-				5	15
6	Conductivity	µs/cm	936	904	933	NS*	NS*
7	BOD	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	215.48	195.43	150.33	250	1000
9	Total Hardness	mg/l	500	420	470	75	600
10	Calcium	mg/l	55.31	58.52	49.70	30	200
11	Salinity	‰	0.39	0.35	0.27	NS*	NS*
12	Mg as Mg	mg/l	87.966	66.582	84.078	0.3	100
13	Fluorides as F	mg/l	0.33	0.24	0.35	1	1.5
14	Sulphate as SO_4	mg/l	30.03	29.80	18.94	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	4.16	2.55	6.17	45	No Relaxation
17	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
18	Sodium as Na	mg/l	113.91	109.93	111.24	NS*	NS*
19	Potassium as K	mg/l	5.02	3.37	5.06	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 13: Drinking Water Quality Monitoring Parameters for Sewa sadan–3, Workshop I and Custom Building at Kandla

Sr. No.	Parameter	Unit	Sewa Sadan – 3	Workshop	Custom Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.3	7.4	7.6	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	458	454	374	500	2000
3	Turbidity	NTU	1	1	0	1	5
4	Odor	-				Agreeable	Agreeable
5	Color	-				5	15
6	Conductivity	µs/cm	915	908	747	NS*	NS*
7	BOD	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	176.39	185.41	180.40	250	1000
9	Total Hardness	mg/l	490	390	420	200	600
10	Calcium	mg/l	44.09	72.14	68.14	75	200
11	Salinity	‰	0.32	0.33	0.33	NS*	NS*
12	Mg as Mg	mg/l	92.34	51.03	60.75	30	100
13	Fluorides as F	mg/l	0.27	0.28	0.23	1	1.5
14	Sulphate as SO_4	mg/l	26.80	22.18	35.12	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	3.49	1.28	1.34	45	100
17	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	1.0
18	Sodium as Na	mg/l	110.08	108.70	93.00	NS*	NS*
19	Potassium as K	mg/l	3.45	3.34	3.22	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 14: Drinking Water Quality Monitoring Parameters for Port Colony Kandla, Hospital Kandla and A.O. Building at Gandhidham.

Sr. No.	Parameter	Unit	Port Colony Kandla	Hospital Kandla	A.O. Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 :
1	pH	-	7.5	7.2	7.3	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	454	400	411	500	2000
3	Turbidity	NTU	0	1	1	1	5
4	Odour	-				Agreeable	Agreeable
5	Color	-				5	15
6	Conductivity	µs/cm	911	800	823	NS*	NS*
7	BOD	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	195.43	180.40	160.36	250	1000
9	Total Hardness	mg/l	460	380	460	200	600
10	Calcium	mg/l	64.13	72.14	64.13	75	200
11	Salinity	‰	0.35	0.33	0.29	NS*	NS*
12	Mg as Mg	mg/l	72.9	48.6	72.9	30	100
13	Fluorides as F	mg/l	0.27	0.27	0.38	1	1.5
14	Sulphate as SO_4	mg/l	24.49	32.81	41.58	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	1.68	4.09	0.40	45	100
17	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	1.0
18	Sodium as Na	mg/l	110.12	102.64	104.59	NS*	NS*
19	Potassium as K	mg/l	3.33	3.46	3.20	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified,

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 15: Drinking Water Quality Monitoring Parameters for School Gopalpuri, Guest House) and E - Type Quarter at Gopalpuri, Gandhidham

Sr. No.	Parameter	Unit	Gopalpuri School	Guest House	E - Type Quarter	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.5	7.6	7.4	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	407	420	459	500	2000
3	Turbidity	NTU	1	0	1	1	5
4	Odor	-				Agreeable	Agreeable
5	Color	-				5	15
6	Conductivity	µs/cm	814	846	908	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	200.45	160.36	190.42	250	1000
9	Total Hardness	mg/l	480	430	370	200	600
10	Calcium	mg/l	44.09	52.10	40.08	75	200
11	Salinity	‰	0.36	0.29	0.34	NS*	NS*
12	Mg as Mg	mg/l	89.91	72.9	65.61	30	100
13	Fluorides as F	mg/l	0.25	0.25	0.11	1	1.5
14	Sulphate as SO_4	mg/l	26.11	22.64	11.09	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	1.48	1.28	0.60	45	100
17	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	1.0
18	Sodium as Na	mg/l	100.96	104.36	106.73	NS*	NS*
19	Potassium as K	mg/l	3.27	3.08	3.30	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100 ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 16: Drinking Water Quality Monitoring Parameters for F-Type Quarter, Hospital Gopalpuri and Tuna Port.

Sr. No.	Parameter	Unit	F - Type Quarter	Hospital Gopalpuri	Tuna Port	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.2	7.3	7.4	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	490	404	1473	500	2000
3	Turbidity	NTU	0	1	0	1	5
4	Odor	-				Agreeable	Agreeable
5	Color	-				5	15
6	Conductivity	µs/cm	880	805	2940.0	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	160.36	155.35	701.56	250	1000
9	Total Hardness	mg/l	400	460	560	200	600
10	Calcium	mg/l	44.09	72.14	112.22	75	200
11	Salinity	‰	0.29	0.28	1.27	NS*	NS*
12	Mg as Mg	mg/l	70.47	68.04	68.04	30	100
13	Fluorides as F	mg/l	0.27	0.30	2.70	1	1.5
14	Sulphate as SO_4	mg/l	45.28	22.87	136.50	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	1.41	1.74	6.71	45	100
17	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	1.0
18	Sodium as Na	mg/l	107.30	102.85	265.00	NS*	NS*
19	Potassium as K	mg/l	3.09	3.11	4.48	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified, BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6-0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 17: Drinking Water Quality Monitoring Parameters for Vadinar Jetty and Port Colony at Vadinar.

Sr. No.	Parameter	Unit	Vadinar Jetty	Port Colony Vadinar	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.5	7.6	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	460	456	500	2000
3	Turbidity	NTU	1.00	1.00	1	5
4	Odor	-			Agreeable	Agreeable
5	Color	-			5	15
6	Conductivity	µs/cm	780	772	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	140.31	110.25	250	1000
9	Total Hardness	mg/l	420	380	200	600
10	Calcium	mg/l	84.17	72.14	75	200
11	Salinity	‰	0.25	0.20	NS*	NS*
12	Mg as Mg	mg/l	51.03	48.60	30	100
13	Fluorides as F	mg/l	0.28	0.22	1	1.5
14	Sulphate as SO_4	mg/l	63.40	51.20	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	1.82	0.72	45	100
17	Iron as Fe	mg/l	BQL	BQL	0.3	1.0
18	Sodium as Na	mg/l	55.6	52.2	NS*	NS*
19	Potassium as K	mg/l	2.39	2.11	NS*	NS*
20	Manganese	mg/l	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

4.3 Results & Discussion

The colour of all drinking water samples was found Colourless and odour of the samples also agreeable. All parameters were found within the specified limit as per the Drinking water Standard.

pH

The pH is measure of the intensity of acidity or alkalinity and the concentration of hydrogen ion in water. The pH values for drinking water samples were ranges from 7.20-7.60 and mean value was 7.38. All the sampling points showed pH values within the prescribed limit by Indian Standards.

Total Dissolved Solids (TDS)

TDS values in the studied area varied between 374-490 mg/l. The average TDS value was found 439 mg/l. The TDS values were within the permissible limit at all sampling location prescribed limit by Indian standards.

Conductivity

Electrical Conductivity is the ability of a solution to transfer (conduct) electric current. Conductivity is used to measure the concentration of dissolved solids which have been ionized in a polar solution such as water. The conductivity in the samples collected during the month of August ranged from 747-941 µs/cm and mean value was 874.76 µs/cm.

BOD

BOD value in the studied area was found Below Quantification Limit (2.0 mg/l). IS 10500:2012 does not show any standard values for BOD in drinking water.

Chlorides

Excessive chloride concentration increase rates of corrosion of metals in the distribution system. This can lead to increased concentration of metals in the supply. Chloride value in the studied area varied between 150.33– 215.48 mg/l and mean value was 181.93 mg/l. The Chloride was found within the Permissible limit of the Drinking Water Standard.

Calcium

Calcium value in the studied area varied between 40.08–72.14 mg/l and mean was 55.88 mg/l. The Calcium values were found to be within the Permissible limit of the Drinking Water Standard. If calcium is present beyond the maximum acceptable limit, it causes incrustation of pipes.

Magnesium

Magnesium value in the studied area varied between 48.60 – 92.34 mg/l and mean value was 71.90 mg/l. All the locations had Magnesium within the prescribed limits of 30-100 mg/L.

Total Hardness

Hardness value in the studied area varied between 370- 500 mg/l and mean was 434.29 mg/l. The values of total hardness were found within the Permissible limit of the Drinking Water Standard (200-600 mg/L).

Iron

Iron value in the studied area was found Below Quantification Limit (0.009 mg/l) and hence well below the permissible limit as per Indian Standards is 0.3 mg/L. The excess amount of iron causes slight toxicity; gives stringent taste to water.

Fluoride

Fluoride value in the studied area varied between 0.11 – 0.39 mg/l and mean was 0.29 mg/l. The Fluoride values were well below the permissible limit as per Indian Standards is 1.0-1.5 mg/L. Moderate amounts lead to dental effects, but long-term ingestion of large amounts can lead to potentially severe skeletal problems.

Sulphates

Sulphate value in the studied area varied between 11.09 – 45.28 mg/l and mean was 26.87 mg/l. All the sampling points showed sulphate values within the prescribed limits by Indian Standards (200-400 mg/L). Sulphate content in drinking water exceeding the 400 mg/L imparts bitter taste.

Nitrites (NO_2) and Nitrates (NO_3)

Nitrite values in all the water samples were found Below Quantification Limit (0.1 mg/l). There were no specified standard values for Nitrites in Drinking water. The minimum Nitrate value in drinking water of DPA was ranges from 0.40-6.17 mg/l which was well within the permissible limit of the Drinking water Standard.

Salinity

Salinity in drinking water in the present samples collected ranged from 0.27 to 0.39 ‰. There are no prescribed Indian standards for salinity in Drinking water**.**

Sodium and Potassium Salts

Sodium values in the samples collected ranged from 93.00- 113.91 mg/l while average was 106.59 mg/l and Potassium salts ranged from 3.08 to 5.06 mg/l while average was 3.53 mg/l. There are no prescribed limits of Sodium and Potassium in Indian standards for Drinking water**.**

Heavy Metals in Drinking Water

In the present study period drinking water samples were analyzed for Mn, Cr, Cu, Cd, As, Hg, Pb and Zn. All these heavy metals were well Below the Quantification limits prescribed by the Indian Standards Similar values observed by Mistry et al., 2019.

Bacteriological Study

Analysis of the bacteriological parameter (E-coli and total coliform) at all location shows that Bacteria were not detectable. This shows that drinking water samples were safe for human consumption as per tested parameters.

4.4 Conclusions

These results were compared with acceptable limits as prescribed in IS 10500:2012 – Drinking Water Specification. It was seen from the analysis data that during the study period the water was safe for human consumption as per analyzed parameters only at all drinking water monitoring stations.

5.0 Noise Level Monitoring

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. Noise Monitoring was done at 13 stations at Kandla, Vadinar and Township area.

5.1 Method of Monitoring

Sampling was done at all stations for 24 hour period. Data was recorded using automated sound level meter. The intensity of sound was measured in sound pressure level (SPL) and common unit of measurement is decibel (dB).

5.2 Results

Table 18: Noise Monitoring data for ten locations of Deendayal Port and three locations of Vadinar Port

Sr. No.	Location	Day Time Average Noise Level (SPL) in dB(A)	Night Time Average Noise Level (SPL) in dB(A)
	Sampling Time	**6:00 am to 10:00 PM**	**10:00PM to 6:00 AM**
1	Marine Bhavan	73.6	68.4
2	Nirman Building 1	70.0	68.0
3	Tuna Port	68.9	67.5
4	Main Gate North	71.5	68.3
5	West Gate I	69.3	65.1
6	Canteen Area	67.1	62.3
7	Main Road	74.8	69.5
8	ATM Building	73.2	67.8
9	Wharf Area /Jetty Area	70.1	68.1
10	Port & Custom Office	69.7	63.2
Vadinar Port			
11	Entrance Gate of Vadinar Port	58.0	57.1
12	Nr. Port Colony, Vadinar	64.9	44.7
13	Nr. Vadinar Jetty	61.0	57.4

5.3 Conclusions

Transportation systems are the main source of noise pollution in urban areas. Construction of buildings, highways, and roads cause a lot of noise, due to the usage of air compressors, bulldozers, loaders, dump trucks, and pavement breakers. Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships.

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. The Day Time Noise Level (SPL) in all 10 locations at Deendayal Port ranged from 67.1 dB(A) to 74.8 dB(A) while at Vadinar port 3 location ranged from 58.0 dB(A) to 64.9 dB(A) which was within the permissible limits of 75 dB(A) for the industrial area for the daytime. The Night Time Average Noise Level (SPL) in all locations of Deendayal Port ranged from 62.3 dB to 69.5 dB(A) while at Vadinar port which was within the permissible limits of 70 dB(A) for the industrial area for the night time.

6.0 Soil Monitoring

Sampling and analysis of soil samples were undertaken at six locations within the study area (Deendayal Port and Vadinar Port) as a part of EMP. The soil sampling locations are initially decided based on the locations as provided in the tender document of the Deendayal Port.

Table No.:-19. Soil Sampling Location

Sr. No.	Name of Location	Location Code	Latitude	Longitude	Remarks
1.	Tuna Port	SL-1	22° 58' 10.18"N	70° 6' 3.7"E	Near main gate of Port
2.	IFFCO Plant	SL-2	23° 26' 8.37"N	70° 13' 4.4"E	10 m away from main gate
3.	Khori creek	SL-3	22° 58' 10.18"N	70° 6' 3.7"E	Sand from creek after tide
4.	Nakti Creek	SL-4	23° 2' 1.10"N	70° 9' 33.6"E	
5.	DPA admin site	SL-5	22° 26' 30.9"N	69° 40' 37.03"E	Vadinar
6.	DPA colony	SL-6	22° 23' 57.09"N	69° 42' 49.42"E	

6.1 Methodology

The soil samples were collected in the month of August 2022. The samples collected from the all locations are homogeneous representative of each location. At random locations were identified at each location and soil was dug from 30 cm below the surface. It was uniformly mixed before homogenizing the soil samples. The samples were filled in polythene bags, labeled in the field with number and site name and sent to laboratory for analysis.

6.2 Results

Table-20: Chemical Characteristics of Soil in the Study Area for Tuna port, IFFCO, Khori Creek, Nakti Creek, DPA admin site, DPA colony.

Sr. No.	Parameter	Unit	Station Name					
			SL1	SL2	SL3	SL4	SL5	SL6
			Tuna Port	IFFCO Plant	Khori Creek	Nakti Creek	DPA Admin Site	DPA Colony
			Near main gate of Port	10 m away from main gate	Sand from creek after tide		Vadinar	
1	Texture		Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	pH	-	7.50	7.90	7.90	8.00	7.6	7.40
3	Electrical Conductivity	µs/cm	15,330.00	2,000.00	6,490.00	16,000.0	635.0	590.0
4	Moisture	%	15.00	3.00	16.00	14.00	6.00	7.00
5	Total Organic	%	0.28	0.16	0.40	0.70	0.42	0.28
6	Alkalinity	mg/kg	500.00	600.00	500.00	700.00	300.00	400.00
7	Total Nitrogen	%	0.02	0.01	0.03	0.06	0.04	0.02
8	Chloride	mg/kg	2,730.0	1,067.0	2,078.0	2,419.0	443.0	265.0
9	Sulphate	mg/kg	1,053.00	520.00	1,500.00	536.00	45.0	48.0
10	Phosphorus	mg/kg	4.20	3.10	4.80	2.30	BQL	BQL
11	Potassium	mg/kg	145.00	78.00	100.00	207.00	26.00	37.00
12	Sodium	mg/kg	2,104.00	1,224.00	1,900.00	1,185.00	91.00	207.00
13	Calcium	mg/kg	2,765.00	1,783.00	2,104.00	2,044.00	1,252.00	1,617.00
14	Copper as Cu	mg/kg	23.40	108.40	22.70	22.60	49.90	44.00
15	Lead as Pb	mg/kg	7.30	BQL	11.70	15.60	BQL	BQL
16	Nickel as Ni	mg/kg	31.30	23.00	23.00	13.70	24.60	22.90
17	Zinc as Zn	mg/kg	45.60	47.40	48.70	51.80	32.80	28.60
18	Cadmium as Cd	mg/kg	BQL	BQL	BQL	BQL	1.1	BQL

BQL- Below Quantification Limit, (TN: 0.001%, Cd: 1.0mg/kg)

6.3 Discussion

- The data shows that value of pH ranges from 7.4 at DPA Colony (Vadinar) to 8.0 at (Nakti Creek) at Deendayal Port. The average value was 7.72 that all soil samples were neutral to slight basic. Nakti Creek sample showed maximum conductivity of 16000 µs/cm and minimum was 590 µs/cm while mean was 638 µs/c.
- Total organic Carbon ranged from 0.16 % to 0.70 % and mean was 0.37 %.
- The concentration of Phosphorus and Potassium in the soil samples varies from 2.30 mg/kg at Nakti Creek to 4.8 mg/kg at Khori Creek and 26 mg at DPA Admin Site (Vadinar) to 207 mg/kg at Nakti Creek and mean was 98.83 mg/kg. The concentration of Phosphorous was found BQL at Vadinar and DPA Kandala phosphorus values were ranged from 3.1-4.8.

These differences in NPK in soil at different locations are due to the dissimilar nature of soil at each of the locations. Samples SL3 & SL4 (Khori Creek & Nakti Creek) were coastal soil; where as other locations are inland locations and have different chemical properties.

Heavy Metals in the Soil

Traces of Copper, Lead, Nickel and Zinc were observed in the soil samples collected from all the four locations of Deendayal Port and two locations of Vadinar Port. Cadmium metal was below detection limit in the Soil.

7.4 Conclusion

The soils of Deendayal Port and Vadinar Port appears to be neutral to basic with varying levels of Chloride, Sulphate, NPK and Calcium. As the nature of soil at different locations are different with respect to its proximity to the sea, the samples showed high degree of variations in their chemical properties.

7.0 Sewage Treatment Plant Monitoring

This involves safe collection of waste water (spent/used water) from wash areas, bathroom, industrial units, etc., waste from toilets of various buildings and its conveyance to the treatment plant and final disposal in conformity with the requirement and guidelines of State Pollution Control Board and other statutory bodies.

7.1 Methodology for STP Monitoring

To monitor the working efficiency of Sewage Treatment Plant (STP), STP Inlet and Outlet Samples were collected once a week. Locations selected are namely Gopalpuri Township, Deendayal Port and Vadinar. Samples were collected in 1 lit. Carboys and were analyzed in laboratory for various parameters.

Table No. 21. Sewage Treatment Plant

Sr. No.	Location of STP	Types of Treatment	STP Capacity	Treated water Utilization
1.	Gopalpuri Township	MBBR	450 KLD	Plantation and Gardening
2.	Deendayal Port, Kandla	MBBR	600 KLD	Discharge to marine through pipeline, Plantation, Gardening
3.	Vadinar Port Colony	MBBR	1.5 MLD	Plantation and Gardening

7.2 Results

Table 22: Sewage Water Monitoring at Kandla STP (1st Week)

Date of Sampling	02.08.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.48	7.31	6.5 - 8.5
2	Total Suspended Solids	mg/l	100	47.6	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	91	50	100
5	BOD @ 27 °C	mg/l	28.0	14.0	30
Aeration Tank					
6	MLSS	mg/l	10.0		
7	MLVSS	%	87.0		

Table 23: Sewage Water Monitoring at Kandla STP (2nd Week)

Date of Sampling	08.08.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.51	7.38	6.5 - 8.5
2	Total Suspended Solids	mg/l	120.2	48.9	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	111	40	100
5	BOD @ 27 °C	mg/l	33.0	11.0	30
Aeration Tank					
6	MLSS	mg/l	12.0		
7	MLVSS	%	89.0		

Table 24: Sewage Water Monitoring at Kandla STP (3rd Week)

Date of Sampling	16.08.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.39	7.21	6.5 - 8.5
2	Total Suspended Solids	mg/l	129.8	49.9	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	110	50	100
5	BOD @ 27 °C	mg/l	34.0	16.0	30
Aeration Tank					
6	MLSS	mg/l	10.0		
7	MLVSS	%	85.0		

Table 25: Sewage Water Monitoring at Kandla STP (4th Week)

Date of Sampling	23.08.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.54	7.32	6.5 - 8.5
2	Total Suspended Solids	mg/l	104	43.6	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	111	70	100
5	BOD @ 27 °C	mg/l	35.0	21.0	30
Aeration Tank					
6	MLSS	mg/l	14.0		
7	MLVSS	%	88.0		

Table 26: Sewage Water Monitoring at Gopalpuri STP (1st Week)

Date of Sampling	02.08.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Gopalpuri STP I/L	Gopalpuri STP O/L	
1	pH	-	7.53	7.28	6.5 - 8.5
2	Total Suspended Solids	mg/l	87	57.7	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	70	40	100
5	BOD @ 27 °C	mg/l	12.0	6.0	30
Aeration Tank					
6	MLSS	mg/l	14.0		
7	MLVSS	%	77.0		

Table 27: Sewage Water Monitoring at Gopalpuri STP (2nd Week)

Date of Sampling	06.08.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Gopalpuri STP I/L	Gopalpuri STP O/L	
1	pH	-	7.48	7.21	6.5 - 8.5
2	Total Suspended Solids	mg/l	109.6	34.4	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	92.0	30.0	100
5	BOD @ 27 °C	mg/l	26.0	8.0	30
Aeration Tank					
6	MLSS	mg/l	21.0		
7	MLVSS	%	80.0		

Table 28: Sewage Water Monitoring at Gopalpuri STP (3rd Week)

Date of Sampling	16.08.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Gopalpuri STP I/L	Gopalpuri STP O/L	
1	pH	-	7.58	7.41	6.5 - 8.5
2	Total Suspended Solids	mg/l	119.6	38.7	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	90	30	100
5	BOD @ 27 °C	mg/l	27.0	10.0	30
Aeration Tank					
6	MLSS	mg/l	11.0		
7	MLVSS	%	82.0		

Table 29: Sewage Water Monitoring at Gopalpuri STP (4th Week)

Date of Sampling	23.08.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Gopalpuri STP I/L	Gopalpuri STP O/L	
1	pH	-	7.49	7.28	6.5 - 8.5
2	Total Suspended Solids	mg/l	99.4	38.5	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	91	40	100
5	BOD @ 27 °C	mg/l	29.0	11.0	30
Aeration Tank					
6	MLSS	mg/l	12.0		
7	MLVSS	%	90.0		

Table 30: Sewage Water Monitoring at Vadinar STP (1st Week)

Date of Sampling	02.08.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar O/L	
1	pH	-	7.49	7.32	6.5 - 8.5
2	Total Suspended Solids	mg/l	83.3	47.8	100
3	Residual Chlorine	mg/		<0.5	-
4	COD	mg/l	90.0	30	100
5	BOD @ 27 °C	mg/l	30.0	10.0	30

Table 31: Sewage Water Monitoring at Vadinar STP (2nd Week)

Date of Sampling	06.08.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar O/L	
1	pH	-	7.58	7.39	6.5 - 8.5
2	Total Suspended Solids	mg/l	82.8	53.8	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	88	40	100
5	BOD @ 27 °C	mg/l	26.0	12.0	30

Table 32: Sewage Water Monitoring at Vadinar STP (3rd Week)

Date of Sampling	16.08.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar O/L	
1	pH	-	7.68	7.45	6.5 - 8.5
2	Total Suspended Solids	mg/l	99.7	42.4	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	130	70	100
5	BOD @ 27 °C	mg/l	39.0	22.0	30

Table 33: Sewage Water Monitoring at Vadinar STP (4th Week)

Date of Sampling	23.08.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar O/L	
1	pH	-	7.49	7.37	6.5 - 8.5
2	Total Suspended Solids	mg/l	107.9	53.6	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	108	68	100
5	BOD @ 27 °C	mg/l	32.0	20.0	30

7.3 Conclusions:

The GPCB specification for pH, TSS, Residual Chlorine, COD and BOD for STP outlet were 6.5 to 8.5, 100 mg/l, 0.5 mg/l, 100 mg/l and 30 mg/l respectively. The outlet values for pH were ranges from 7.21-7.41, 7.21-7.38, and 7.32-7.45 at Gopalpuri, DPA and Vadinar respectively. The Total Suspended Solids values were 34.4-57.7 mg/l, 43.6-49.9 mg/l, and 42.4-53.8 mg/l at Gopalpuri, DPA and Vadinar respectively. The COD values were ranges from 30-40 mg/l, 11-21 mg/l, and 42.4-53.8 at Gopalpuri, DPA and Vadinar respectively. The BOD values were ranges from 6-11 mg/l, 11-21 mg/l, and 10-22 mg/l at Gopalpuri, DPA and Vadinar respectively. At all sampling locations Residual Chlorine were found below detectable limit. All parameters for STP outlet are within limit.

8.0 Marine Water Monitoring

Marine Water Quality

The Forty Second Amendment to the Constitution in 1976 underscored the importance of 'green thinking'. Article 48A enjoins the state to protect and improve the environment and safeguard the forests and wildlife in the country. Further, Article 51A (g) states that the "fundamental duty of every citizen is to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures".

Policy Statement for Abatement of Pollution (1992) has suggested developing relevant legislation and regulation, fiscal incentives, voluntary agreements and educational programs and information campaigns. It emphasizes the need for integration by incorporating environmental considerations into decision making at all levels by adopting frameworks namely, pollution prevention at source, application of best practicable solution, ensure polluter pays for control of pollution, focus on heavily polluted areas and river stretches and involve public in decision-making. The National Conservation Strategy and Policy Statement on Environment and Development, (1992) aimed at "integrating environmental concerns with developmental imperatives to meet the challenges by redirecting the thrust of our developmental process so that the basic needs of our people could be fulfilled by making judicious and sustainable use of natural resources." The priorities mentioned in this policy document include the sustainable use of land and water resources, prevention and control of pollution and preservation of biodiversity.

The National Water Policy, (2002) contains provisions for developing, conserving, sustainable utilizing and managing this important water resources and need to be governed by national perspectives.

Sampling Stations

The monitoring of marine environment for the study of biological and ecological parameters was carried out on 05th & 06th August-2022 in harbor regions of DPA & Vadinar during Neap tide period of New moon phase of Lunar Cycle. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 12th & 16th August-2022 in harbor regions of DPA & Vadinar during Spring tide period first quarter of Lunar Cycle.

Plankton samples from sub surface layer was collected both during high tide period and low tide period from 3 water quality monitoring stations of DPA harbor area and two stations in Nakti creek and one station in Khori creek. The same sampling schedule was repeated during consecutive spring tide and neap tide in same month. Plankton samples from sub surface layer was collected both during high tide period and low tide period from 1 water quality monitoring stations near Vadinar jetty area during spring tide and neap tide in this month. Collected water samples were processed for estimation

of Chlorophyll- a, Pheophytin- a, qualitative & quantitative evaluation of phytoplankton, qualitative & quantitative evaluation zooplanktons (density and their population).

Sampling Locations

Offshore monitoring requirement	Number of locations
Offshore Installations	3 in Kandla creek 2 in Nakti creek 1 in Khori creek 1 near Vadinar Jetty 1 near 1st SBM
Total Number of locations	**8**

8.1 Marine Water Quality and Results

Marine water quality of marine waters of Deendayal Port Harbor waters, Khori & Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each month. The results of marine water quality from table no 34 to 41. During low tide DPA-6 Nakti-II location monitoring was not possible due to non-availability of marine water.

Table 34: Marine Water Quality Monitoring Parameters for location near DPA colony

Sr. No.	Parameters	Unit	Kandla Creek Near DPA colony (1)			
			23°0'58"N 70°13'22."E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.42	7.53	7.36	7.42
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	‰	32.6	33.9	33.0	33.9
5	Turbidity	NTU	45	41	46	41
6	Total Dissolved Solids	mg/l	44479	46712	37902.0	38329.0
7	Total Suspended Solids	mg/l	399	336	708	650.9
8	Total Solids	mg/l	54878	53304	43002.0	41470.0
9	DO	mg/l	5.2	5.1	5.5	5.2
10	COD	mg/l	88.0	80.0	90.0	88.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.40	0.20	0.46	0.36
13	Phosphate	mg/l	0.31	0.35	0.37	0.04
14	Sulphate	mg/l	2194.5	1640.1	2183	1594
15	Nitrate	mg/l	1.48	2.15	2.15	1.81
16	Nitrite	mg/l	0.13	0.11	0.15	0.15
17	Calcium	mg/l	641.28	721.44	721.44	761.52
18	Magnesium	mg/l	1773.9	1555.2	1628.1	1652.4
19	Sodium	mg/l	8744.0	9175.0	9489.0	10005.0
20	Potassium	mg/l	314.0	304.0	394.0	399.0
21	Iron	mg/l	3.53	2.00	0.82	0.76
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 35: Marine Water Quality Monitoring Parameters for location near passenger Jetty One at Kandla

Sr. No.	Parameters	Unit	Near passenger Jetty One (2)			
			23° 0'18 "N 70°13'31"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.38	7.41	7.31	7.51
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	‰	34.4	34.9	33.5	31.2
5	Turbidity	NTU	38	39	43	39
6	Total Dissolved Solids	mg/l	45846	47471	35126.0	37344.0
7	Total Suspended Solids	mg/l	338	763	701.2	670.7
8	Total Solids	mg/l	51696	53886	36372.0	38582.0
9	DO	mg/l	4.9	4.8	5	5.3
10	COD	mg/l	76.0	80.0	72.0	70.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.58	0.20	0.64	0.24
13	Phosphate	mg/l	0.24	0.38	0.30	0.42
14	Sulphate	mg/l	1986.6	1686.3	1917	1594
15	Nitrate	mg/l	3.49	3.29	4.56	2.82
16	Nitrite	mg/l	0.09	BQL	0.11	0.06
17	Calcium	mg/l	601.20	561.12	681.36	641.28
18	Magnesium	mg/l	1725.3	1603.8	1701	1676.7
19	Sodium	mg/l	9698.0	9777.0	10209.0	10707.0
20	Potassium	mg/l	321.0	323.0	398.0	312.0
21	Iron	mg/l	0.27	BQL	3.24	0.81
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Nitrite: 0.05mg/lCu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 36: Marine Water Quality Monitoring Parameters for location Near Coal Berth

Sr. No.	Parameters	Unit	Near Coal Berth			
			22°59'12"N 70°13'40"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.48	7.28	7.48	7.26
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	‰	33.0	33.5	32.6	33.0
5	Turbidity	NTU	47	42	45	43
6	Total Dissolved Solids	mg/l	45002	48675	38044.0	38337.0
7	Total Suspended	mg/l	379	540	644.4	812.4
8	Total Solids	mg/l	53900	52430	40806.0	39676.0
9	DO	mg/l	4.7	4.6	4.8	4.9
10	COD	mg/l	82.0	78.0	78.0	74.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.66	0.36	0.84	0.48
13	Phosphate	mg/l	0.22	0.34	0.31	0.38
14	Sulphate	mg/l	1755.6	2102.1	1675	2056
15	Nitrate	mg/l	2.95	2.01	2.28	1.95
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	681.36	601.20	681.36	721.44
18	Magnesium	mg/l	1506.6	1603.8	1749.6	1701
19	Sodium	mg/l	8903.0	10695.0	10366.0	10110.0
20	Potassium	mg/l	327.0	315.0	367.0	320.0
21	Iron	mg/l	BQL	BQL	0.37	0.49
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 37: Marine Water Quality Monitoring Parameters for location Khori creek at Kandla

Sr. No.	Parameters	Unit	DPA 4			
			Near 15/16 Berth			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.35	7.31	7.38	7.43
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	‰	33.9	33.0	33.9	34.4
5	Turbidity	NTU	43	45	40	44
6	Total Dissolved Solids	mg/l	51513	54554	43382.0	43962.0
7	Total Suspended Solids	mg/l	429	677	802.5	771.1
8	Total Solids	mg/l	53302	56146	47570.0	44902.0
9	DO	mg/l	4.5	5	5.1	5.4
10	COD	mg/l	60.0	52.0	62.0	57.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.60	0.68	0.66	0.80
13	Phosphate	mg/l	0.23	0.28	0.27	0.31
14	Sulphate	mg/l	2055.9	1790.25	1917	1698
15	Nitrate	mg/l	2.82	4.56	3.22	4.77
16	Nitrite	mg/l	BQL	BQL	0.07	0.10
17	Calcium	mg/l	761.52	681.36	641.28	721.44
18	Magnesium	mg/l	1603.8	1628.1	1701	1628.1
19	Sodium	mg/l	10287.0	10094.0	10236.0	10922.0
20	Potassium	mg/l	319.0	322.0	331.0	265.0
21	Iron	mg/l	BQL	BQL	1.23	BQL
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 38: Marine Water Quality Monitoring Parameters for location Nakti Creek near Tuna Port

Sr. No.	Parameters	Unit	Nakti Creek Near Tuna Port			
			22°57'49."N 70° 7'0.67"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.43	7.38	7.26	7.21
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	‰	33.5	33.9	33.0	32.6
5	Turbidity	NTU	43	42	45	38
6	Total Dissolved Solids	mg/l	52618	55692	37078.0	38995.0
7	Total Suspended Solids	mg/l	414	321	727.6	760.1
8	Total Solids	mg/l	54138	58860	38012.0	40230.0
9	DO	mg/l	5.3	5.1	5.6	5.7
10	COD	mg/l	92.0	88.0	90.0	87.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.52	0.40	0.56	0.52
13	Phosphate	mg/l	0.31	0.19	0.34	0.23
14	Sulphate	mg/l	1871.1	2148.3	1698	2056
15	Nitrate	mg/l	4.83	3.29	4.50	2.95
16	Nitrite	mg/l	0.05	0.08	0.06	0.10
17	Calcium	mg/l	641.28	561.12	761.52	641.28
18	Magnesium	mg/l	1749.6	1749.6	1652.4	1701
19	Sodium	mg/l	10930.0	10903.0	10481.0	10121.0
20	Potassium	mg/l	312.0	314.0	289.0	340.0
21	Iron	mg/l	BQL	BQL	0.58	BQL
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 39: Marine Water Quality Monitoring Parameters for location Nakti Creek Near NH-8A at Kandla

Sr. No.	Parameters	Unit	Nakti Creek Near NH-8A			
			23° 02'01"N 70° 09'31"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.52	Sampling not possible during Low Tide	7.55	Sampling not possible during Low Tide
2	Color	-	Colorless		Colorless	
3	Odor	-	Odorless		Odorless	
4	Salinity	‰	34.9		33.5	
5	Turbidity	NTU	41		46	
6	Total Dissolved Solids	mg/l	47273		42444.0	
7	Total Suspended Solids	mg/l	817		797.7	
8	Total Solids	mg/l	49186		44304.0	
9	DO	mg/l	4.6		5.3	
10	COD	mg/l	110.0		106.0	
11	BOD	mg/l	BQL		BQL	
12	Silica	mg/l	0.72		0.68	
13	Phosphate	mg/l	0.38		0.38	
14	Sulphate	mg/l	2829.75		2795	
15	Nitrate	mg/l	3.76		3.42	
16	Nitrite	mg/l	0.10		0.11	
17	Calcium	mg/l	641.28		601.2	
18	Magnesium	mg/l	1773.9		1773.9	
19	Sodium	mg/l	10735.0		8053.0	
20	Potassium	mg/l	318.0		272.0	
21	Iron	mg/l	BQL		0.28	
22	Chromium	mg/l	BQL		BQL	
23	Copper	mg/l	BQL		BQL	
24	Arsenic	mg/l	BQL		BQL	
25	Cadmium	mg/l	BQL		BQL	
26	Mercury	mg/l	BQL		BQL	
27	Lead	mg/l	BQL		BQL	
28	Zinc	mg/l	BQL		BQL	

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 40: Marine Water Quality Monitoring Parameters for locations Nr. Vadinar Jetty

Sr. No.	Parameters	Unit	Nr.Vadinar Jetty			
			22°26'25.26"N 69°40'20.41"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.45	7.32	7.43	7.36
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	‰	33.9	33.5	33.9	33.5
5	Turbidity	NTU	39	40	43	45
6	Total Dissolved Solids	mg/l	53711	54732	36344.0	34479.0
7	Total Suspended Solids	mg/l	357	331	694.3	641.9
8	Total Solids	mg/l	55404	55480	37996.0	35268.0
9	DO	mg/l	4.5	4.3	5.6	5.3
10	COD	mg/l	80.0	76.0	74.0	72.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.80	0.64	0.84	0.66
13	Phosphate	mg/l	0.36	0.38	0.40	0.42
14	Sulphate	mg/l	2841.3	2691.15	3095	2564
15	Nitrate	mg/l	4.83	5.50	4.16	5.30
16	Nitrite	mg/l	0.08	0.07	0.10	0.09
17	Calcium	mg/l	681.36	721.44	561.12	601.2
18	Magnesium	mg/l	1530.9	1458	1749.6	1773.9
19	Sodium	mg/l	11900.0	10708.0	10202.0	10436.0
20	Potassium	mg/l	4436.0	474.0	473.0	474.0
21	Iron	mg/l	BQL	BQL	0.21	0.23
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	0.41	0.78	0.36

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 41: Marine Water Quality Monitoring Parameters for locations Nr. Vadinar SPM

Sr. No.	Parameters	Unit	Nr. Vadinar SPM			
			22°30'56.15"N 69°42'12.07"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.28	7.21	7.47	7.33
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	‰	34.4	33.0	34.4	34.9
5	Turbidity	NTU	43.0	46.0	42	44
6	Total Dissolved Solids	mg/l	54703.0	52022.0	36956.0	41939.0
7	Total Suspended Solids	mg/l	263.3	251.3	670.4	699.7
8	Total Solids	mg/l	55716.0	53868.0	38388.0	42668.0
9	DO	mg/l	4.6	4.4	5.4	5.2
10	COD	mg/l	96.0	94.0	92.0	96.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.80	0.72	0.78	0.80
13	Phosphate	mg/l	0.41	0.50	0.49	0.54
14	Sulphate	mg/l	2379.3	2795.1	2287	2888
15	Nitrate	mg/l	2.82	3.76	2.28	3.02
16	Nitrite	mg/l	0.05	BQL	0.07	0.05
17	Calcium	mg/l	761.52	641.28	721.44	681.36
18	Magnesium	mg/l	1385.1	1482.3	1628.1	1628.1
19	Sodium	mg/l	11630.0	11510.0	11437.0	12000.0
20	Potassium	mg/l	421.0	426.0	433.0	504.0
21	Iron	mg/l	BQL	BQL	BQL	BQL
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	0.2	BQL	0.15	0.11

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l)

8.2 Results & Discussion for Marine water samples

Marine water quality of Deendayal Port Harbor waters, Khori and Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each month. The Heavy metal analyzed and found below quantification limit.

Turbidity

During spring tide the Turbidity values was ranges from 38-47 NTU at DPA Kandla and 39-46 NTU at Vadinar while during Neap Tide pH values was ranges from 38-46 NTU at DPA Kandla and 42-45 NTU at Vadinar. Turbidity is the amount of particulate matter that is suspended in water. Turbidity measures the scattering effect that suspended solids have on light: the higher the intensity of scattered light, the higher the turbidity (Yap et al, 2011). Materials that cause water to be turbid include clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, plankton and microscopic organisms (Lawler, 2004).

Color and Odor

All marine samples for Odor and Color were found agreeable at all locations.

pH

During spring tide the pH values was ranges from 7.28-7.53 at DPA Kandla and 7.21-7.45 at Vadinar while during Neap Tide pH values was ranges from 7.21-7.55 at DPA Kandla and 7.33-7.47 at Vadinar.

Total Dissolved Solids (TDS)

TDS values in the studied area during Spring Tide varied between 44479 to 55692 mg/l at DPA Kandla and 52022 to 54732 mg/l at Vadinar while during Neap Tide TDS values was varied 35125 to 43962 mg/l at DPA Kandla and 34479 to 41939 mg/l at Near Vadinar.

Calcium

Calcium value in the studied area during Spring Tide varied between 561.1 to 761.5 mg/l at DPA Kandla and 641.3 to 761.5 mg/l at Vadinar while during Neap Tide calcium values between 601.2 to 761.5 mg/l at DPA Kandla and 561.1 to 721.4 at Vadinar.

Magnesium

Magnesium value in the studied area during Spring Tide varied between 1506.6 to 1773.9 mg/l at DPA Kandla and 1385.1 to 1530.9 mg/l at Vadinar while during Neap Tide magnesium values between 1628.10 to 1773.90 mg/l at DPA Kandla and 1628.10 to 1773.90 at Vadinar. Calcium and magnesium both play an important role in antagonizing the toxic effects of various ions and neutralizing the excess acid produced (Narayan R. et. al., 2007)

Nitrate

Nitrate value in the studied area during Spring Tide varied between 1.5-4.8 mg/l at DPA Kandla and 2.8-5.5 mg/l at Vadinar while during Neap Tide Nitrate values between 1.81-4.77 mg/l at DPA Kandla and 2.28-5.3 at Vadinar.

The variations were observed due to variation in phytoplankton excretion, oxidation of ammonia, reduction of nitrate and by recycling of nitrogen and bacterial decomposition of planktonic detritus (Asha and Diwakar, 2007).

Iron

Iron values in the studied area during Spring Tide was found 0.3 to 3.5 mg/l at DPA Kandla and below quantification limit (BQL) at Vadinar while during Neap Tide the iron values was varied 0.28 to 3.24 mg/l at DPA Kandla and 0.21 to 0.23 at Vadinar.

Sulphates

Sulphate values in the studied area during Spring Tide was found 1640.1 to 2829.8 mg/l at DPA Kandla and 2379.3 to 2841.3 mg/l at Vadinar while during Neap Tide the Sulphate values was varied 1594.0 to 2795.0 mg/l at DPA Kandla and 2287.0 to 3095.0 at Vadinar.

Salinity

Salinity values in the studied area during Spring Tide was found 32.6 to 34.9 ‰ at DPA Kandla and 33.0 to 34.4 ‰ at Vadinar while during Neap Tide the Salinity values was varied 31.2 to 34.4 ‰ at DPA Kandla and 33.5 to 34.8 ‰ at Vadinar.

Sodium and Potassium Salts

During Spring Tide the Sodium values ranged from 8744.0-10930.0 mg/l at DPA Kandla & 10708.0-11900.0 mg/l at Vadinar and Potassium salts ranged from 304.0-327.0 mg/l at DPA Kandla & 265.0-399.0 mg/l at Vadinar while during Neap Tide the sodium values was ranges from 10708.0-11900.0 mg/l at DPA Kandla & 10202-12000 mg/l at Vadinar and Potassium salts ranged from 421.0-474.0 mg/l at DPA Kandla & 433.0-504.0 mg/l at Vadinar.

DO

The DO refers to the amount of oxygen dissolved in the water and it is particularly important in limnology (aquatic ecology) (Weiss 1970). The fate and behavior of DO is of critical importance to marine organisms in determining the severity of adverse impacts (Best et al. 2007). The major factor controlling dissolved oxygen concentration is biological activity: photosynthesis producing oxygen while respiration and nitrification consume oxygen (Best et al. 2007). From the studied samples, DO in marine water during Spring Tide was found in ranges from 4.5-5.3 mg/l at DPA Kandla and 4.8-5.7 mg/l at Vadinar while during Neap Tide 4.3-4.6 mg/l at DPA Kandla and 5.2-5.6 mg/l at Vadinar.

BOD

BOD in marine water at all sampling location in the studied samples was found Below Quantification limit. BOD shows the amount of dissolved oxygen needed by microorganisms to decompose or decompose organic matter under aerobic conditions (Salmin, 2005).

Heavy Metals in Marine Water

In the present study period marine water samples were analyzed for Cr, Cu, Cd, As, Hg, Pb and Zn. All these heavy metals were well Below the Quantification limits prescribed by the Indian Standards.

The heavy metal pollution from industry, domestic activities, transportation and natural sources from rocks flow to the river or ocean waters and accumulate in the waters and marine biota. The heavy metals in waters at certain concentrations will change their function to toxic to the life of waters (Murtini et al., 2001).

9.3 Conclusion

In the present study period marine water samples were analyzed and found inline as per Primary Water Quality criteria for class-IV WATERS (For Harbour Waters).

9.0 Marine Sediments

The deep-sea ocean floor is made up of sediment. This sediment is composed of tiny particles such as fine sand, silt, clay, or animal skeletons that have settled on the ocean bottom. Over long periods of time, some of these particles become compressed and form stratified layers. Scientists that study these layers look at particle size, particle composition, and origin to help them create historical records of the deep ocean floor. This process is called weathering. Weathering can be either mechanical or chemical. Mechanical weathering can occur as ice, wind, or water wears away the rock's surface. Chemical weathering can occur as rocks are dissolved by a chemical such as acid rain. The particles created as a result of weathering are called terrigenous sediments. These particles are transported to the ocean by wind and by rivers and streams. Once the particles enter the ocean, they are dispersed by waves, currents, and tides. The heaviest and largest particles that reach the oceans, such as sand, settle very quickly to the bottom as a result of gravity. Sand is deposited near the coast whereas the smaller silt and clay particles are transported farther distances offshore before they settle to the bottom. Sediments are an important component of aquatic ecosystems because they provide nutrients and habitat for aquatic organisms (Benhamed et al. 2016). However, human activities result in accumulation of toxic substances such as heavy metals in marine sediments. Heavy metals are well-known environmental pollutants due to their toxicity, persistence in the environment, and bioaccumulation. Metals affect the ecosystem because they are not removed from water by self-purification, but accumulate in sediments and enter the food chain (Astakhov et al. 2015).

Sediment samples were collected with Van Veen Grab from the six locations in Kandla Port Waters and two locations in Vadinar Port. Benthic surface grab samplers look like giant metal jaws. They dig into the bottom and take a bite of the sediment. These samplers are good for collecting softer, sandy or silty sediments that do not contain rocks. A box corer is a cross between a surface sampler and a sediment corer. It is a special device that is used to collect an undisturbed sample of the very top surface layers and the sediment underneath. Samples were collected and preserved in silver foil in ice box to prevent the contamination/decaying of the samples.

10.1 Results

The Sediment Quality results are given in below from table no. 41 & 42.

Table 41: Results of Analysis of Sediment of Kandla & Vadinar Port (Neap Tide)

Sr. No.	Parameters	Unit	DPA – 1	DPA - 2	DPA - 3	DPA - 4	DPA - 5	Jetty	SPM
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	0.21	1.07	1.38	1.31	1.09	1.29	1.03
3	Organic Carbon	mg/kg	0.12	0.62	0.80	0.76	0.63	0.75	0.60
4	Inorganic Phosphate	mg/kg	90.00	106.00	90.00	100.00	108.00	80.00	90.00
5	Moisture	%	4.80	16.00	14.00	21.60	19.20	5.20	7.40
6	Aluminum	mg/kg	ND	ND	ND	ND	ND	ND	ND
7	Silica	mg/kg	7.90	7.20	9.80	5.60	10.60	13.20	15.20
8	Phosphate	mg/kg	2.80	2.09	2.10	1.80	1.96	6.80	5.20
9	Sulphate	mg/kg	522.00	500.00	580.00	480.00	460.00	470.00	410.00
10	Nitrite	mg/kg	0.11	0.11	0.12	0.11	0.11	0.12	0.10
11	Nitrate	mg/kg	BQL	BQL	BQL	BQL	BQL	6.80	7.90
12	Calcium	mg/kg	1705.00	1619.00	1520.00	1216.00	1343.00	1765.00	1918.00
13	Magnesium	mg/kg	886.00	1336.00	640.00	761.00	720.00	796.00	822.00
14	Sodium	mg/kg	590.00	990.00	422.00	390.00	440.00	1106.00	1290.00
15	Potassium	mg/kg	270.00	310.00	120.00	190.00	270.00	310.00	280.00
16	Chromium	mg/kg	54.60	19.70	20.40	26.70	37.30	33.60	25.20
17	Nickel	mg/kg	10.80	9.20	9.80	13.00	16.70	15.10	11.40
18	Copper	mg/kg	BQL	BQL	BQL	5.70	6.80	7.00	5.50
19	Zinc	mg/kg	5.20	7.60	6.80	11.90	17.50	15.30	8.80
20	Cadmium	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
21	Lead	mg/kg	10.90	BQL	BQL	BQL	BQL	9.30	BQL
22	Mercury	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
23	Arsenic	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL

*ND - Not Detected, BQL: Below Quantification Limit (NO3:10.0mg/kg, Cd: 1.0mg/kg, Hg: 1.0mg/kg, As: 1.0mg/kg).

Table 42 : Results of Analysis of Sediment of Kandla & Vadinar Port (Spring Tide)

Sr. No.	Parameters	Unit	DPA – 1	DPA - 2	DPA - 3	DPA - 4	DPA - 5	Jetty	SPM
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	0.83	0.52	0.38	0.71	0.86	0.64	0.71
3	Organic Carbon	mg/kg	0.48	0.30	0.22	0.41	0.50	0.37	0.41
4	Inorganic Phosphate	mg/kg	116.00	80.00	90.00	100.00	100.00	106.00	100.00
5	Moisture	%	24.00	24.00	15.00	23.00	30.00	22.00	17.00
6	Aluminum	mg/kg	ND	ND	ND	ND	ND	ND	ND
7	Silica	mg/kg	10.20	8.80	9.20	7.60	10.30	12.20	18.00
8	Phosphate	mg/kg	2.76	2.03	1.92	2.51	2.13	8.78	7.47
9	Sulphate	mg/kg	531.00	501.00	501.00	515.00	502.00	499.00	480.00
10	Nitrite	mg/kg	0.11	0.12	0.11	0.10	0.12	0.10	0.11
11	Nitrate	mg/kg	BQL	BQL	BQL	BQL	BQL	10.80	11.02
12	Calcium	mg/kg	2254.00	1503.00	1763.00	1643.00	1603.00	1603.00	1863.00
13	Magnesium	mg/kg	990.00	1312.00	607.00	680.00	826.00	760.00	935.00
14	Sodium	mg/kg	528.00	967.00	395.00	373.00	394.00	1196.00	1353.00
15	Potassium	mg/kg	288.00	317.00	140.00	202.00	286.00	384.00	335.00
16	Chromium	mg/kg	138.60	28.70	16.20	30.00	29.50	62.80	18.20
17	Nickel	mg/kg	33.30	13.30	7.40	14.80	14.10	42.50	8.00
18	Copper	mg/kg	21.30	8.40	BQL	BQL	6.90	25.80	6.90
19	Zinc	mg/kg	31.30	12.60	BQL	17.30	10.40	34.30	BQL
20	Cadmium	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
21	Lead	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
22	Mercury	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
23	Arsenic	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL

*ND - Not Detected, BQL: Below Quantification Limit (NO3:10.0mg/kg,Cd: 1.0mg/kg,Hg: 1.0mg/kg, As: 1.0mg/kg)

9.2 Discussion of Marine Sediment samples

Marine Sediments of Deendayal Port Harbor waters, Khori and Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each month. The Heavy metal analyzed and found below quantification limit.

9.3 Conclusion

The sediment types are majority Sandy loamy. Also all heavy metals found below Quantification limit wise Al, Pb, Cd, Hg , As and Nitrate for some locations.

10.0 INTRODUCTION:

Sampling Stations:

The monitoring of marine environment for the study of biological and ecological Parameters was carried out on 05th August 2022 in harbour region of DPA at Kandla Creek, and on 06 th August 2022 in creeks near by the port during Neap tide. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 12th August, 2022 in harbour region of DPA at Kandla Creek and on13rd August, 2022 in creeks near by the port during spring tidal condition.

Plankton samples from sub surface layer was collected both during high tide period and low tide period from 3 water quality monitoring stations of DPA harbour area and two stations in Nakti creek and one station in Khori creek. Sampling at second sampling station of Nakti creek was possible only during high tide period. The same sampling schedule was repeated during consecutive spring and neap tide in same month.

Plankton samples from sub surface layer were collected during high tide period and low tide period from monitoring station near Vadinar jetty at Path Finder Creek during Neap tide on 06/08/2022 and Spring tide period on 13/08/2022. Collected water samples were processed for estimation of Chlorophyll-a, Pheophytin-a, qualitative & quantitative evaluation of phytoplankton, qualitative &quantitative evaluation zooplankton density and their population).

TABLE 43. SAMPLING LOCATIONS

monitoring requirement	**Number of locations**
Kandla creek	3 in Kandla creek
Nakti creek	2 in Nakti creek
Khori Creek	1 in Khori creek
Vadinar jetty	1 near Vadinar Jetty
SPM	1 near I stSPM
Total Number of locations	**8**

11.1 Sampling methodology adopted:

A marine sampling is an estimation of the body of information in the population. The theory of the sampling design is depending upon the underlying frequency distribution of the population of interest.

The requirement for useful water sampling is to collect a representative sample of suitable volume from the specified depth and retain it free from contamination during retrieval.

50 litres of the water sample were collected from Sub surface by using bucket. From the collected water sample 1 litres of water sample were taken in an opaque plastic bottle for chlorophyll estimation, thereafter plankton samples were collected by using filtration assembly with nylon bolt cloth of 20 µm mesh size.

Samples Processing for chlorophyll estimation:

Samples for the chlorophyll estimation were preserved in ice box on board in darkness to avoid degradation in opaque container covered with aluminum foil. Immediately after reaching the shore after sampling, 1 litre of collected water sample was filtered through GF/F filters (pore size 0.45 µm) by using vacuum filtration assembly. After vacuum filtration the glass micro fiber filter paper was grunted in tissue grinder, macerating of glass fiber filter paper along with the filtrate was done in 90% aqueous Acetone in the glass tissue grinder with glass grinding tube. Glass fiber filter paper will assist breaking the cell during grinding and chlorophyll content was extracted with 10 ml of 90% Acetone, under cold dark conditions along with saturated magnesium carbonate solution in glass screw cap tubes. After an extraction period of 24 hours, the samples were transferred to calibrated centrifuge tubes and adjusted the volume to original volume with 90% aqueous acetone solution to make up the evaporation loss. The extract was clarified by using centrifuge in closed tubes. The clarified extracts were then decanted in clean cuvette and optical density was observed at wavelength 664, 665 nm. By using corrected optical density, Chlorophyll-a value was calculated as given in (APHA, 2017).

PLANKTON:

The entire area open water in the sea is the pelagic realm. Pelagic organisms live in the open sea. In contrast to the pelagic realm, the benthic realm comprises organisms and zone of the bottom of the sea. Vertically the pelagic realm can be dividing into two zones based on light penetration; upper photic or euphotic zone and lower dark water mass, aphotic zone below the photic zone.

The term plankton is general term for organisms have such limited powers of locomotion that they are at the mercy of the prevailing water movement. Plankton is subdivided to phytoplankton and zooplankton. Phytoplankton is free floating organisms that are capable of photosynthesis and zooplankton is the various free floating animals.

Pelagic zone, represents the entire ocean water column from the surface to the deepest depths, is home to a diverse community of organisms. Differences in their locomotive ability categorize the organisms in the pelagic realm into two, ***plankton*** and ***nekton*** (Lalli and Parsons, 1997). ***Plankton*** consists of all organisms drifting in the water and is unable to swim against water currents, whereas ***Nekton*** includes organisms having strong locomotive power. Ecological studies on the plankton community, which form the base of the aquatic food chain, help in the better understanding of the dynamics and functioning of the marine ecosystem. The term 'Plankton' first coined by Victor Hensen (1887),

Plankton, (Greek word: *planktos*meaning "passively drifting or wandering") is defined as drifting or free-floating organisms that inhabit the pelagic zone of water. Based on their mode of nutrition planktonic organisms are categorised into phytoplankton (organisms having an autotrophic mode of nutrition) and zooplankton (organisms having a heterotrophic mode of nutrition).

Phytoplankton in the marine environment:

Phytoplankton is free floating unicellular, filamentous and colonial eutrophic organisms that grow in aquatic environments whose movement is more or less dependent upon water currents. These micro flora acts as primary producers as well as the basis of food chain, source of protein, bio purifier and bio indicators of the aquatic ecosystems of which diverse array of the life depends .They are considered as an important component of aquatic flora, play a key role in maintaining equilibrium between abiotic and biotic components of aquatic ecosystem.

The phytoplankton includes a wide range of photosynthetic and phototrophic organisms. Marine phytoplankton is mostly microscopic and unicellular floating flora, which are the primary producers that support the pelagic food-chain. The two most prominent groups of phytoplankton are diatoms (Bacillariophyceae) and dinoflagellates (Dinophyceae).The phytoplankton those normally captured in the net from the Gulf of Kutch is normally dominated by these two major groups; diatoms and dinoflagellates. Phytoplankton also include numerous and diverse collection of extremely small, motile algae which are termed micro flagellates (naked flagellates) as well as and Cyanophytes (blue-green algae).

Algae are an ecologically important group in most aquatic ecosystems and have been an important component of biological monitoring programs. Algae are ideally suited for water quality assessment because they have rapid reproduction rates and very short life cycles, making them valuable indicators of short-term impacts.

Aquatic populations are impacted by anthropogenic stress, resulting in a variety of alterations in the biological integrity of aquatic systems. Algae can serve as an indicator of the degree of deterioration of water quality, and many algal indicators have been used to assess environmental status.

Zooplankton in the marine environment:

Zooplankton includes a taxonomically and morphologically diverse community of heterotrophic organisms that drift in the waters of the world's oceans. Qualitative and quantitative studies on zooplankton community are a prerequisite to delineate the ecological processes active in the marine ecosystem. Zooplankton community plays a pivotal role in the pelagic food web as the primary consumers of phytoplankton and act as the food source for organisms in the higher trophic levels, particularly the economically essential groups such as fish larvae and fishes. They also function in the cycling of elements in the marine ecosystem. The dynamics of the zooplankton community, their reproduction, and growth and survival rate are all significant factors determining the recruitment and abundance of fish stocks as they form an essential food for larval, juvenile and adult fishes

(Beaugrand et al., 2004). Zooplankton grazing in the marine environment controls the primaryProduction and helps in determining the pelagic ecosystem (Banse, 1995). Through grazing in surface waters and following the production of sinking faecal matters and also by the active transportation of dissolved and particulate matter to deeper waters via vertical migration, they help in the transport of organic carbon to deep ocean layers and thus act as key drivers of biological pump' in the marine ecosystem. Zooplankton grazing and metabolism also, transform particulate organic matter into dissolved forms, promoting primary producer community, microbial demineralization, and particle export to the ocean's interior.

The categorisation of zooplankton into various ecological groups is based on several factors such as duration of planktonic life, size, food preferences and habitat. As they vary significantly in size from microscopic to metazoic forms, the classification of zooplankton based on size has paramount importance in the field of quantitative plankton research.

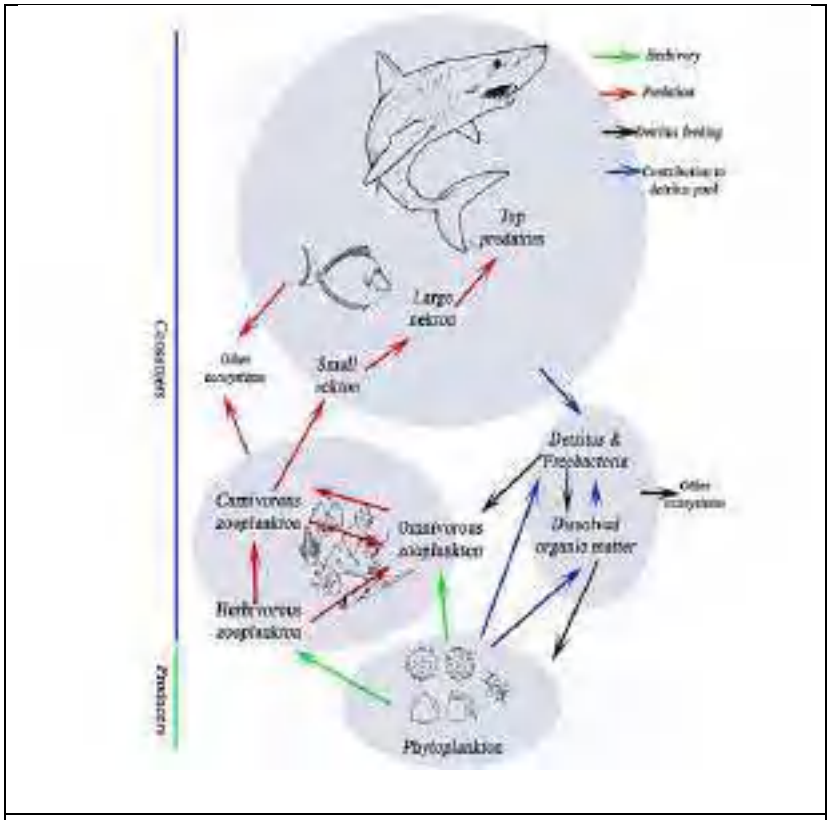
Based on the duration of planktonic life, zooplankton are categorised into Holoplankton (organisms which complete their entire lifecycle as plankton) and Meroplankton (organisms which are planktonic during the early part of their lives such as the larval stages of benthic and nektonic organisms). Tychoplankton are organisms which live a brief planktonic life, such as the benthic crustaceans (Cumaceans, mysids, isopods) which ascend to the water column at night for feeding and certain ectoparasitic copepods, they leave the host and spend their life as plankton during their breeding cycle.

Zooplankton can be subdivided into holoplankton, i.e., permanent members of the plankton (e.g., Calanoid copepods), and meroplankton, i.e., temporary members in the plankton e.g., larvae of fish, shrimp, and crab). The meroplankton group consists of larval and young stages of animals that will adopt a different lifestyle once they mature. In contrast to phytoplankton which consist of a relatively smaller variety of organisms, Zooplankton are extremely divers, consist of a host of larval and adult forms representing many animal phylum.

Among the zooplankton one group always dominate than others; members of sub class copepods (Phylum Athropoda) and Tintinids (Phylum Protozoa) among the net planktons. These small animals are of vital importance in marine ecosystem as one of the primary herbivores animals in the sea, and it is they provide vital link between primary producer (autotrophs) and numerous small and large marine consumers.

As their community structure and function are highly susceptible to changes in the environmental conditions regular monitoring of their distribution as well as their interactions with various physicochemical parameters is inevitable for the sustainable management of the ecosystem (Kusum et al., 2014). Of all the marine zooplankton groups, copepods mainly Calanoid copepods are the dominant groups in marine subtropical and tropical waters and exhibit considerable diversity in morphology and habitats they occupy (Madhupratap, 1991;)

It has been well established that potential of pelagic fishes viz. finfishes, crustaceans, molluscs and marine mammals either directly or indirectly depend on zooplankton. The herbivorous zooplankton is efficient grazers of the phytoplankton and is referred to as living machines transforming plant material into animal tissue. Hence they play an essential role as the intermediaries for nutrients/energy transfer between primary and tertiary trophic levels. Due to their large density, shorter lifespan, drifting nature, high group/species diversity and different tolerance to the stress, they used as the indicator organisms for the physical, chemical and biological processes in the aquatic ecosystem (Ghajbhiye, 2002).



Simplified marine food web

Spatial distribution of Plankton:

A characteristic of plankton population is that they tend to occur in patches, which are varying spatially on a scale of few meters to far as few kilometres in distance. They also vary in time scale, season as well as vertically in the water column. It is this patchiness and its constant changes in time and spot, that has made it so difficult for plankton biologist to learn about the ecology of plankton. The biological factors that causes this patchiness is due to the ability of zooplankton to migrate vertically and graze out the phytoplankton at a rapid rate that can create patchiness. Similarly the active swimming ability by certain zooplankton organisms can cause to aggregate in dense group.

At its most extreme, because the water in which plankton is suspended is constantly moving, each sample taken by the plankton biologists remain a different volume of water, so each sample is unique and replicate does not exist.

Plankton in AUGUST also exhibit vertical patchiness. Physical factors contribute to this type of patchiness include light intensity, nutrients and density gradients in the water column.

Phytoplankton in particular tends to be unequally distributed vertically, which leads to the existence of different concentration of a chlorophyll value between photic zone and below the photic zone.

Methodology adopted for Plankton sampling:

Mixed plankton sample were obtained from the sub surface layer at each sampling locations by towing the net horizontally with the weight .After the tow of about 15-30minutes, plankton net was pulled up and washed down to the tail and collected the plankton adhered to plankton net in the collection bucket at the bottom by springing outer and inner surface of the net with sea water, while the net was hanging with the mouth upward.

Preservation and storage:

Both filtered plankton and those collected from the plankton net were preserved with 5% buffered formalin and stored in 1L plastic container for further processing in the laboratory.

Sample concentration:

The collected plankton samples were concentrated by using centrifuge and made up to 50 ml with 5% formalin -Glycerine mixture.

Taxonomic evaluation:

Before processing, the sample was mixed carefully and a subsample was taken with a calibrated Stempel-pipette. 1 ml of the concentrated plankton samples were transferred on a glass slide with automatic pipette. The plankton sample on the glass slides were stained by using Lugol's iodine and added glycerine to avoid drying while observation. The plankton samples were identified by using Labex triangular Research microscope with photographic attachment. Microphotographs of the plankton samples were taken for record as well as for confirming the identification. The bigger sized zooplankton was observed through dissecting stereomicroscope with magnification of 20-30 x. Plankton organisms in the whole slide were identified to the lowest taxon possible. A thorough literature search was conducted for the identification of the different groups of zooplankton that were encountered

Cell counts by drop count method:

The common glass slide mounted with a 1ml of concentrated phytoplankton/zooplankton sample in glycerol and covered with cover slip 22x 60mm was placed under the compound microscope provided with a mechanical stage. The plankton was then counted from the microscopic field of the left top corner of the slide. Then slide is moved horizontally along the right side and plankton in each microscopic field was thus counted. When first microscopic field row was finished the next consecutive row was adjusted using the mechanical device of the stage. In this way all the plankton

present in entire microscopic field are counted. From this total number in 1ml of the concentrated plankton, total number of plankton in the original volume of sample filtered was calculated as units/L.

BENTHIC ORGANISMS:

Benthos is those organisms that are associated with the sea bed or benthic habitats. Epi- benthic organisms live attached to a hard substratum or rooted to a shallow depth below the surface. In fauna organisms live below the sediment–water interface. Interstitial organisms live and move in pore water among sedimentary grains.

Because the benthic organisms are often collected and separated on sieves, a classification based on the overall size is used. Macro benthos include organisms whose shortest dimension is greater than or equal to 0.5 mm. Meio benthos are smaller than 0.5mm but larger than 42µ in size.

The terms such as macro fauna and Meio fauna generally have little relevance with taxonomic classification. The terms Meio fauna and macro fauna depend on the size. Meio fauna were considered as good bioassay of community health and rather sensitive indicators of environmental changes

SAMPLING METHODOLOGY ADOPTED FOR SUB TIDAL REGION:

Van veen sampler ($0.09m^2$) was used for sampling bottom sediments. Two sets of sediments were sampled from each location, one for macro fauna and other for Meio fauna. The macro fauna in the sediments were sieved on board to separate out the organisms. The fixation of Meio fauna is normally done by bulk fixation of the sediment sample. The bulk fixation is done by using 10% formalin (Buffered with borate). The organisms were preserved with seawater as diluting agent.

Sample sieving:

Sediments samples were sieved to extract the organisms. Sieving was performed carefully as possible to avoid any damage to the animals. The large portion of the sediment was split in to smaller portions and mixed with sea water in a bucket. The cohesive lumps were broken down by continuous stirring. The disaggregated sediments were then passed through the sieves.

Sample staining:

Sorting of the Meio fauna from the sieve is difficult task especially in the preserved material, because organisms are not easily detectable. To facilitate the animal detection the entire sample retained on the sieve after sieving operation were stained by immersing the sieve in a flat bottom tub with 1% Rose Bangal stain; a protein stain. A staining period of 10-30 minutes is sufficient for sample detection.

DIVERSITY INDICES:

On the whole, diversity indices provide more information about community composition than simply species richness (number of species present); they also, take the relative abundances of different species into account. Based on this fact, diversity indices therefore depend not only on species richness but on the evenness, or equitability, with which individuals are distributed among the different species (Magurram, A. E. (1988)

A diversity index is a measure of species diversity within a community that consists of co-occurring populations of several (two or more) different species. It includes two components: richness and evenness. Richness is the measure of the number of different species within a sample showing that more the types of species in a community, the higher is the diversity or greater is the richness. Evenness is the measure of relative abundance of the different species with in a community.

The basic idea of diversity index is to obtain a quantitative estimate of biological variability that can be used to compare biological entities composed of discrete components in space and time (CarolH.R.*etal*. 1998). Biodiversity is commonly expressed through indices based on species richness and species abundances (Whittaker 1972, Lande 1996, Purvis and Hector 2000). Biodiversity indices are a non-parametric tool used to describe the relationship between species number and abundance. The most widely used bio diversity indices are Shannon Weiner index and Simpson's index.

A diversity Index is a single statistic that incorporates information on richness and evenness. The diversity measures that incorporate the two concepts may be termed heterogeneity measures (Magurran, 2004).

Any study intended to interpret causes and effect of adverse impact on Biodiversity of communities require suitable measures to evaluate specie richness and Diversity. The former is number of species in community, while latter is a function of relative frequency of different species. Species richness is the iconic measure of biological diversity (Magurran, 2004). Several indices have been created to measure the diversity of species; however, the most widely used in the last decades are the Shannon (1948) and Simpson (1949) (Buzas and Hayek 1996; Gorelick 2006), with the components of diversity: richness (*S)* and evenness (*J)*

Simpson's diversity index

Simpson's index (**D**) is a measure of diversity, which takes into account both species richness, and evenness of abundance among the species present. The Simpson index is one of the meaningful and robust biodiversity measures available. (Magurran ,2004).

The formula for calculating D is presented as:

$$D = \frac{\sum n_i(n_i - 1)}{N(N-1)}$$

Where n_i = the total number of organisms of each individual species

N = the total number of organisms of all species

The value of D ranges from 0 to 1. With this index, 0 represents infinite diversity and, 1, no diversity. When D increases diversity decreases. Simpson's index is therefore usually expressed as 1-D or 1/D. (Magurran, 2004)

Low species diversity suggests:

- relatively few successful species in the habitat

- the environment is quite stressful with relatively few ecological niches and only a few organisms are really well adapted to that environment
- food webs which are relatively simple
- change in the environment would probably have quite serious effects

High species diversity suggests:

- a greater number of successful species and a more stable ecosystem
- more ecological niches are available and the environment is less likely to be hostile complex food webs
- environmental change is less likely to be damaging to the ecosystem as a whole

Species richness indices

The species richness***(S)*** is simply the number of species present in an ecosystem. Species richness Indices of species richness are widely used to quantify or monitor the effects of anthropogenic disturbance. A decline in species richness may be concomitant with severe or chronic human-induced perturbation (Fair Fair weather 1990,) Species richness measures have traditionally been the mainstay in assessing the effects of environmental degradation on the biodiversity of natural assemblages of organisms (Clarke &Warwick, 2001)

Species richness is the iconic measure of biological diversity (Magurran, 2004). The species richness***(S)*** is simply the number of species present in an ecosystem. This index makes no use of relative abundances. The term species richness was coined by McIntosh (1967) and oldest and most intuitive measure of biological diversity (Magurran, 2004).

Margalef's diversity index is a species richness index. Margalef's Species richness index (d), or indices that describe the evenness of the distribution of the numbers of individuals among species, were derived.

The value of a diversity index increases both when the number of types increases and when evenness increases. For a given number of types, the value of diversity index is maximised when all types are equally abundant (Rosenzweig, M. L. (1995).

Shannon-Wiener's index:

An index of diversity commonly used in plankton community analyses is the Shannon-Wiener's index **(H),** which emphasizes not only the number of species (richness or variety), but also the apportionment of the numbers of individuals among the species (Odum 1971 and Reish 1984). Shannon-Wiener's index **(H)** reproduces community parameters to a single numberby using an equation.

Shannon and Weiner index represents entropy. It is a diversity index taking into account the number of individuals as well as the number of taxa. It varies from 0 for communities with only single taxa to high values for community with many taxa each with few individuals. This index can also determine the pollution status of a water body. Normal values range from 0 to 4. This index is a combination of species present and the evenness of the species. Examining the diversity in the range of polluted and

$$H' = -\sum_{j=1}^{s} \frac{n_j}{N} \ln\left(\frac{n_j}{N}\right)$$

unpolluted ecosystems, Wilham and Dorris (1968) concluded that the values of the index greater than 3 indicate clean water, values in the range of 1 to 3 are characterized by moderate pollution and values less than 1 are characterized as heavily polluted

11.2 RESULTS:

CHLOROPHYLL-a:

Algal biomass was estimated by converting Chlorophyll value. In the sub surface water chlorophyll-a was varying from 0.342-0.51 mg/m^{3}with an average value 0.424 mg/m^{3}of in harbour region of DPA in Kandla Creek during sampling done in spring tide period of August 2022. In the nearby creeks chlorophyll-a was varying from 0.179 - 0.662 mg/m^3, with an average value 0.416mg/m^3.Pheophytin–a level was below detectable limit- the all the sampling stations during springtide.

In the sub surface water chlorophyll-a was varying from 0.452-0.676 mg/m^{3}with an average value 0.561 mg/m^3,in harbour region of DPA in Kandla Creek during sampling done in Neap tide period of August2022. In the nearby creeks chlorophyll-a was varying from 0.476-0.762 mg/m^3 with an average value 0.616mg/m^3.Pheophytin–a level was below detectable limit- the all the sampling stations.

In the sub surface water chlorophyll-a was varying from 0.526-0.818 mg/m^3 in harbour region of DPA OOT (Vadinar) in path finder Creek during sampling done in spring tide period of August 2022. In the sub surface water chlorophyll-a was varying from 0.555-0.646 mg/m^3.in harbour region of DPA OOT in path finder Creek during sampling done in Neap Tide period of August, 2022

Table No.:-44 VARIATIONS IN CHLOROPHYLL –a PHEOPHYTIN- a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPA HARBOUR AREA IN KANDLA CREEK, NEAR BY CREEKS AND DPA OOT JETTY IN PATH FINDER CREEK AND SPM NEAR VADINARDURING SPRING TIDE IN AUGUST 2022

Sr. No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPA HARBOUR AREA KANDLA CREEK					
1	DPA1	High tide	0.510	BDL	34.17
		Low tide	0.450	BDL	30.15
2	DPA 2	High tide	0.399	BDL	26.73
		Low tide	0.417	BDL	27.94
3	DPA 3	High tide	0.426	BDL	28.54
		Low tide	0.342	BDL	22.91
CREEKS					
4	DPA-4 Khori-I	High tide	0.662	BDL	44.35
		Low tide	0.392	BDL	26.26
5	DPA-5 Nakti-I	High tide	0.417	BDL	27.94
		Low tide	0.432	BDL	28.94
6	DPA-6 Nakti-II	High tide	0.179	BDL	11.99
PATHFINDER CREEK VADINAR					
7	VADINAR-I jetty	High tide	0.757	BDL	50.72
8		Low tide	0.654	BDL	43.82
9	SPM	High tide	0.818	BDL	54.81
10	SPM	Low tide	0.526	BDL	35.24

BDL: Below Detectable Limit.

Table No.:- 45 VARIATIONS IN CHLOROPHYLL –a PHEOPHYTIN- a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPA HARBOUR AREA ,NEAR BY CREEKS AND DPA OOT JETTY IN PATH FINDER CREEK AND SPM NEAR VADINAR DURING NEAP TIDE IN AUGUST 2022

Sr. No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPA HARBOUR AREA KANDLA CREEK					
1	DPA1	High tide	0.452	BDL	30.28
		Low tide	0.676	BDL	45.29
2	DPA 2	High tide	0.578	BDL	38.73
		Low tide	0.454	BDL	30.42
3	DPA 3	High tide	0.642	BDL	43.01
		Low tide	0.565	BDL	37.86
CREEKS					
4	DPA-4 Khori-I	High tide	0.762	BDL	51.05
		Low tide	0.543	BDL	36.38
5	DPA-5 Nakti-I	High tide	0.672	BDL	45.02
		Low tide	0.629	BDL	42.14
6	DPA-6 Nakti-II	High tide	0.476	BDL	31.89
PATHFINDER CREEK VADINAR					
7	VADINAR-I jetty	High tide	0.646	BDL	43.28
8		Low tide	0.630	BDL	42.21
9	SPM	High tide	0.613	BDL	41.07
10	SPM	Low tide	0.555	BDL	37.19

BDL: Below Detectable Limit.

PHYTOPLANKTON POPULATION:

For the evaluation of the Phytoplankton population in DPA harbour area and within the immediate surroundings of the port, sampling was conducted from 5 sampling locations (3 in harbour area and two in Nakti creek) during high tide period and low tide period of spring tide and neap tide.

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by Diatoms, Blue green algaen algae and Dinoflagellates during spring tide period. Diatoms were represented by 27genera. Blue green algaen was represented by 4genera and Dinoflagellates were represented by 4 genera during the sampling conducted in spring tide in AUGUST, 2022. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 37-357 units/ L during high tide period and132-215units/ L during low tide of Spring Tide.

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by Diatoms, Blue green algaen algae and DinoflagellatesduringNeap tide period.Diatoms were represented by 27 genera, Blue green algaen algae were represented 4 genera and Dinoflagellates with3 genera during the sampling conducted in Neap tide in AUGUST, 2022. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from65-211units/ L during high tide period and 75-158units/ L during low tide of Neap Tide.

For the evaluation of the Phytoplankton population in DPA OOT jetty area in Path Finder creek sampling was conducted from two sampling locations; jetty area during high tide period and low tide of spring tide and Neap tide period.

The phytoplankton community of the sub surface water in the path finder creeks was represented by Diatoms, Blue green algaen algae and Dinoflagellates during spring tide period. Diatoms were represented by 32 genera, Blue green algaen algae by 3 genera and Dinoflagellates 4 genera each during the sampling conducted in spring tide in AUGUST, 2022.Phytoplankton of the sampling stations at sub surface layer in the (harbour area was 156 units/ L during high tide period and 263 units/ L during low tide of Spring Tide. Phytoplankton of the sampling stations at sub surface layer in the *SPM area* was varying from 275units/ L during high tide period and 210 units/ L during low tide of Spring Tide.)

The phytoplankton community of the sub surface water in the path finder creeks was represented by Diatoms, Blue green algaen and Dinoflagellates during Neap tide period. Diatoms were represented by 28 genera and Blue green algaen algae by 2genera and Dinoflagellates by 3 genera during the sampling conducted in Neap tide in AUGUST, 2022. Phytoplankton of the sampling stations at sub surface path finder creek near OOT Jetty (Vadinar) was varying from 183 units/ L during high tide period and 204 units/ L during low tide of Neap Tide. Phytoplankton of the sampling stations at sub surface path finder creek near SPM area was varying from 128 units/ L during high tide period and 180 units/ L during low tide of Neap Tide.

Species Richness Indices and Diversity Indices:

Margalef's diversity index (Species Richness)

Margalef's diversity index (Species Richness) of phytoplankton communities in the Kandla creek and nearby creeks sampling stations was varying from 2.216- 3.597 with an average of 2.901 during the sampling conducted in High tide period of spring tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek region and nearby creeks was varying from 2.048- 2.979 with an average of 2.580 during the consecutive low tide period.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations in Kandla creek and nearby creeks was varying from 2.311- 3.41 with an average of 2.982 during the sampling conducted in High tide period of Neap tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek region and nearby creeks was varying from2.548 - 3.903 with an average of3.102 during consecutive low tide.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations was5.149 at OOT jetty area and 5.163 at SPM area during the sampling conducted in High tide period of spring tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the path finder creek near OOT jetty was 5.743 and 4.488 at SPM during the consecutive low tide period.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations was 3.455 at OOT jetty area and 3.091 at SPM area during the sampling conducted in High tide period of Neap tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the path finder creek near OOT jetty was 3.949 and SPM area was 3.466 during the consecutive low tide period.

Shannon-Wiener's index:

Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.557- 0.816 between selected sampling stations with an average value of 0.727 during high tide period of spring tide at Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.629-0.748 between selected sampling stations with an average value of 0.687 during consecutive low tide at Kandla creek and nearby creeks.

Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.703–0.867 between selected sampling stations with an average value of 0.796 during high tide period of neap tide at Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.711- 0.824 between selected sampling

stations with an average value of 0.773 during consecutive low tide at Kandla creek and nearby creeks.

Shannon-Wiener's Index (H) of phytoplankton communities in the stations was 0.854 at OOT jetty (Vadinar) area and 0.799 at SPM area during the sampling conducted in High tide period of spring tide. While Shannon-Wiener's Index (H) of phytoplankton communities in the path finder creek near OOT jetty was 1.051 and 0.809 at SPM during the consecutive low tide period.

Shannon-Wiener's Index (H) of phytoplankton communities in the stations was 0.884 at OOT jetty (Vadinar) area and 1.013 at SPM area during the sampling conducted in High tide period of Neap tide. While Shannon-Wiener's Index (H) of phytoplankton communities in the path finder creek near OOT jetty was 0.843 and at SPM area was 0.896 during the consecutive low tide period.

Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon-Wiener's index increases as both the richness and the evenness of the community increase. This result indicates that diversity of phytoplankton of Kandla Harbour region and nearby creeks is less but with abundant population of few, with relatively few ecological niches and only very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson's diversity index:

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks, which was varying from 0.506- 0.838 between selected sampling stations with an average of 0.701 during high tide period of spring tide. Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks except few, which was varying from 0.592- 0.753 between selected sampling stations with an average of 0.686 during consecutive low tide.

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations except few in Kandla Harbour region and nearby creeks, during high tide period and low tide period during Neap tide also, which was varying from 0.710 - 0.814 with an average value of 0.762 between selected sampling stations during high tide period and 0.715- 0.782 varying from with an average value of 0.753 between selected sampling stations during consecutive low tide period Low species diversity suggests a relatively few successful species in this habitat.

Simpson diversity index (1-D) of phytoplankton communities in the stations was 0.733 at OOT jetty area and 0.678 at SPM area during the sampling conducted in High tide period of spring tide at Path finder creek. While Simpson diversity index (1-D) of phytoplankton communities in the path finder creek near OOT jetty was 0.813 and 0.739 at SPM during the consecutive low tide period in the path finder creek.

Simpson diversity index (1-D) of phytoplankton communities in the stations was 0.812 at OOT jetty area and 0.888 at SPM area during the sampling conducted in High tide period of Neap tide at Path finder Creek. While Simpson diversity index (1-D) of phytoplankton communities in the path finder creek near OOT jetty was 0.748 and at SPM area was 0.822 during the consecutive low tide period.

Low species diversity suggests a relatively few successful species in this habitat. The environment is quite stressful with relatively few ecological niches and only a few organisms are really well adapted to that environment. Any change in the environment would probably have quite serious effects.

Table No.:-46 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND ,NEAR BY CREEKS DURING SPRING TIDE IN AUGUST 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% Of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	260	21/35	60.00	3.597	0.8159	0.7253
	2	156	14/35	40.00	2.574	0.723	0.7361
	3	208	17/35	48.57	2.998	0.7342	0.6929
	4	357	19/35	54.29	3.062	0.557	0.5064
	5	160	16/35	45.71	2.956	0.7237	0.7074
	6	37	9/35	25.71	2.216	0.8095	0.8378
LOW TIDE	1	215	17/35	48.57	2.979	0.6291	0.5923
	2	182	16/35	45.71	2.882	0.6631	0.6387
	3	140	14/35	40.00	2.631	0.7477	0.7487
	4	132	11/35	31.43	2.048	0.658	0.6997
	5	163	13/35	37.14	2.356	0.7383	0.7526

Table No.:-47 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND ,NEAR BY CREEKS DURING NEAP TIDE IN AUGUST 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	141	14/34	41.18	2.627	0.7025	0.7095
	2	180	13/34	38.24	2.311	0.7174	0.7217
	3	171	18/34	52.94	3.306	0.8196	0.7642
	4	196	19/34	55.88	3.41	0.8279	0.7792
	5	211	19/34	55.88	3.363	0.8671	0.7859
	6	65	13/34	38.24	2.875	0.8435	0.8135
LOW TIDE	1	75	12/34	35.29	2.548	0.7374	0.7571
	2	142	15/34	44.12	2.825	0.7749	0.7429
	3	158	16/34	47.06	2.963	0.7114	0.7151
	4	130	20/34	58.82	3.903	0.8235	0.7684
	5	98	16/34	47.06	3.272	0.8179	0.7818

Table No.:- 48 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND, NEAR BY CREEKS DURING SPRING TIDE IN AUGUST2022

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	DIATOMS	37-347	27/35	77.14
			BLUE GREEN ALGAEN	2-4	4/35	11.43
			DINOFLAGELLATES	3-9	4/35	11.43
			TOTAL PHYTO PLANKTON	**37-357**		
LOW TIDE	Sub surface	5	DIATOMS	130-211	27/35	77.14
			BLUE GREEN ALGAEN	2-4	4/35	11.43
			DINOFLAGELLATES	1-3	4/35	11.43
			TOTAL PHYTO PLANKTON	**132-215**	**35**	-

Table No.:-49 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND, NEAR BY CREEKS DURING NEAP TIDE IN AUGUST 2022

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	DIATOMS	57-205	27/34	79.41
			BLUE GREEN ALGAEN	2-8	4/34	11.76
			DINOFLAGELLATES	4-5	3/34	8.83
			TOTAL PHYTO PLANKTON	**65-211**		
LOW TIDE	Sub surface	5	DIATOMS	74-156	27/34	79.41
			BLUE GREEN ALGAEN	1-4	4/34	11.76
			DINOFLAGELLATES	2-4	3/34	8.83
			TOTAL PHYTO PLANKTON	**75-158**	**34**	-

Table No.:-50 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING SPRING TIDE IN AUGUST 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	jetty	156	27/39	69.23	5.149	0.854	0.733
	SPM	275	30/39	76.92	5.163	0.799	0.678
LOW TIDE	jetty	263	33/39	84.62	5.743	1.051	0.813
	SPM	210	25/39	64.10	4.488	0.809	0.739

Table No.:-51 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING NEAP TIDE IN AUGUST 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	183	19/33	57.58	3.455	0.884	0.812
	SPM	128	16/33	48.48	3.091	1.013	0.888
LOW TIDE	Jetty	204	22/33	66.67	3.949	0.8431	0.748
	SPM	180	19/33	57.58	3.466	0.8957	0.822

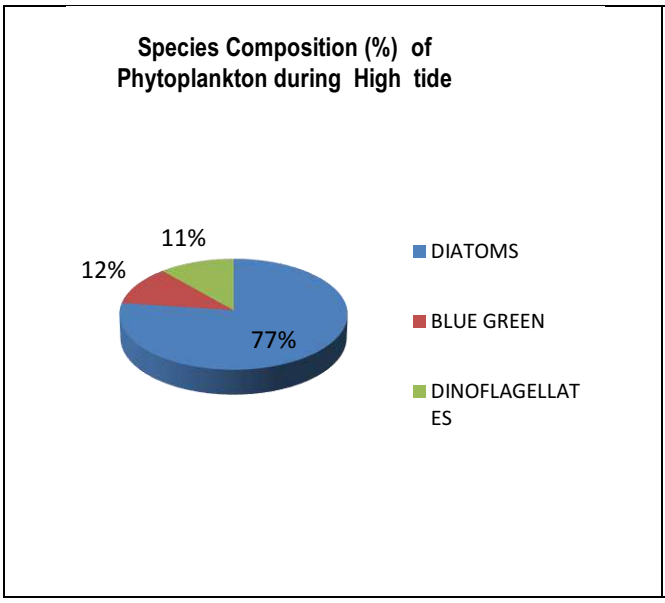
Table No.:-52 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPA OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING SPRING TIDE IN AUGUST 2022

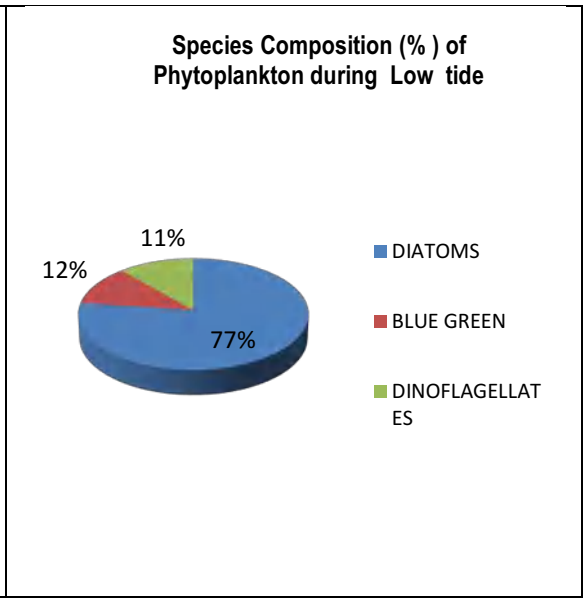
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	BLUE GREEN ALGAEN	1-2	3/39	7.69
			DIATOMS	152-270	32/39	82.05
			DINOFLAGELLATES	3-4	4/39	10.26
			TOTAL PHYTO PLANKTON	**156-275**		
LOW TIDE	Sub surface	2	BLUE GREEN ALGAEN	1-8	3/39	7.69
			DIATOMS	207-250	32/39	82.05
			DINOFLAGELLATES	2-5	4/39	10.26
			TOTAL PHYTO PLANKTON	**210-263**	**39**	

Table No.:- 53 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPA OOT AT PATH FINDER CREEK, VADINAR & NEAR BY SPM, DURING NEAP TIDE IN AUGUST 2022

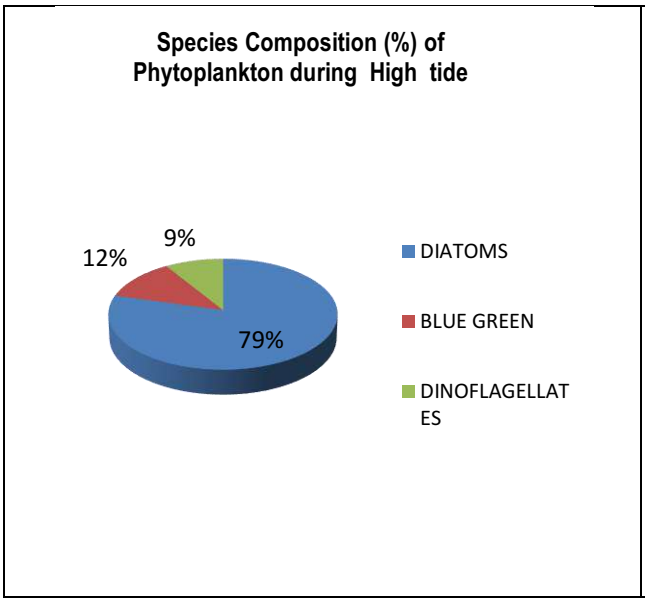
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	BLUE GREEN ALGAEN	1-1	2/33	6.06
			DIATOMS	127-180	28/33	84.85
			DINOFLAGELLATES	2-4	3/33	9.09
			TOTAL PHYTO PLANKTON	**128-183**		
LOW TIDE	Sub surface	2	BLUE GREEN ALGAEN	2-15	2/33	6.06
			DIATOMS	164-202	28/33	84.85
			DINOFLAGELLATES	2-4	3/33	9.09
			TOTAL PHYTO PLANKTON	**180-204**	33	

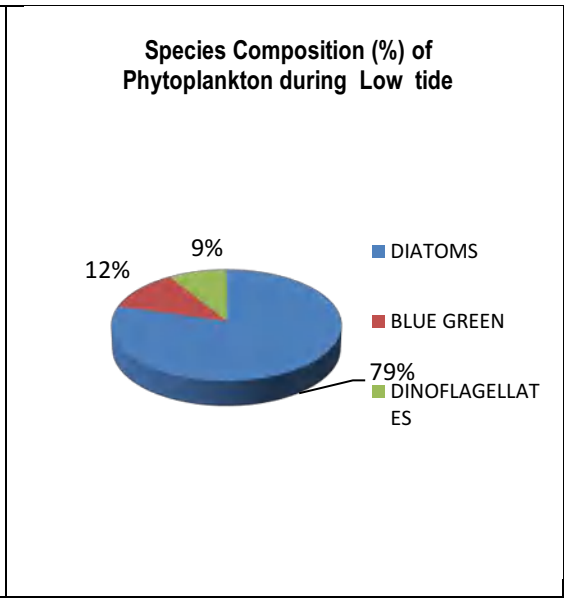
Species Composition (%) of Phytoplankton during High tide and Low tide period during spring tide in Kandala creek and nearby creeks



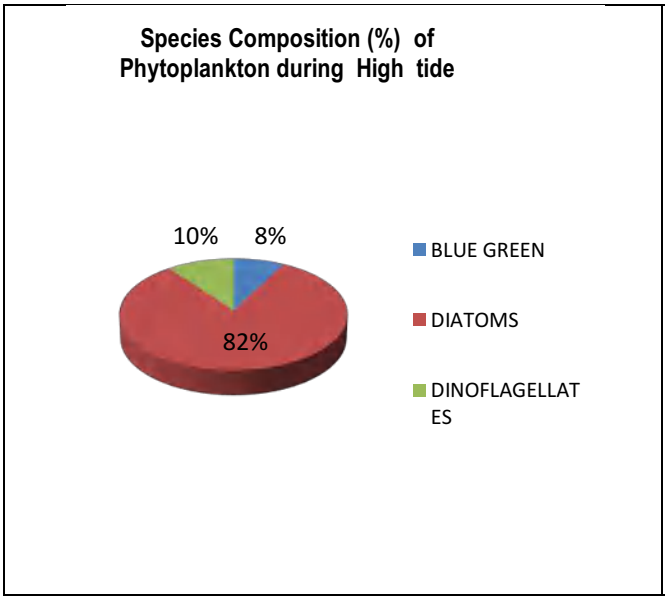


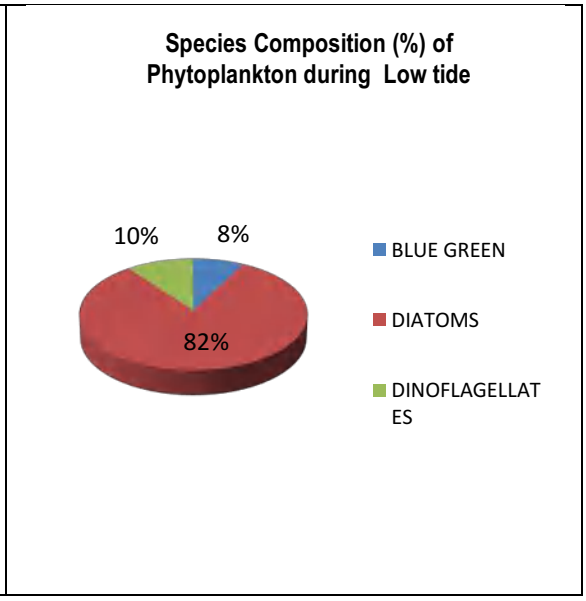
Species Composition (%) of Phytoplankton during High tide and Low tide period during Neap tide in Kandla creek and nearby creeks



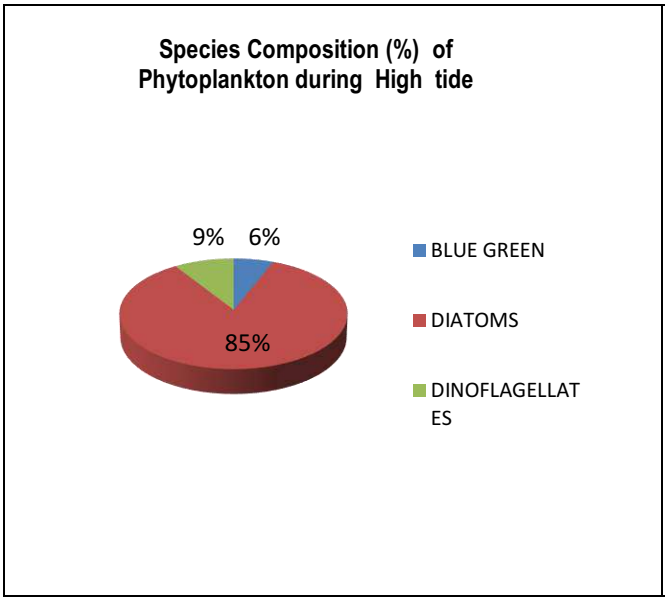


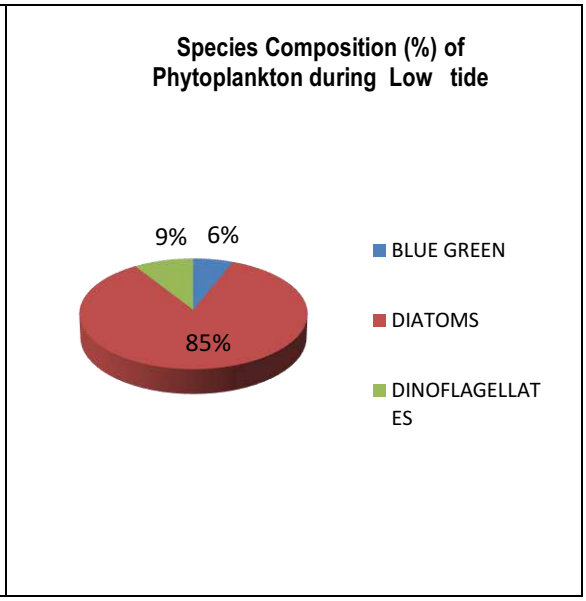
Species Composition (%) of Phytoplankton during High tide and Low tide period during spring tide in Path Finder Creek, Vadinar





Species Composition (%) of Phytoplankton during High tide and Low tide period during Neap tide in Path Finder Creek, Vadinar





ZOOPLANKTON POPULATION:

For the evaluation of the Zooplankton population in DPA harbour area and within the immediate surroundings of the port sampling was conducted from 6 sampling locations (3 in harbour area and two in Nakti creek and one in Khoricreek) during high tide period and low tide period of spring tide and Neap tide in August, 2022. The Zooplankton community of the sub surface water in the harbour and nearby creeks during spring tide was represented by mainly nine groups; Tintinids, Copepods, Rotifers,Arrow worms,Mysids,Urochordata,Ciliates, Foraminiferans, Nematodes and 8 larval forms.The Zooplankton community of the sub surface water in the harbour and nearby creeks during neap tide was represented by mainly seven groups; Tintinids, Copepods,Mysids, Urochordata, Arrow worms, Ciliates,Nematode and 9 larval forms.

Zooplankton of the sampling stations at sub surface layer in the DPA harbour area and nearby creek was varying from 30-90 x10^3 N/ m^3 during high tide and 40-49x10^3 N/ m^3during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPA harbour area and nearby creek was varying from 15-134x10^3 N/ m^3 during high tide and42-98x10^3 N/ m^3during low tide of Neap Tide period.

For the evaluation of the Zooplankton population in DPA OOT jetty area in Path Finder creek and SPM in Vadinar selected 2 sampling locations (1 in jetty area and one near SPM).

During spring tide sampling plankton sample were collected at Jetty area and near SPM during consecutive high tide period and low tide period. During Neap tide sampling Plankton samples were collected from jetty area and SPM during consecutive high tide period and low tide period.

The Zooplankton community of the sub surface water in the path finder creek during spring tide was represented by mainly Six groups Titinids, Copepods, Arrow worms, Urochordata, Mysids, Medusaand 5 larval forms. The Zooplankton community of the sub surface water in the path Finder creeks at Jetty region and SPM during neap tide was represented by mainly seven groups, Tintinnids, Copepods, Arrow worms, Mysids, Urochordata, Foraminifera, Nematodeand 8 larval forms.

Zooplankton of the sampling stations at sub surface layer in the DPA OOT Jetty area of path finder creek was 91 $x10^3$ N/m^3 during high tide and $142x10^3$ N/m^3 during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPASPM area of path finder creek was $131x10^3$ N/ m^3 during high tide and$118x10^3$ N/ m^3 during low tide of spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPA OOT jetty area in path finder creek was recorded $111x10^3$ N/ m^3during high tide and $117x10^3$ N/ m^3 during consecutive low tide period of Neap tide. Zooplankton of the sampling stations at sub surface layer in the DPASPM area in path finder creek was recorded $68x10^3$ N/m^3during high tide and 72 $x10^3$ N/m^3 during consecutive low tide period of Neap Tide.

Species Richness Indices and Diversity Indices:

Margalef's diversity index (Species Richness) S

Margalef's diversity index (Species Richness) of Zooplankton communities in the stations Kandla creek region and nearby creeks were varying from 2.058- 3.778 with an average of 2.988 during the sampling conducted in High tide period. Margalef's diversity index (Species Richness) S of Zooplankton communities varying from 2.338- 3.524 with an average of 2.801 during the sampling conducted in low tide period during Spring tide.

Margalef's diversity index (Species Richness) of Zooplankton communities in the Kandla creek region and nearby creeks sampling stations were varying from 2.373- 3.497 with an average of 2.876 during the sampling conducted in high tide and varying from2.006- 3.49 with an average of 2.683 during the sampling conducted in low tide during Neap tide period.

(pending) Margalef's diversity index (Species Richness) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted inconsecutive High tide period and low tide of spring tide was recorded as 5.986 and 5.448 respectively. Margalef's diversity index (Species Richness) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 4.308 and 3.354 respectively.

Margalef's diversity index (Species Richness) S of Zooplankton communities near Jetty at Path finder creek was varying from 3.61- 3.36 respectively during the sampling conducted in consecutive High tide period and Low tide period of Neap tide. While Margalef's diversity index (Species Richness) of

Zooplankton communities near SPM at Path finder creek were varying from 3.555-2.806 respectively during the consecutive High tide and low tide period.

Shannon-Wiener's index:

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of0.742-0.894 between selected sampling stations with an average value of0.829 during high tide period of spring tide. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.816-1.016 between selected sampling stations with an average value of0.889 during consecutive low tide period.

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.785-0.927 between selected sampling stations with an average value of 0.860 during high tide period of Neap tide. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range 0.680- 0.984 of between selected sampling stations with an average value of 0.827 during consecutive low tide period.

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 1.238-1.262 respectively. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 1.105-1.029 respectively.

Shannon-Wiener's Index (H) of Zooplankton communities near jetty at Path finder creek was varying from 0.969-1.002 respectively during the sampling conducted consecutive High tide period and Low tide period of Neap tide. While Shannon-Wiener's Index (H) of Zooplankton communities near SPM at Path finder creek was varying from 1.012-0.825 during the consecutive High tide and low tide period.

Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon-Wiener's index increases as both the richness and the evenness of the community increase. This result indicates that diversity of Zooplankton of Kandla Harbour region and nearby creeks stations is slightly high with very minimum diverse population but very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson's diversity index:

Simpson diversity index (1-D) of Zooplankton communities was below 0.9 most of sampling stations in the Kandla Harbour region and nearby creeks during high tide and low tide of spring tide period except few stations, which was varying from 0.724-0.82 between selected sampling stations with an

average of 0.794 during high tide period and was varying from 0.823- 0.895 with an average value of 0.852 between selected sampling stations during low tide.

Simpson diversity index (1-D) of Zooplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks during high tide and low tide period of Neap tide except few, which was varying from 0.760- 0.847 between selected sampling stations with an average of 0.824 during high tide period and was varying from 0.684--0.869 with an average value of 0.796 between selected sampling stations during consecutive low tide .This species diversity suggests a relatively few successful species in this habitat during AUGUST2022 sampling.

Simpson diversity index (1-D) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.922 and 0.921 respectively. Simpson diversity index (1-D) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.904 and 0.895 respectively.

Simpson diversity index (1-D) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of Neap tide was recorded as 0.846- 0.872 respectively. Simpson diversity index (1-D) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.885 and 0.794 respectively.

Table No.:- 54 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND NEAR BY CREEKS DURING SPRING TIDEIN AUGUST 2022

Tide	Sampling Station	Abundance In Nx10^3/ m^3	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	73	15/32	46.88	3.263	0.8942	0.82
	2	50	15/32	46.88	3.579	0.8864	0.7984
	3	71	14/32	43.75	3.05	0.8603	0.8197
	4	90	18/32	56.25	3.778	0.8124	0.7238
	5	60	10/32	31.25	2.198	0.7786	0.796
	6	30	8/32	25.00	2.058	0.7424	0.8046
LOW TIDE	1	40	14/32	43.75	3.524	0.9659	0.8667
	2	49	14/32	43.75	3.34	1.016	0.8946
	3	47	10/32	31.25	2.338	0.8175	0.8233
	4	40	10/32	31.25	2.44	0.818	0.8321
	5	45	10/32	31.25	2.364	0.8256	0.8414

Table No.:- 55 ZOOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA HARBOUR AREAAT KANDLA CREEK AND NEAR BY CREEKS DURING NEAP TIDE INAUGUST 2022

Tide	Sampling Station	Abundance In No x10^3/ m^3	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	134	15/32	46.88	2.858	0.8817	0.8268
	2	103	12/32	37.50	2.373	0.8644	0.8471
	3	96	15/32	46.88	3.067	0.9265	0.841
	4	97	17/32	53.13	3.497	0.8411	0.7599
	5	92	14/32	43.75	2.875	0.8602	0.8323
	6	15	8/32	25.00	2.585	0.7846	0.8381
LOW TIDE	1	50	11/32	34.38	2.556	0.7817	0.7959
	2	54	9/32	28.13	2.006	0.7598	0.775
	3	98	17/32	53.13	3.49	0.9844	0.8687
	4	77	15/32	46.88	3.223	0.9308	0.8554
	5	42	9/32	28.13	2.14	0.6804	0.6841

Table No.:- 56 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND NEAR BY CREEKS DURING SPRING TIDE IN AUGUST 2022

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton x10^3 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinids	4-10	6/32	18.74
			Copepods	16-40	9/32	28.12
			Rotifers	1-2	1/32	3.13
			Arrow worms	0-2	1/32	3.13
			Mysids	2-4	1/32	3.13
			Urochordata	2-3	2/32	6.25
			Ciliates	1-4	1/32	3.13
			Larval forms	12-50	8/32	25.00
			Foraminferans	0-1	2/32	6.24
			Nematode	0	1/32	3.13
			TOTAL ZOOPLANKTON N/ M^3	**30-90**	**32**	
LOW TIDE	Sub surface	5	Tintinids	2-8	6/32	18.74
			Copepods	18-29	9/32	28.12
			Rotifers	0-4	1/32	3.13
			Arrow worms	1-2	1/32	3.13
			Mysids	1-2	1/32	3.13
			Urochordata	2-4	1/32	6.25
			Ciliates	1-2	1/32	3.13
			Larval forms	13-21	8/32	25.00
			Foraminferans	1-4	2/32	6.24
			Nematode	0-1	1/32	3.13
			TOTAL ZOOPLANKTON N/M^3	**40-49**	**32**	

Table No.:- 57 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA HARBOUR AREA IN KANDLA CREEK AND, NEAR BY CREEKS DURING NEAP TIDE IN AUGUST 2022

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton x10^3 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinids	4-10	5/32	15.62
			Copepods	4-50	11/32	34.37
			Arrow worms	1-2	1/32	3.13
			Mysids	1-3	2/32	6.25
			Urochordata	2-4	2/32	6.25
			Ciliates	0-1	1/32	3.13
			Larval forms	9-81	9/32	28.12
			Nematode	1-2	1/32	3.13
			TOTAL ZOOPLANKTON N/M^3	**15-134**	**32**	
LOW TIDE	Sub surface	5	Tintinids	8-12	5/32	15.62
			Copepods	8-45	11/32	34.37
			Arrow worms	0-1	1/32	3.13
			Mysids	0-4	2/32	6.25
			Urochordata	0-2	2/32	6.25
			Ciliates	0-1	1/32	3.13
			Larval forms	31-50	9/32	28.12
			Nematode	0	1/32	3.13
			TOTAL ZOOPLANKTON N/M^3	**42-98**	**32**	

Table No.:- 58 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING SPRING TIDE IN AUGUST 2022

Tide	Sampling Station	Abundance In x10^3N / m^3	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	91	28/29	96.55	5.986	1.238	0.922
	SPM	131	22/29	75.86	4.308	1.105	0.904
LOW TIDE	Jetty	142	28/29	96.55	5.448	1.262	0.921
	SPM	118	17/29	58.62	3.354	1.029	0.895

Table No.:- 59 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURINGNEAP TIDE IN AUGUST 2022

Tide	Sampling Station	Abundance In N$x10^3/m^3$	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	111	18/31	58.06	3.61	0.969	0.846
	SPM	68	16/31	51.61	3.555	1.012	0.885
LOW TIDE	Jetty	117	17/31	54.84	3.36	1.002	0.872
	SPM	72	13/31	41.94	2.806	0.825	0.794

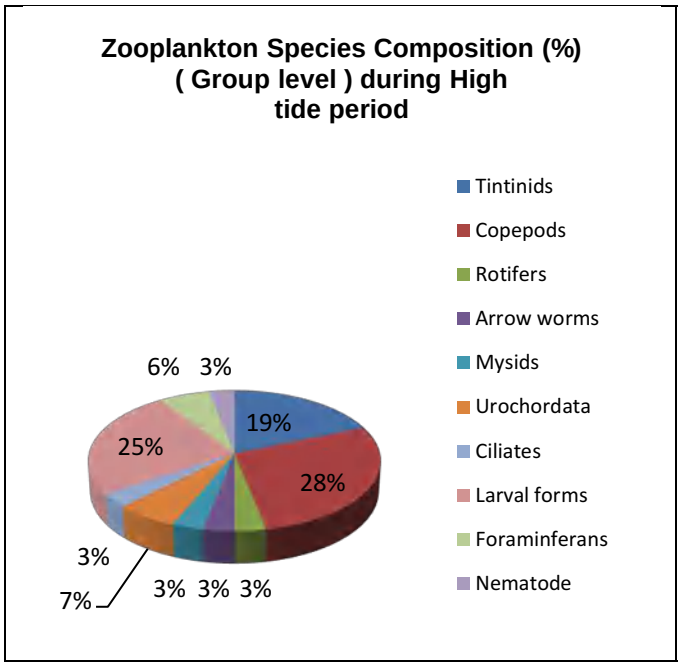
Table No.:- 60 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA OOT AREAATPATH FINDER CREEK AND NEAR BY SPM DURING SPRING TIDE IN AUGUST 2022

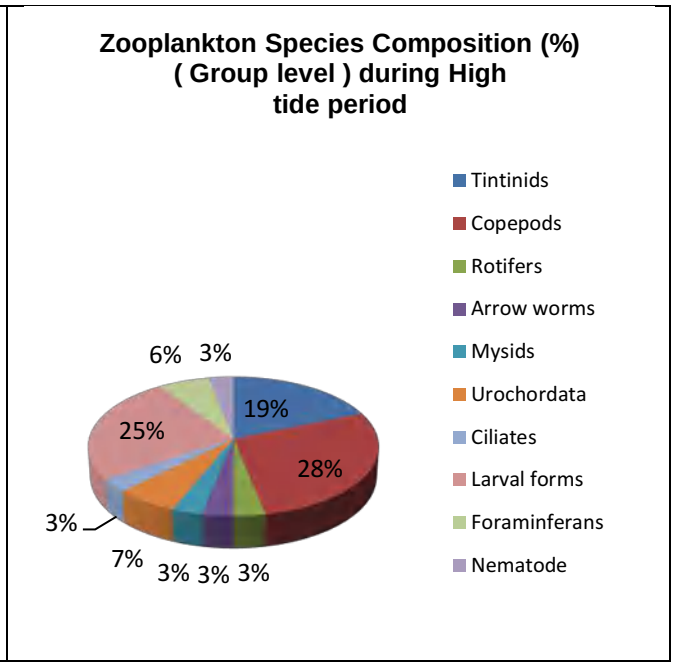
Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^3$ Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	Tintinids	9-24	5/29	17.24
			Copepods	34-56	13/29	44.82
			Arrow worms	1-2	1/29	3.45
			Mysids	2-3	2/29	6.90
			Urochordata	4-5	2/29	6.90
			Medusa	0-1	1/29	3.45
			Larval forms	39-42	5/29	17.24
			TOTAL ZOOPLANKTON NO/L	**91-131**	**29**	
LOW TIDE	Sub surface	2	Tintinids	19-29	5/29	17.24
			Copepods	50-54	13/29	44.82
			Arrow worms	1-4	1/29	3.45
			Mysids	1-4	2/29	6.90
			Urochordata	1-6	2/29	6.90
			Medusa	0-1	1/29	3.45
			Larval forms	41-49	5/29	17.24
			TOTAL ZOOPLANKTON NO/L	**118-142**	**29**	

Table No.:- 61 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING NEAP TIDE IN AUGUST 2022

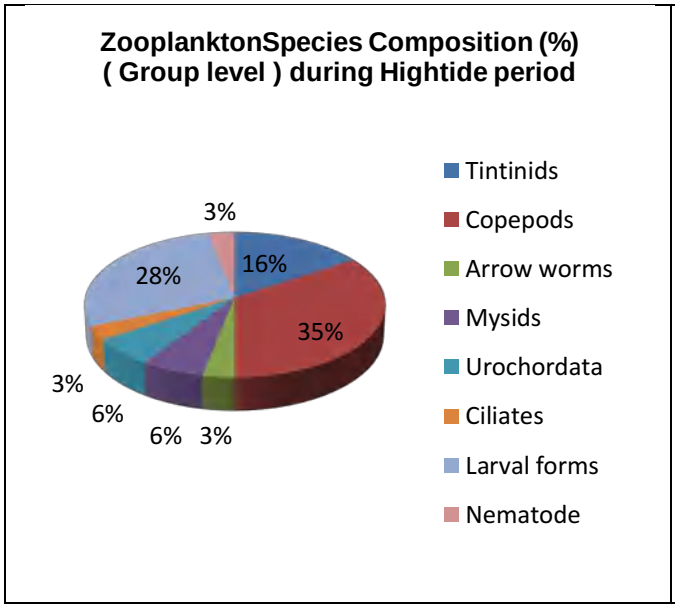
Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^3$ Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	Tintinids	12-18	6/31	19.34
			Copepods	17-22	12/31	38.70
			Arrow worms	0-1	1/31	3.23
			Mysids	0	1/31	3.23
			Urochordata	0-1	1/31	3.23
			Larval forms	32-74	8/31	25.81
			Foraminifera	0-1	1/31	3.23
			Nematode	0-1	1/31	3.23
			TOTAL ZOOPLANKTON	**68-111**	**31**	
LOW TIDE	Sub surface	2	Tintinids	3-17	6/31	19.34
			Copepods	27-34	12/31	38.70
			Arrow worms	0	1/31	3.23
			Mysids	0-2	1/31	3.23
			Urochordata	0	1/31	3.23
			Larval forms	42-64	8/31	25.81
			Foraminifera	0	1/31	3.23
			Nematode	0	1/31	3.23
			TOTAL ZOOPLANKTON	**72-117**	**31**	

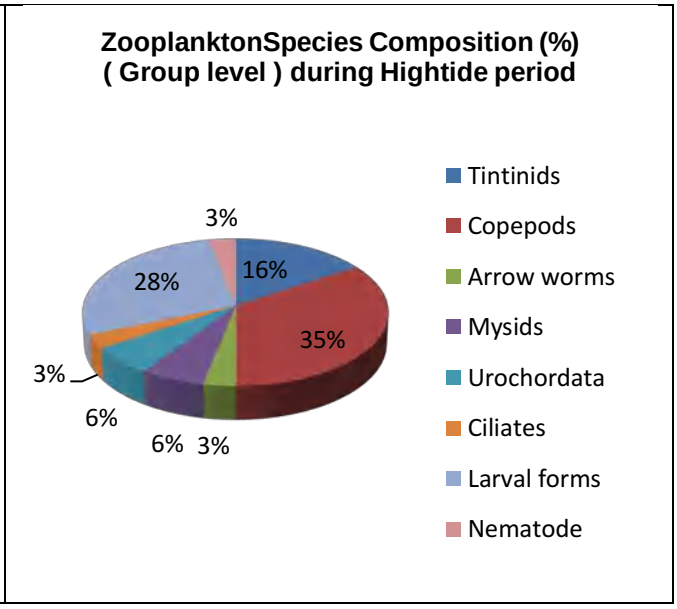
Species Composition (%) of Zooplankton during High tide and Low tide period of Spring tide In Kandla Creek and nearby Creeks



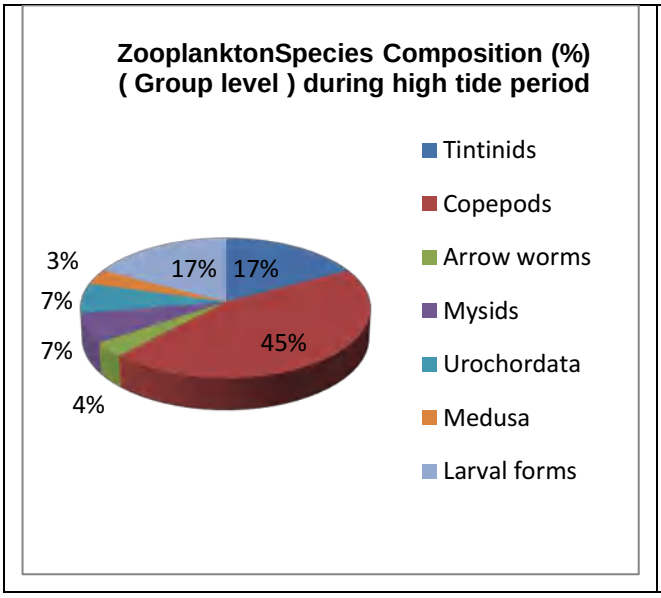


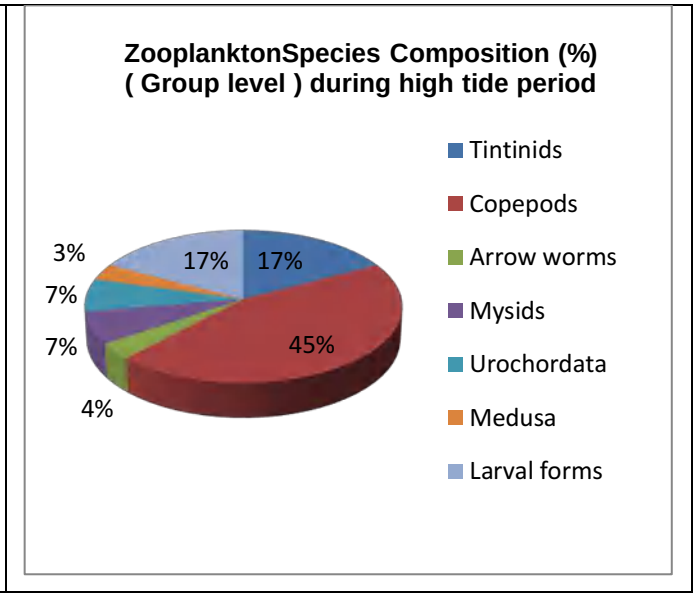
Species Composition (%) of Zooplankton during High tide and Low tide period of Neap tide In Kandla Creek and nearby Creeks



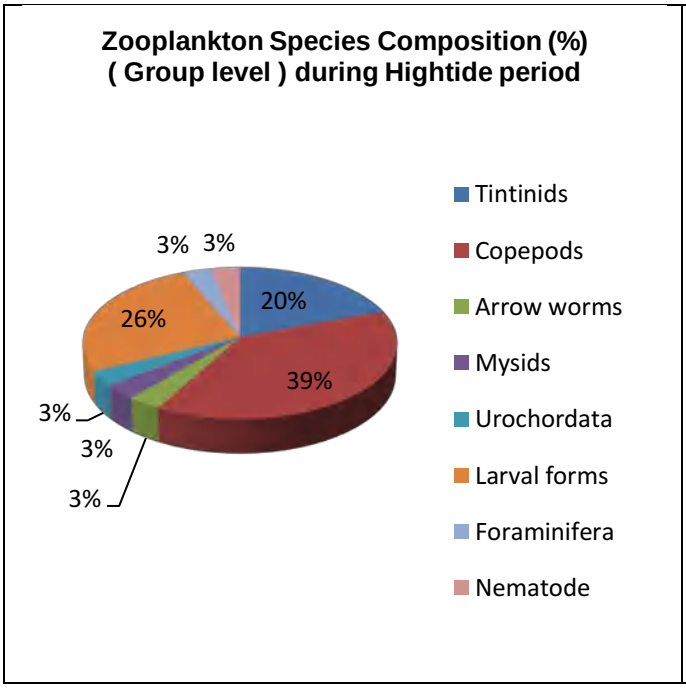


Species Composition (%) of Zooplankton during High tide and Low tide period of Spring tide In Path Finder Creek and near Jetty





Species Composition (%) of Zooplankton during High tide and Low tide period of Neap tide In Path Finder Creek near jetty and nearby SPM



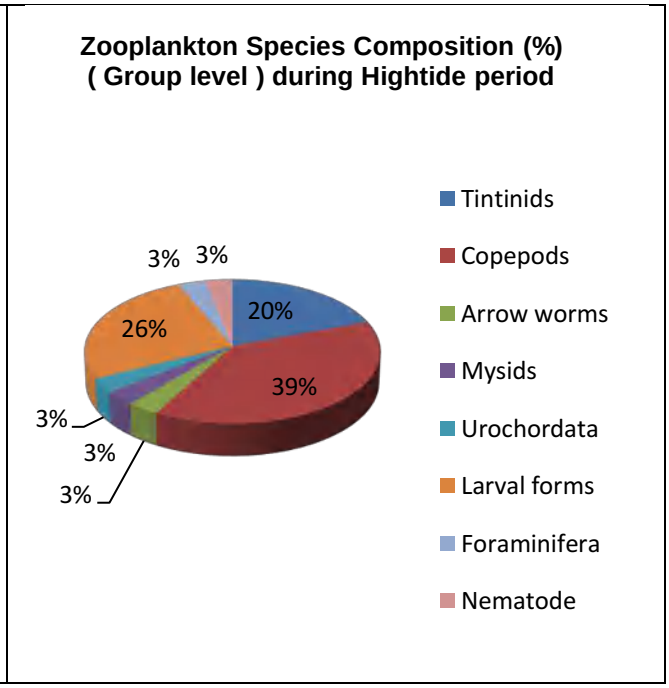


Table No.:- 62 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS OF DPA HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURINGSPRING TIDE OF AUGUST 2022

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAEN ALGAE	Cyanophyta	Cyanophyceae	Nostocales	Oscillatoriaceae	*Arthrospira sp.*	B1	Very sparse
					Lyngbya sp.	B2	Very sparse
					Oscillatoria sp.	B3	Very sparse
			Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B4	Very sparse
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Biddulphiales	Biddulphiaceae	*Biddulphia*sp.	D1	Scattered
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp	D2	Abundant
			Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D3	Scattered
			Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D4	Very sparse
				Hemiaulaceae	*Cerataulina sp.*	D5	Very sparse
					Hemiaulus sp	D6	Very sparse
				Streptothecaceae	*Helicotheca sp*	D7	Very sparse
			Leptocylindrales	Leptocylindraceae	*Leptocylindrus sp*	D8	Very sparse
			Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D9	Dominant
			Rhizosoleniales	Rhizosoleniaceae	*Dactyliosolen sp.*	D10	Very sparse
					Rhizosolenia sp.	D11	Very sparse
			Thalassiosirales	Lauderiaceae	*Lauderia sp*	D12	Very sparse
				Thalassiosiraceae	*Planktoniella sp*	D13	Very sparse
			Triceratiales	Triceratiaceae	*Odontella* sp.	D14	Very sparse
					Triceratium sp.	D15	Very sparse
		Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria* sp.	D16	Very sparse
					*Nitzschia*sp	D17	Very sparse
					Pseudo-ntzschia sp	D18	Sparse
			Naviculales	Naviculaceae	*Navicula* sp	D19	Very sparse
				Pleurosigmataceae	*Pleurosigma* sp	D20	Sparse
				Pinnulariaceae	*Pinnularia sp*	D21	Very sparse
			Surirellales	Surirellaceae	*Surirella* sp	D22	Very sparse
		Fragilariophyceae	Fragilariales	Fragilariaceae	*Asterionellopsis sp*	D23	Sparse
					*Fragilaria*sp	D24	Very sparse

					*Synedra*sp	D25	Sparse
			Thalassionematales	Thalassionemataceae	*Thalassionema sp.*	D26	Very sparse
					Thalassiothrix sp.	D27	Scattered
DINO FLAGELLATES	Dinoflagellata / Dinozoa	Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Very sparse
			Gonyaulacales	Pyrophacaceae	*Pyrophacus sp.*	DF2	Very sparse
				Ceratiaceae	*Ceratium furca*	DF3	Sparse
					Ceratium tripos	DF4	Sparse

Table No.:- 63 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPA HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING AND NEAP TIDE OF AUGUST 2022:

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAEN ALGAE	Cyanophyta	Cyanophyceae	Nostocales	Oscillatoriaceae	*Arthrospira sp.*	B1	Very sparse
					Oscillatoria sp.	B2	Sparse
			Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B3	Very sparse
			Stigonematales	Stigonemataceae	*Stigonema sp.*	B4	Very sparse
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D1	Abundant
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp.	D2	Sparse
			Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D3	Scattered
			Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D4	Very sparse
				Hemiaulaceae	*Cerataulina sp.*	D5	Sparse
				Streptothecaceae	*Helicotheca sp*	D6	Very sparse
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D7	Very sparse
					Guinardia sp.	D8	Very sparse
			Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D9	Dominant
			Thalassiosirales	Thalassiosiraceae	*Planktoniella*sp	D10	Very sparse
				Lauderiaceae	*Lauderia* sp	D11	Very sparse
				Skeletonemataceae	*Skeletonema* sp	D12	Very sparse
			Triceratiales	Triceratiaceae	*Odontella* sp.	D13	Scattered
					Triceratium sp.	D14	Very sparse

		Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria* sp.	D15	Very sparse
					Nitzschia sp	D16	Very sparse
					Pseudo-nitzschia sp.	D17	Very sparse
			Naviculales	Naviculaceae	*Navicula* sp	D18	Very sparse
				Pleurosigmataceae	*Pleurosigma* sp.	D19	Very sparse
			Surirellales	Surirellaceae	*Campylodiscus* sp	D20	Very sparse
					Surirella sp.	D21	Very sparse
		Fragilariophyceae	Fragilariales	Fragilariaceae	*Asterionellopsis sp*	D22	Very sparse
					*Fragilaria*sp	D23	Very sparse
					*Synedra*sp	D24	Sparse
			Licmophorales	Licmophoraceae	*Licmophora sp.*	D25	Very sparse
			Thalassionematales	Thalassionemataceae	*Thalassionema sp.*	D26	Sparse
					Thalassiothrix sp.	D27	Scattered
DINO FLAGELLATES	Dinoflagellata / Dinozoa	Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Very sparse
			Gonyaulacales	Ceratiaceae	*Ceratium furca*	DF2	Very sparse
					Ceratium tripos	DF3	Very sparse

Table No.:- 64 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPA OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINARDURING SPRING TIDE OF AUGUST 2022:

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAEN ALGAE	Cyanophyta	Cyanophyceae	Nostocales	Oscillatoriaceae	*Lyngbya sp.*	B1	Very sparse
					Oscillatoria sp.	B2	Very sparse
			Stigonematales	Stigonemataceae	*Stigonema sp.*	B3	Very sparse
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D1	Scattered
			Chaetocerotales	Chaetocerotaceae	*Bacteriastrum sp*	D2	Very sparse
					Chaetoceros sp	D3	Dominant
			Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D4	Scattered
					Palmeria sp.	D5	Very sparse
			Corethrales	Corethraceae	*Corethron* sp	D6	Very sparse
			Hemiaulales	Bellerocheaceae	*Bellerochea* sp.	D7	Very sparse
				Hemiaulaceae	*Cerataulina sp.*	D8	Very sparse
			Leptocylindrales	Leptocylindraceae	*Leptocylindrus sp*	D9	Very sparse
			Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D10	Abundant
			Melosirales	Melosiraceae	*Melosira sp*	D11	Very sparse
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D12	Very sparse
			Thalassiosirales	Skeletonemataceae	*Skeletonema sp.*	D13	Very sparse
				Lauderiaceae	*Lauderia* sp	D14	Sparse
			Triceratiales	Triceratiaceae	*Odontella* sp.	D15	Scattered
					Triceratium sp.	D16	Sparse
		Bacillariophyceae	Achnanthales	Achnanthaceae	*Achnanthes* sp	D17	Very sparse
			Bacillariales	Bacillariaceae	*Bacillaria* sp.	D18	Sparse
					Nitzschia sp	D19	Very sparse
					*Pseudo-nitzschia*sp	D20	Sparse
			Naviculales	Naviculaceae	*Meuniera sp.*	D21	Very sparse
					Navicula sp	D22	Very sparse
				Pleurosigmataceae	*Pleurosigma* sp	D23	Very sparse
				Pinnulariaceae	*Pinnularia sp*	D24	Very sparse
			Surirellales	Entomoneidaceae	*Entomoneis sp.*	D25	Very sparse

				Surirellaceae	*Surirella* sp.	D26	Very sparse
					Campylodiscus sp	D27	Very sparse
		Fragilariophyceae	Climacospheniales	Climacospheniaceae	*Climacosphenia sp.*	D28	Very sparse
			Fragilariales	Fragilariaceae	*Synedra sp.*	D30	Very sparse
			Striatellales	Striatellaceae	*Striatella sp.*	D31	Very sparse
			Thalassionematales	Thalassionemataceae	*Thalassionema sp.*	D32	Very sparse
					Thalassiothrix sp.	D33	Very sparse
DINOFLAGELLATES	Dinoflagellata / Dinozoa	Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Very sparse
			Dinophysales	Dinophysaceae	*Dinophysis sp.*	DF2	Very sparse
			Gonyaulacales	Ceratiaceae	*Ceratium furca*	DF3	Very sparse
					Ceratium tripos	DF4	Very sparse

Table No.:- 65 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPAOOT AREA AT PATH FINDER CREEKAND NEARBY SPM AT VADINAR DURING AND NEAP TIDE OF AUGUST 2022:

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAEN ALGAE	Cyanophyta	Cyanophyceae	Nostocales	Oscillatoriaceae	*Oscillatoria sp.*	B1	Scattered
			Stigonematales	Stigonemataceae	*Stigonema sp.*	B2	Very sparse
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D1	Sparse
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp	D2	Abundant
			Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D3	Scattered
			Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D4	Very sparse
				Hemiaulaceae	*Cerataulina sp.*	D5	Very sparse
				Streptothecaceae	*Helicotheca sp*	D6	Very sparse
			Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D7	Dominant
			Melosirales	Melosiraceae	*Melosira sp*	D8	Very sparse
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D9	Very sparse
			Thalassiosirales	Lauderiaceae	*Lauderia* sp.	D10	Very sparse
				Thalassiosiraceae	*Planktoniella*sp	D11	Very sparse
					Thalassiosira sp	D12	Very sparse
			Triceratiales	Triceratiaceae	*Odontellasp*	D13	Sparse
					Triceratium sp	D14	Very sparse
		Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria* sp.	D15	Scattered
					Nitzschia sp	D16	Sparse
					*Pseudo-nitzschia*sp	D17	Very sparse
			Naviculales	Naviculaceae	*Navicula* sp	D18	Very sparse
				Pinnulariaceae	*Pinnularia sp*	D19	Very sparse
				Pleurosigmataceae	*Pleurosigma* sp	D20	Sparse
			Surirellales	Entomoneidaceae	*Entomoneis sp.*	D21	Very sparse
				Surirellaceae	*Campylodiscus* sp	D22	Very sparse
					Surirella sp.	D23	Very sparse
		Fragilariophyceae	Fragilariales	Fragilariaceae	*Fragilaria*sp	D24	Very sparse
					Synedra sp.	D25	Dominant

			Licmophorales	Licmophoraceae	*Licmophora sp.*	D26	Scattered
			Thalassionematales	Thalassionemataceae	*Thalassionema sp.*	D27	Very sparse
					Thalassiothrix sp.	D28	Scattered
DINO FLAGELLATES	Dinoflagellata / Dinozoa	Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Very sparse
				Ceratiaceae	*Ceratium furca*	DF2	Very sparse
					Ceratium tripos	DF3	Very sparse

Table No.:- 66 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPA HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKSDURING SPRING TIDE OF AUGUST 2022:

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnus sp.*	T1	Very sparse
				Codonellidae	*Tintinnopsis failakkaensis*	T2	Very sparse
					Tintinnopsis gracilis	T3	Very sparse
					Tintinnopsis radix	T4	Very sparse
				Tintinnidae	*Amphorellopsis sp.*	T5	Very sparse
				Xystonellidae	*Favella sp.*	T6	Very sparse
COPEPODS	ARTHROPODA	Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Scattered
					Parvocalanus sp.	C2	Very sparse
				Acartiidae	*Acartia sp.*	C3	Very sparse
				Clausocalanidae	*Clausocalanus sp.*	C4	Very sparse
				Centropagidae	*Centropages sp.*	C5	Very sparse
				Temoridae	*Temora sp.*	C6	Very sparse
			Cyclopoida	Oithonidae	*Oithona sp.*	C7	Abundant
			Harpacticoida	Ectinosomatidae	*Microsetella* sp.	C8	Sparse
				Euterpinidae	*Euterpina sp.*	C9	Very sparse
ROTIFERS	ROTIFERA	Rotifera Subclass: Eurotatoria	Superorder: Monogononta Order:Ploimida	Brachionidae	*Brachionus plicatilis*	R1	Very Sparse
ARROW WORMS	CHAETOGNATHA	Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse

MYSIDS	ATHROPODA CRUSTACEA	Malacostraca	Mysida, Decapoda	Solenoceridae	*Solenocera sp.*	M1	Very sparse
UROCHORDATA	CHORDATA SUB PHYLUM UROCHORDATA	Appendicularia		Fritillariidae	*Fritillaria sp.*	U1	Very sparse
				Oikopleuridae	*Oikopleura sp.*	U2	Very sparse
CILIATES	CILIOPHORA	Oligohymenophorea	Sessilida	Zoothamniidae	*Zoothamnium sp.*	CI1	Very sparse
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of copepods	L1	Dominant
BRACHYURA LARVAE	ARTHROPODA (CRUSTACEA)	Malacostraca Decapoda			Brachyuran zoea larvae	L2	Very sparse
BARNACLE LARVAE	ATHROPODA CRUSTACEA	Maxillopoda Thecostraca			Cirripede larvae	L3	Very sparse
CYPHONAUTES LARVAE	BRYOZOA				Cyphonautes larvae	L4	Very sparse
FISH LARVAE	CHORDATA SUBPHYLUM: VERTEBRATA	Superclass: Pisces			Fish larvae	L5	Very sparse
ECHINODERMATA LARVAE	ECHINODERMATA				Ophiopluteus larvae	L6	Very sparse
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L7	Very sparse
POLYCHAETE LARVAE	ANNELIDA	Polychaeta			Trochophore larvae	L8	Sparse
FORAMINIFERA	FORAMINIFERA	Globothalamea	Rotaliida	Globigerinidae	*Globigerina* sp.	F1	Very sparse
				Rotalliidae	*Rotalia* sp.	F2	Very sparse
NEMATODE	NEMATODA				Unidentified nematodes	N1	Very sparse

Table No.:- 67 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING OF DPA HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKSDURING NEAP TIDE OF AUGUST 2022:

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnus sp.*	T1	Very sparse
				Codonellidae	*Tintinnopsis failakkaensis*	T2	Very sparse
					Tintinnopsis gracilis	T3	Very sparse
					Tintinnopsis radix	T4	Very sparse
				Xystonellidae	*Favella sp.*	T5	Very sparse
COPEPODS	ARTHROPODA	Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Abundant
					Parvocalanus sp.	C2	Very sparse
				Acartiidae	*Acartia sp.*	C3	Very sparse
				Clausocalanidae	*Clausocalanus sp.*	C4	Very sparse
				Centropagidae	*Centropagessp.*	C5	Very sparse
				Eucalanidae	*Pareucalanus sp.*	C6	Very sparse
					Subeucalanus sp.	C7	Very sparse
				Temoridae	*Temora sp.*	C8	Very sparse
			Cyclopoida	Oithonidae	*Oithona sp.*	C9	Abundant
				Ectinosomatidae	*Microsetella* sp.	C10	Scattered
				Euterpinidae	*Euterpina sp.*	C11	Very sparse
ARROW WORMS	CHAETOGNATHA	Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse
MYSIDS	ATHROPODA CRUSTACEA	Malacostraca	Mysida, Decapoda	Penaeidae	*Metapenaeus sp.*	M1	Very sparse
				Solenoceridae	*Solenocera sp.*	M2	Sparse
UROCHORDATA	CHORDATA SUB PHYLUM UROCHORDATA	Appendicularia		Fritillariidae	*Fritillaria sp.*	U1	Very sparse
				Oikopleuridae	*Oikopleura sp.*	U2	Very sparse
CILIATES	CILIOPHORA	Oligohymenophorea	Sessilida	Zoothamniidae	*Zoothamnium sp.*	CI1	Very sparse
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of copepods	L1	Dominant
BRACHYURA LARVAE	ARTHROPODA (CRUSTACEA)	Malacostraca	Decapoda		Brachyuran zoea larvae	L2	Very sparse
BARNACLE	ATHROPODA	Maxillopoda			Cirripede larvae	L3	Abundant

LARVAE	CRUSTACEA	Thecostraca					
CYPHONAUTES LARVAE	BRYOZOA				Cyphonautes larvae	L4	Very sparse
FISH LARVAE	CHORDATA SUBPHYLUM: VERTEBRATA	Superclass: Pisces			Fish larvae	L5	Very sparse
ECHINODERMATA LARVAE	ECHINODERMATA				Ophiopluteus larvae	L6	Very sparse
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L7	Very sparse
POLYCHAETE LARVAE	ANNELIDA	Polychaeta			Trochophore larvae	L8	Scattered
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of bivalves	L9	Very sparse
NEMATODE	NEMATODA				Unidentified nematodes	N1	Very sparse

Table No.:- 68 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPA OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINARDURING SPRING TIDE OF AUGUST 2022:

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnus sp.*	T1	Sparse
				Codonellidae	*Tintinnopsis failakkaensis*	T2	Very sparse
					Tintinnopsis gracilis	T3	Sparse
					Tintinnopsis radix	T4	Scattered
				Dictyocystidae	*Luminella sp.*	T5	Very sparse
COPEPODS	ARTHROPODA	Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Abundant
					Parvocalanus sp.	C2	Very sparse
				Centropagidae	*Centropages sp.*	C3	Very sparse
				Clausocalanidae	*Clausocalanus sp.*	C4	Very sparse

				Eucalanidae	*Pareucalanus sp.*	C5	Very sparse
					Subeucalanus sp.	C6	Very sparse
				Temoridae	*Temora sp.*	C7	Very sparse
			Cyclopoida	Oithonidae	*Oithona sp.*	C8	Abundant
			Harpacticoida	Clytemnestridae	*Clytemnestra sp.*	C9	Very sparse
				Euterpinidae	*Euterpina sp.*	C10	Scattered
				Ectinosomatidae	*Microsetella* sp.	C11	Sparse
			Poicilostomatatoida	Corycaeidae	*Corycaeus sp.*	C12	Very sparse
				Oncaeidae	*Oncaea sp.*	C13	Very sparse
ARROW WORMS	CHAETOGNATHA	Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse
MYSIDS	ATHROPODA CRUSTACEA	Malacostraca	Mysida, Decapoda	Penaeidae	*Metapenaeus sp.*	M1	Very sparse
				Solenoceridae	*Solenocera sp.*	M2	Very sparse
UROCHORDATA	CHORDATA SUB PHYLUM UROCHORDATA	Appendicularia		Fritillariidae	*Fritillaria sp.*	U1	Very sparse
				Oikopleuridae	*Oikopleura sp.*	U2	Very sparse
MEDUSA	PHYLUM CNIDARIA	Hydrozoa			Unidentified medusa	ME1	Very sparse
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of copepods	L1	Dominant
BRACHYURA LARVAE	ARTHROPODA (CRUSTACEA)	Malacostraca Decapoda			Brachyuran zoea larvae	L2	Very sparse
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L3	Very sparse
POLYCHAETE LARVAE	ANNELIDA	Polychaeta			Trochophore larvae	L4	Scattered
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of bivalves	L5	Sparse

Table No.:- 69 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPAOOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING NEAP TIDE OF AUGUST 2022:

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnus sp.*	T1	Very sparse
				Codonellidae	*Tintinnopsis failakkaensis*	T2	Very sparse
					Tintinnopsis gracilis	T3	Scattered
					Tintinnopsis radix	T4	Sparse
					Tintinnopsis tocantinensis	T5	Very sparse
				Xystonellidae	*Favella* sp.	T6	Very sparse
COPEPODS	ARTHROPODA	Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Scattered
					Parvocalanus sp.	C2	Very sparse
				Centropagidae	*Centropages sp.*	C3	Very sparse
				Clausocalanidae	*Clausocalanus sp.*	C4	Very sparse
				Eucalanidae	*Subeucalanus sp.*	C5	Very sparse
				Temoridae	*Temora sp.*	C6	Very sparse
			Cyclopoida	Oithonidae	*Oithona sp.*	C7	Scattered
			Harpacticoida	Clytemnestridae	*Clytemnestra sp.*	C8	Very sparse
				Euterpinidae	*Euterpina sp.*	C9	Sparse
				Ectinosomatidae	*Microsetella* sp.	C10	Sparse
			Poicilostomatatoida	Corycaeidae	*Corycaeus sp.*	C11	Very sparse
				Oncaeidae	*Oncaea sp.*	C12	Very sparse
ARROW WORMS	CHAETOGNATHA	Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse
MYSIDS	ATHROPODA CRUSTACEA	Malacostraca	Mysida, Decapoda	Penaeidae	*Metapenaeus sp.*	M1	Very sparse
UROCHORDATA	CHORDATA SUB PHYLUM UROCHORDATA	Appendicularia		Oikopleuridae	*Oikopleura sp.*	U1	Very sparse
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of copepods	L1	Dominant
ASCIDIAN	CHORDATA	Ascidiacea			Ascidian tadpole	L2	Very sparse

LARVAE	SUBPHYLUM: TUNICATA				larvae		
BARNACLE LARVAE	ARTHROPODA CRUSTACEA	Maxillopoda Thecostraca			Cirripede larvae	L3	Sparse
CYPHONAUTES LARVAE	BRYOZOA				Cyphonautes larvae	L4	Very sparse
ECHINODERMATA LARVAE	ECHINODERMATA				Ophiopluteus larvae	L5	Very sparse
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L6	Sparse
POLYCHAETE LARVAE	ANNELIDA	Polychaeta			Trochophore larvae	L7	Abundant
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of bivalves	L8	Sparse
FORAMINIFERA	FORAMINIFERA	Globothalamea	Rotaliida	Globigerinidae	*Globigerina sp.*	F1	Very sparse
NEMATODE	NEMATODA				Unidentified nematodes	N1	Very sparse

BENTHIC ORGANISMS:

Few Benthic organisms were observed in the collected sediments by using the Van-veen grabs during the sampling conducted during spring tide period and Neap tide period from DPA harbour region and nearby creek. The meio-benthic organisms during spring tide and Neap tide were represented by Polychaetes *Dasybranchus* sp., Notomastus sp., and *Paraonis* sp. Population of benthic fauna was varying from 10-60 N/m^2 during spring tide and0-40 N/m^2 during Neap tide

Table No.:- 70 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPA HARBOUR AREA CREEKS DURING SPRING TIDE IN AUGUST 2022

ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS						
REPRESENTATION BY GROUP	DPA HARBOUR			CREEKS		
Benthic fauna						
POLYCHAETES	DPA-1	DPA-2	DPA-3	DPA-4	DPA-5	DPA-6
Family : Capitellidae *Dasybranchus* sp.	10	0	0	20	40	-
Family Spionidae *Prinispo* sp.	10	10	20	10	20	-
Total Polychaetes N/M^2	20	10	20	30	60	-
TOTAL Benthic Fauna NUMBER/ M^2	20	10	20	30	60	-

NS : No sample

Table No.:- 70 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPA HARBOUR AREA CREEKS DURING NEAP TIDE IN AUGUST 2022

ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS						
REPRESENTATION BY GROUP	DPA HARBOUR			CREEKS		
Benthic fauna						
POLYCHAETES	DPA-1	DPA-2	DPA-3	DPA-4	DPA-5	DPA-6
Family : Capitellidae *Dasybranchus* sp.	20	0	0	0	10	-
Family Spionidae *Prinispo* sp.	20	0	0	10	30	-
Total Polychaetes N/M^2	40	0	0	10	30	
TOTAL Benthic Fauna NUMBER/ M^2	40	0	0	10	30	

11.0 Conclusive Summary and Remedial measures Suggested

- The AAQ monitoring of five locations at Deendayal Port Kandla indicates that the mean PM_{10} and $PM_{2.5}$ values for four locations viz. Marine Bhavan, Oil Jetty area, Estate Office and Coal storage area were found higher than the permissible limit (standards100 µg/m^3, 60 µg/m^3). The higher concentration of Particulate matter at Marine Bhavan may be due to vehicles emissions during loading-unloading of food grains and timbers; at Oil Jetty area due to industrial activities and heavy vehicles transportation; at Estate office due to construction work, vehicles emission produced from trucks, heavy duty vehicles that pass through the road outside Kandla port and Oil jetty area; while at Coal Storage area lifting of coal from grab yard and other coal handling processes. Moreover, the transportation of coal produces pollution from heavy vehicles. At Gopalpuri location, concentration of PM_{10} varied from 89-119 µg/m^3 and mean value was observed 101 µg/m^3, concentration of $PM_{2.5}$ was ranged from 44-59 µg/m^3 and mean was found 51 µg/m^3. At Tuna port PM_{10} and $PM_{2.5}$ were found within permissible limit of NAAQS.
- The AAQ monitoring signal building concentration of PM_{10} exceed the permissible limit and $PM_{2.5}$ was found within limit while at admin building had PM_{10} concentration was exceed the permissible limit and $PM_{2.5}$ shown slight increased.
- The concentration of monthly average of value was found 124 and 114 µg/m^3 exceed higher (Standard Limit 100 µg/m$^{3)}$. The average concentration of $PM_{2.5}$ at Admin building was found 65 µg/m^3 which was exceed standard limit and at Signal building was found 58 µg/m^3 within the limit (60 µg/m$^{3)}$.
- Further, precautionary measures and management strategies to minimize the effect of particulate as well as gaseous pollutants have also been suggested for achieving its ambient levels in and around Kandla Port and Vadinar Port, Gujarat, India.

- Drinking water at all the twenty locations was found potable and it was found within in line of BIS standards (IS 10500-2012).
- Transportation systems are the main source of noise pollution in project areas. Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. All sampling location were within the permissible limit day time 75 dB(A) and night time 70 dB (A) for the industrial area.

- The treated sewage water of Kandla STP, Deendayal Port Colony (Gopalpuri) and Vadinar were in line with the standards set by the Gujarat Pollution Control Board.
- It was suggested to monitor the STP performance on regular basis to avoid flow of contamination / Polluted water into the sea.
- Good species diversity suggests a relatively successful species in this habitat. A greater number of successful species and a more stable ecosystem. More ecological niches are available and the environment is less likely to be hostile complex food webs environmental change is less likely to be damaging to the ecosystem as a whole.
- The mean day time temperature at Deendayal Port was 29.81 °C. The day-time maximum temperature was 35.4°C and minimum was 25.7 °C. The mean night time temperature recorded was 27.57 °C. The mean Solar Radiation in August month was 109.08 w/m^2. The maximum solar radiation was recorded 663.7 w/m^2 in 6th August, 2022 and the minimum solar radiation was recorded 0.23 w/m^2 in 5th August, 2022. The mean Relative humidity was 88.15 % for the month of August. Maximum Relative humidity was recorded 99.55 % and minimum Relative humidity was recorded 58 %. The average wind velocity for the entire month of August was 0.55 m/s. Maximum wind velocity was recorded 9.2 m/s. The wind direction was mostly West-South.

Reasons for higher Values of PM_{10}

- The unloading of coal directly in the truck, using grabs cause coal to spread in air as well as coal dust to fall on ground. This settled coal dust again mixes with the air while trucks travel through it.
- Also, the coal loaded trucks were not always covered with tarpaulin sheets and these results in spillage of coal from trucks/dumpers during its transit from vessel to yard or storage site. This also increased PM values around marine Bhavan & Coal storage area.

Remedial Measures

The values of PM_{10} & $PM_{2.5}$ during the month of August, 2022 were beyond the permissible limit at all locations mentioned above Except Gopalpuri and Tuna Port. Given below are the remedial measures suggest to minimize the Air pollution.

- During August, 2022 overall ambient air quality of the DPA was within GPCB permissible limits except TSPM, PM_{10}, $PM_{2.5}$ at Coal storage area, Marine Bhavan, Estate Office and Oil Jetty area. To improve air quality the port was using number of precautionary measures,

such as maintained a wide expanse of Green zone, initiated Inter-Terminal Transfer (ITT) of tractor-trailers, Centralized Parking Plaza, providing shore power supply to tugs and port crafts, the use of LED lights at DPA area helps in lower energy consumption and decreases the carbon foot prints in the environment, time to time cleaning of paved and un paved roads, use of tarpaulin sheets to cover dumpers at project sites etc. are helping to achieve the cleaner and green future at port.

Solution towards the Green port:

Today, it is increasingly recognized that air pollution hurts human health. Consequently, efficient mitigation strategies need to be implementation for substantial environmental and health co-benefits.

The guidelines can be considered a basis for governments for the implementation of a strategic plan focused on the reduction of multi pollutant emission, as well as of the overall air pollution related risk.

- The plantation should be all along the periphery of the port and inside and outside the port along with the road. Trees having high dust trapping efficiency (*Azadirachta indica, Cassia fistula, Delonix regia, Ficus religiosa, Pterocarpus marsupium*) are to be grown alongside the roads.
- The water sprinkling should be use at each and every stage of transporting coal up the loading of truck to avoid generation of coal dust.
- The vehicles should be covered during transportation and the vehicle carrying the coal should not be overloaded by raising the height of carriage.
- The water sprinklers should be use during transportation of loaded heavy vehicles on raw road.
- It should be ensure that regular sweeping of coal internal, main road and space a free circulation.
- Practice should be initiated for using mask as preventative measure, to avoid Inhalation of dust particle- Mask advised in sensitive areas.
- Department for use maintenance should have a routine checkup noise level by replacing bearings, tights of all loose parts that can vibrate.
- Speed control is also an effective way to mitigate noise pollution, the lowest sound emission arise from vehicles moving smoothly.
- Use of renewable energy like solar energy should be optimal and ensure to work continuously.

- Keep neat and clean public transport and all basic items at public interaction places as much as possible.
- Technology like Electric cart, Inter-Terminal Transfer (ITT) are worthy selection to reduce Port operation efficiency and fuel cost.
- Conventional RTGCs should be altered as E-RTGCs counting inside the port completely.
- Initiate Natural Gas (CNG) as fuel by all buses and trucks.

Green Ports Initiative

- Deendayal Port is committed to sustainable development and adequate measures are being taken to maintain the Environmental well-being of the Port and its surrounding environs. Weighing in the environmental perspective for sustained growth, the Ministry of Shipping had started „Project Green Ports‟ which will help in making the Major Ports across India cleaner and greener. „Project Green Ports‟ will have two verticals - one is „Green Ports Initiatives‟ related to environmental issues and second is „Swachh Bharat Abhiyaan‟.

- The Green Port Initiatives include twelve initiatives such as preparation and monitoring plan, acquiring equipments required for monitoring environmental pollution, acquiring dust suppression system, setting up of waste water treatment plants/ garbage disposal plant, setting up Green Cover area, projects for energy generation from renewable energy sources, completion of shortfalls of Oil Spill Response (OSR) facilities (Tier-I), prohibition of disposal of almost all kind of garbage at sea, improving the quality of harbour wastes etc.

- Deendayal port has also appointed GEMI as an Advisor for “Making Deendayal Port a Green Port - Intended Sustainable Development under the Green Port Initiatives.

- Deendayal Port has also signed MOU with Gujarat Forest Department in August 2019 for Green Belt Development in an area of 31.942 Ha of land owned by Deendayal Port Trust. The plantation is being carried out by the Social Forestry division of Kachchh.

ENVIRONMENTAL MONITORING REPORT FOR DEENDAYAL PORT AUTHORITY

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ENVIRONMENTAL MONITORING PLAN FOR DEENDAYAL PORT ENVIRONMENTALMONITORING REPORT- SEPTEMBER, 2022

1. EXECUTIVE SUMMARY

Monitoring of various environmental aspects of the Deendayal port by M/s Detox Corporation Pvt. Ltd. has been carried out through collection of samples, analysis of the same, comparing results with respect to the national standards and any other relevant standards by GBCB/CPCB/MoEF & CC to understand status of various parameters in the Environment of the Deendayal Port. The results shall address the identified impacts and suggest measures to minimize the environmental impact due to various operations at Deendayal Port.

A) Ambient Air

The monitoring of Ambient Air quality at 6-locations at Deendayal Port Authority Kandla and 2- location at Vadinar Port on 24 hourly basis for TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2, NH_3, CO_2, CO, C_6H_6 and NMHC in twice a week 24 hourly at uniform intervals (as per NAAQS) at Gopalpuri, Tuna Port, Marine Bhavan building, Coal storage area, Estate building, Oil jetty and at Vadinar port, Vadinar Jetty and Vadinar colony area using respirable dust sampler, Fine particulate sampler and gaseous sampler.

The Maximum TSPM values in month of September 2022 were found 588 µg/m^3 at Coal Storage area on 29.09.2022 and minimum 85 µg/m^3 at Tuna Port on 01.09. 2022. The Maximum PM_{10} values were 434 µg/m^3 at Coal Storage area on 29.09.2022 and minimum was 53 µg/m^3 at Tuna Port on 01.09. 2022. The $PM_{2.5}$ values were found from 144 µg/m^3 maximum at Coal Storage area on 29.09. 2022 and minimum was 24 µg/m^3 at Tuna Port on 01.09. 2022. The PM_{10} and $PM_{2.5}$ values were found for four locations (Marine Bhavan Building, Coal Storage Area and Estate Office Building) to exceed the permissible limit.

At Oil Jetty location concentration of PM_{10} was found slightly exceed the permissible limit, the concentration of $PM_{2.5}$ was within the permissible limit. Gopalpuri and Tuna port, all parameters of ambient air quality were found within the limit.

The AAQ monitoring for Vadinar at Admin building mean value of PM_{10} had shown slightly exceed while $PM_{2.5}$ was within the permissible limit and signal building the concentration of PM_{10} and $PM_{2.5}$ was within the limit.

The overall values of September for Gaseous SO_2, NO_2, NH_3, CO_2, CO, C_6H_6 concentration were within the permissible limit at all location and NMHC were found BQL (Below Quantification Limit).

B) Weather

The mean day time temperature at Deendayal Port was 29.11 °C. The day-time maximum temperature was 34.4°C and minimum was 24.9 °C. The mean night time temperature recorded was 27.51 °C. The mean Solar Radiation in September month was 199.87 w/m^2. The maximum solar radiation was recorded 942.3 w/m^2 in 28th September, 2022 and the minimum solar radiation was recorded 0.93 w/m^2 in 12th September, 2022. The mean Relative humidity was 84.81 % for the month of September. Maximum Relative humidity was recorded 99.0 % and minimum Relative humidity was recorded 64.0 %. The average wind velocity for the entire month of September was 5.64 m/s. Maximum wind velocity was recorded 28.1 m/s. The wind direction was mostly West-South.

C) Marine Ecology (Flora and Fauna) / Marine Water / Sediments:

The results obtained from the study for the month of September 2022 for biological and ecological parameters in marine water for Arabian Sea at surrounding area of Deendayal Port Authority (DPA) Kandla and Vadinar were not affected by Port activities.

D) Drinking Water Quality

The drinking water being supplied to Deendayal Port was safe for drinking purpose. At all drinking water monitoring stations around port area were in line with the standard limit as per the drinking water specifications given in IS 10500:2012 as per tested parameters only.

The average results for 20 locations were as: pH were found Min 7.28 and maximum 7.6, TDS were found min 374.0 mg/l and Max found 1473.0 mg/l, Chloride were found Min 130.29 mg/l and Max 651.45 mg/l, Total Hardness were found Min 380.0 mg/l and Max 568.0 mg/l and Calcium were found Min 36.07 mg/l and Max101.80 mg/l, color were colorless and odor were odorless. In all water samples BOD, Heavy metal like manganese, Hexavalent chromium, Copper, Cadmium, Arsenic, Mercury, Lead, zinc all are found BQL (Below Quantification Limit). The bacterial count (E-coli & Coliform) is absent in all drinking water samples.

E) Monitoring Performance of Sewage Treatment Plant

It was seen that the performance of STP at Deendayal Township, DPA STP Plant and Vadinar STP plant was satisfactory by overall. The treatment plant was well maintained during [September 2022] with considerable removal efficiency achieving the standards prescribed for final disposal. At Gopalpuri STP, the pollutant removal efficiency for Average values of TSS, BOD and COD were 62%, 64% and 66% respectively. At Kandla STP, removal efficiency for TSS, BOD and COD were 52%, 60% and 63% respectively & at Vadinar STP removal efficiency for TSS, BOD and COD was 46%, 42% and 42%

respectively. At all STP location the outlet pH were ranged from 7.21-7.42,Total Suspended Solids were found 24.6-57.5 mg/l , Residual Chlorine were below Detection Limit (Less Than 0.5) , COD were found 20-60mg/l and 3day BOD @ 27 °C were found 6-18.2 mg/l.

F) Noise

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. The Day Time Noise Level (SPL) in all 10 locations at Deendayal Port Authority ranged from 58.7 dB(A) to 74.2 dB(A) while at Vadinar port 3 location ranged from 57.1 dB(A) to 60.5 dB(A) which was within the permissible limits of 75 dB(A) for the industrial area for the daytime. The Night Time Average Noise Level (SPL) in all locations of Deendayal Port Authority ranged from 55.9 dB to 67.7 dB(A) while at Vadinar port ranged from 50.9 dB (A) to 54.8 dB(A) which was within the permissible limits of 70 dB(A) for the industrial area for the night time.

1.0 Introduction

About Deendayal Port

The Deendayal Port is situated in the Kandla Creek and is 90 Kms. From the mouth of Gulf of Kachchh. Latitude: 23° 01" N Longitude: 70° 13"E. Deendayal Port's journey began in 1931 with construction of RCC Jetty by Maharao Khengarji. After partition, Deendayal Port's success story has continued and it rise to the No. 1 Port in India in the year 2007-08 and since then retained the position for the 15 consecutive year. On 31.03.2016, Deendayal Port created history by handling 100 MMT cargoes in a year, the first Major Port to achieve the milestone. Kandla, also known as the Deendayal Port Authority is a seaport in Kutch District of Gujarat state in western India, near the city of Gandhidham. Located on the Gulf of Kutch, it is one of major ports on west coast. Kandla was constructed in the 1950s as the chief seaport serving western India, after the partition of India from Pakistan left the port of Karachi in Pakistan. The Port of Deendayal is located on the Gulf of Kutch on the northwestern coast of India some 256 nautical miles North West of the Port of Karachi in Pakistan and over 430 nautical miles north-northwest of the Port of Mumbai (Bombay). It is the largest port of India by volume of cargo handled. Kandla history Deendayal Port Authority, India's busiest major port in recent years, is gearing to add substantial cargo handling capacity with private sector participation. Deendayal port Authority creates a new record by handling 127.10 million metric tons of cargo during the FY 2021-22, as against 117.566 million metric tons in FY 2020-21. Showing a growth of 8.11 %. Incidentally, DPA is the only major Indian port of handle more than 127 MMT cargo throughout and it has also registered the highest cargo throughput in its history. While the port has flagged off several projects related to infrastructure creation, DPA has successfully awarded the work of augmentation of liquid cargo handling capacity by revamping the existing pipeline network at the oil jetty area in Sept. 2021. Even as much of this growth has come from handling of crude oil imports, mainly for Essar Oil's Vadinar refinery in Gujarat, the port is also taking measures to boost non-POL cargo. Last fiscal, POL traffic accounted for 63 per cent of the total cargo handled at Deendayal Port, as against 59% in 2007-08. The Deendayal Port Authority had commissioned the Off-shore Oil Terminal facilities at Vadinar in the year 1978, for which M/s. Indian Oil Corporation Limited (IOCL) provided Single Bouy Mooring (SBM) system, having a capacity of 54 MMTPA, which was first of its kind in India. Further, significant. Quantum of infrastructural up-gradation has been affected & excellent maritime infrastructure been created at Vadinar for the 32MMTPA Essar Oil Refinery in Jamnagar District. Monitoring of various environmental aspects of the Deendayal port by M/s Detox Corporation Pvt. Ltd. has been carried out through collection of samples, analysis of the same, comparing results with respect to the prescribed standards by GPCB/CPCB/MoEF& CC. The results shall address the identified impacts and suggest measures to minimize the environmental impact due to various operations at Deendayal Port. The environmental monitoring is carried out as per the Environment Management and Monitoring Plan submitted by Detox Corporation Pvt. Ltd.

2. Introduction

Air pollutants are added in the atmosphere from variety of sources that change the composition of atmosphere and affect the biotic environment. The concentration of air pollutants depend not only on the quantities that are emitted from air pollution sources but also on the ability of the atmosphere to either absorb or disperse these emissions. The air pollution concentration vary spatially and temporarily causing the air pollution pattern to change with different locations and time due to changes in meteorological and topographical condition. Air pollution occurs when harmful substances including particulates and biological molecules are introduced into earth's atmosphere. It may cause diseases, allergies or death of humans; it may also cause harm to other living organisms such as animals and food crops, and may damage the natural or built environment. Human activity and natural processes can both generate air pollution. A physical, biological or chemical alteration to the air in the atmosphere can be termed as pollution. It occurs when any harmful gases, dust, smoke enters into the atmosphere and makes it difficult for plants, animals and humans to survive as the air becomes dirty. The consequences of industrialization and the demand for improved quality of life has been increased exposure to air pollution (Vallero, 2014). An air pollutant is a substance in the air that can have adverse effects on humans and the ecosystem. The substance can be solid particles, liquid droplets, or gases. A pollutant can be of natural origin or man-made. Pollutants are classified as primary or secondary. Any gas could qualify as pollution if it reached a high enough concentration to do harm. Theoretically, that means there are dozens of different pollution gases. In practice, about ten different substances cause most concern. Heavy metals represent a class of omnipresent pollutants, with toxic potential, in some cases even at low exposure levels. They concentrate in each tropic level because of their weak mobility, so the concentration in plants is higher than in soil, in herbivore animals higher than in plants, in carnivores' tissues higher than in herbivore, the highest concentration being reached at the end of the tropic chain, at big predacious and human bodies.

Globally, one of the main contributors to emissions of atmospheric pollutants and a significant user of energy is the industrial sector (Conti et al. 2015).

The concentration of air pollutants depends not only on the quantities that are emitted from the polluting sources, but also on the ability of the atmosphere to either absorb or disperse such emissions (USEPA, 2008).

Nowadays, the shipping sector provides low-cost and reliable delivery services in the economic field (Arunachalam et al. 2015). Nevertheless, shipping-related activities have a

considerable impact on air pollution, especially in coastal areas but also globally (Buccolieri et al. 2016). The primary air pollutants are PM, VOCs, NOx, O3, SO2, and CO (Bailey and Solomon 2004). As a consequence, a wide range of options toward "greener" seaports is needed (Bailey and Solomon 2004). Some of these measures are easy to adopt such as the regulation of fuel quality (by using low-sulfur alternative fuels), the speed reduction (Lack et al. 2011), and the use of alternative transportation equipment (Lai et al. 2011).

Clean air is the basic requirement of all living organisms. In recent times, due to population growth, urban sprawl, industrial development, and vehicular boom, the quality of air is deteriorating and being polluted. Pollutants of major public health concerns include particulate matter, carbon monoxide, ozone, nitrogen dioxide, and sulfur dioxide, which pose serious threats to human health and hygiene. In the present study, prime particulate pollutants (PM_{10}, $PM_{2.5}$), and gaseous pollutants (SO_2, and NO_2) were estimated at seven stations in and around Dahej Port, Gujarat, India (Soni and Jagruti Patel, 2017).

Among particulate pollutants, particulate matter (PM) is a ubiquitous entity, and is especially a grave problem due to its higher suspension rate into the atmosphere, and adverse health effects on plants, animals, humans, and materials in the form of visibility reduction, soiling of buildings, etc. (Horaginamani and Ravichandran, 2010; Chaurasia *et al*., 2013).

The sources of air pollutants include vehicles, industries, domestic sources and natural sources. Because of the presence of high amount of air pollutants in the ambient air, the health of the population and property is getting adversely affected. In order to arrest the deterioration in air quality, Govt. of India has enacted Air (Prevention and Control of Pollution) Act in 1981. The responsibility has been further emphasized under Environment (Protection) Act, 1986. It is necessary to assess the present and anticipated air pollution through continuous air quality survey/monitoring programs. Therefore, Central Pollution Control Board had started National Ambient Air Quality Monitoring (NAAQM) Network during 1984 - 85 at national level. The programme was later renamed as National Air Quality Monitoring Programme (NAMP).

2.1 Ambient Air Quality Monitoring

As per the Environmental Monitoring Plan of Deendayal Port Authority, Air monitoring was carried out at six identified locations at Deendayal Port and two locations at Vadinar Port.

Table: 1. Ambient Air Sampling Location

Sr. No.	Name of Location	Location Code	Latitude	Longitude	Remarks
1.	Marine Bhavan	AL-1	23° 0' 26.524"N	70° 13' 22.414"E	**DPA-Kandla**
2.	Oil Jetty	AL-2	23° 1' 45.613"N	70° 13' 11.052"E	
3.	Estate Office	AL-3	23° 1' 11.273"N	70° 12' 48.657"E	
4.	Gopalpuri Hospital	AL-4	23° 4' 53.551"N	70° 8' 7.047"E	
5.	Coal Storage Area	AL-5	22° 59' 31.812"N	70° 13' 9.979"E	
6.	Tuna Port	AL-6	22° 59' 15.291"N	70° 58' 57.018"E	
7.	Signal Building	AL-7	22° 26' 26.750"N	69° 40' 22.127"E	**DPA-Vadinar**
8.	Admin Building	AL-8	22° 26' 25.223"N	69° 40' 19.358"E	

- **Air Quality Monitoring Methodology**

Air quality is measured in all the stations, for 24 hour for Total Suspended Particulate Matter (TSPM), PM_{10}, $PM_{2.5}$, SO_2, NO_2, NH_3 & Benzene and Grab-sampling for CO & CO_2 measurements. The Air samplers are operated for a period of 24 hours and after a continuous operation of 8 hours for gaseous parameters. The absorbing reagents for SO_2:- Absorbing Reagent TCM (Potassium Tetrachloromercurate 0.04M): Mercuric Chloride, Potassium Chloride and EDTA used. For NO_2:- Absorbing Reagent Sodium Hydroxide (NAOH): Sodium Hydroxide and Sodium Arsenite used. For NH_3 need Conc. Sulphuric Acid and Distilled water was used. By replacing 3 times the reagents per day for each parameter namely, SO_2, NO_2, NH_3. The GFA filter paper and PTFE Membrane bound filter paper are used for a period of 24 hours to obtain one sample each of TSPM, PM_{10} & $PM_{2.5}$. The AAQ samples are collected two consecutive days a week as per CPCB guidelines, from all the eight locations as mentioned in the EMP.

2.2 Results

The ambient air quality monitoring data for six stations, viz. Marine Bhavan, Oil Jetty, Port Colony, Gopalpuri Hospital, Tuna Port and Nr. Coal Storage Area for the month of September 2022 are given in Tables 2 to 7. The ambient air quality monitoring data for two stations at Vadinar (Nr. Admin Building &Nr. Signal Building) are given in Tables 8 to 9.

The Movement of heavy transport with uncovered coal transportation, raw road around ambient location may be causes fugitive dust emission from dry conditions. Particulate Matter then enters the atmosphere through the action of wind, vehicular movement, or other activities. The dust produces tends to float in air and spread all around the vicinity. Direction and speed of wind affect the dispersion of the dust particulate matter. Humidity of air also has strong effect on the spreading of particulate matter. With increasing humidity, moisture particles eventually grow in size to a point where ‘dry deposition’ occurs, reducing PM_{10} concentrations in the atmosphere.

Location 1: Marine Bhavan (AL1)

Table 2 : Results of Air Pollutant Concentration at Marine Bhavan										
	Date	**TSPM [µg/m^3]**	**PM_{10} [µg/m^3]**	**$PM_{2.5}$ [µg/m^3]**	**SO_2 [µg/m^3]**		**NOx [µg/m^3]**		**NH_3 [µg/m^3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL1 – 1	01.09.2022	213	132	78	4.16	5.31	15.24	15.01	2.21	4.01
					5.54		13.16		5.39	
					6.23		16.62		4.42	
AL1 – 2	05.09.2022	254	163	85	2.54	3.63	17.31	15.24	5.94	4.60
					4.71		15.24		3.59	
					3.63		13.16		4.28	
AL1 – 3	08.09.2022	403	181	94	5.44	4.95	22.85	22.62	7.46	6.08
					3.26		19.39		4.14	
					6.16		25.62		6.63	
AL1 – 4	12.09.2022	255	155	88	2.90	3.75	17.31	19.39	4.56	4.83
					4.71		21.47		6.49	
					3.63		19.39		3.45	
AL1 – 5	19.09.2022	317	211	94	6.53	5.32	20.08	18.70	5.66	6.95
					4.35		17.31		8.01	
					5.08		18.70		7.18	
AL1 - 6	22.09.2022	333	222	109	2.54	3.87	13.85	15.47	5.11	4.88
					5.44		16.62		6.22	
					3.63		15.93		3.32	
AL1 - 7	26.09.2022	349	238	110	5.08	5.20	14.54	17.08	6.49	6.35
					4.35		19.39		7.46	
					6.16		17.31		5.11	
AL1 – 8	29.09.2022	296	192	96	3.99	4.71	27.70	25.62	3.59	4.70
					5.80		25.62		6.08	
					4.35		23.55		4.42	
Monthly Average		302	187	94		4.59		18.64		5.30
Standard Deviation		61	36	11		0.73		3.83		1.02

Table 2 : Results of Air Pollutant Concentration at Marine Bhavan					
	Date	**C6H6 [µg/m3]**	**HC**	**CO [mg/m3]**	**CO2 [ppm]**
Sampling Period		**8 hr**		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**	**ppm**	**4.0 mg/m3**	**-**
AL1 – 1	01.09.2022	1.154	BDL	1.73	540
AL1 – 2	05.09.2022	1.094	BDL	1.97	893
AL1 – 3	08.09.2022	1.194	BDL	1.51	6836
AL1 – 4	12.09.2022	1.066	BDL	1.61	459
AL1 – 5	19.09.2022	1.223	BDL	1.5	906
AL1 - 6	22.09.2022	1.204	BDL	1.5	632
AL1 - 7	26.09.2022	1.103	BDL	1.35	409
AL1 - 8	29.09.2022	1	BDL	1.26	467
Monthly Average		**1.13**	**-**	**1.55**	**1392.75**
Standard Deviation		**0.08**	**-**	**0.22**	**2207.72**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

At Marine Bhavan, the overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 is attributed mainly by motor vehicle emission produced from various types of automobiles (both diesel and petrol driven). Moreover, the loading and unloading of Food Grains and Timber at Jetty no. 1 and 2 also contributes to the high levels of TSPM and PM_{10}. The mean TSPM value at Marine Bhavan was 302 µg/m^3, the mean PM_{10} value was 187 µg/m^3, and $PM_{2.5}$ value was 94 µg/m^3 which is above the permissible limit prescribed by NAAQS. The average values of SO_2, NO_2 and NH_3 were 4.59 µg/ m^3, 18.64 µg/ m^3 & 5.30 µg/ m^3 respectively; these values were within the permissible limit prescribed by NAAQS.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Marine Bhavan. The mean Benzene concentration was 1.13 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.15 mg/m^3, well below the permissible limit of 4.0 mg/m^3 prescribed by NAAQS.

Location 2: Oil Jetty (AL2)

Table 3 : Results of Air Pollutant Concentration at Oil Jetty

	Date	TSPM [µg/m^3]	PM_{10} [µg/m^3]	$PM_{2.5}$ [µg/m^3]	SO_2 [µg/m^3]		NOx [µg/m^3]		NH_3 [µg/m^3]	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL2 -1	01.09.2022	143	81	49	4.71	4.47	13.16	12.70	5.39	5.99
					5.44		10.39		7.32	
					3.26		14.54		5.25	
AL2 -2	05.09.2022	158	97	57	3.99	3.99	10.39	10.85	4.14	4.93
					4.71		9.70		5.25	
					3.26		12.47		5.39	
AL2 -3	08.09.2022	170	108	59	2.90	2.90	29.09	22.62	1.38	2.76
					3.26		16.62		3.18	
					2.54		22.16		3.73	
AL2 -4	12.09.2022	141	89	50	3.26	3.87	15.24	14.31	3.32	4.10
					3.99		14.54		4.42	
					4.35		13.16		4.56	
AL2 – 5	19.09.2022	175	109	57	3.99	4.59	15.93	16.62	4.70	3.41
					5.44		22.85		2.35	
					4.35		11.08		3.18	
AL2 – 6	22.09.2022	200	120	67	4.71	4.35	19.39	14.08	2.49	3.68
					3.26		8.31		3.45	
					5.08		14.54		5.11	
AL2 – 7	26.09.2022	221	128	65	2.54	2.05	20.78	18.70	6.22	5.48
					1.45		15.24		4.42	
					2.18		20.08		5.80	
AL2 -8	29.09.2022	155	100	54	2.54	3.02	15.24	19.16	4.14	3.50
					2.18		29.09		2.76	
					4.35		13.16		3.59	
Monthly Average		170	104	57		3.66		16.13		4.23
Standard Deviation		28	16	6		0.90		3.88		1.12

Table 3 : Results of Air Pollutant Concentration at Oil Jetty					
	Date	**C_6H_6 [µg/m^3]**	***NMHC**	**CO [mg/m^3]**	**CO2 [ppm]**
Sampling Period		**8 hr**		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL2 -1	01.09.2022	1.114	BDL	1.73	540
AL2 -2	05.09.2022	1.094	BDL	1.97	893
AL2 -3	08.09.2022	1.166	BDL	1.28	3757
AL2 -4	12.09.2022	1.171	BDL	1.9	1413
AL2 – 5	19.09.2022	1.158	BDL	1.63	972
AL2 – 6	22.09.2022	1.059	BDL	1.86	639
AL2 -7	26.09.2022	1.044	BDL	1.53	2072
AL2 -8	29.09.2022	1.173	BDL	1.18	1054
Monthly Average		**1.12**	**-**	**1.64**	**1417.50**
Standard Deviation		**0.05**	**-**	**0.29**	**1061.23**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

Oil Jetty Area, the overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 was mainly by motor vehicle emission produced from various types of vehicles at Oil Jetty Area. The mean TSPM value at Oil Jetty was 170 µg/m^3. The mean PM_{10} value was 104 µg/m^3 which was slightly exceed the permissible limit, $PM_{2.5}$ value was 57 µg/m^3 which is within the permissible limit. The average values of SO_2, NO_2 and NH_3 were within the permissible limit prescribed by NAAQS. The mean concentration of SO_2, NO_2 and NH_3 were 3.66 µg/m^3, 16.13 µg/m^3 and 4.23 µg/m^3 respectively.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Oil Jetty. The mean Benzene concentration was 1.12 µg/m^3 which was well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.64 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 3: Kandla Colony – Estate Office (AL-3)

Table 4 : Results of Air Pollutant Concentration at Estate Office										
	Date	**TSPM [µg/m^3]**	**PM_{10} [µg/m^3]**	**$PM_{2.5}$ [µg/m^3]**	**SO_2 [µg/m^3]**		**NOx [µg/m^3]**		**NH_3 [µg/m^3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL3 – 1	01.09.2022	167	104	54	4.35 2.90 5.08	4.11	15.93 13.16 14.54	14.54	5.25 3.59 4.70	4.51
AL3 – 2	05.09.2022	268	161	95	6.16 4.35 4.71	5.07	12.47 10.39 14.54	12.47	7.04 5.53 4.14	5.57
AL3 – 3	08.09.2022	217	131	74	2.90 5.80 4.71	4.47	20.08 23.55 19.39	21.01	4.28 6.77 3.73	4.93
AL3 – 4	12.09.2022	182	115	63	4.35 7.25 3.99	5.20	14.54 18.04 17.31	16.63	4.70 2.76 5.11	4.19
AL3 – 5	19.09.2022	205	130	71	2.18 4.35 5.44	3.99	23.55 20.78 21.47	21.93	6.49 9.12 8.43	8.01
AL3 – 6	22.09.2022	158	97	51	6.53 4.71 5.80	5.68	17.31 20.78 18.70	18.93	5.53 3.73 7.04	5.43
AL3 – 7	26.09.2022	165	98	55	2.54 5.08 3.63	3.75	15.93 13.16 14.54	14.54	2.90 5.80 4.56	4.42
AL3 – 8	29.09.2022	174	105	63	2.18 5.08 3.99	3.75	12.47 11.77 15.24	13.16	6.35 3.18 4.70	4.74
Monthly Average		192	118	66		4.50		16.65		5.23
Standard Deviation		37	22	14		0.73		3.60		1.22

Table 4 : Results of Air Pollutant Concentration at Estate Office					
Sampling Period	**Date**	**C_6H_6 [µg/m^3]**	***NMHC**	**CO [mg/m^3]**	**CO_2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL3 -1	01.09.2022	1.131	BDL	1.84	2472
AL3 -2	05.09.2022	1.004	BDL	1.8	7985
AL3 -3	08.09.2022	1.194	BDL	1.51	6836
AL3 -4	12.09.2022	1.063	BDL	1.33	957
AL3 – 5	19.09.2022	1.179	BDL	1.67	1775
AL3 – 6	22.09.2022	1.143	BDL	1.55	690
AL3 – 7	26.09.2022	1.21	BDL	1.37	1335
AL3 – 8	29.09.2022	1.141	BDL	1.25	729
Monthly Average		**1.13**	**-**	**1.54**	**2847.38**
Standard Deviation		**0.07**	**-**	**0.22**	**2893.29**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 at Kandla Port Colony (Estate Office) was attributed by vehicle emission produced from trucks and heavy duty vehicles that pass through the road outside Kandla Port Colony. The mean TSPM values at Kandla port Colony were 192 µg/m^3, the mean PM_{10} value was 118 µg/m^3, and $PM_{2.5}$ value was 66 µg/m^3 which is above the permissible limit prescribed by NAAQS. The average values of SO_2, NO_2 and NH_3 were 4.50 µg/m^3, 16.65 µg/m^3 and 5.23 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Kandla Port Colony. The mean Benzene concentration was 1.13 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide was 1.54 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 4: Gopalpuri Hospital (AL-4)

Table 5 : Results of Air Pollutant Concentration at Gopalpuri Hospital										
	Date	**TSPM [µg/m^3]**	**PM_{10} [µg/m^3]**	**$PM_{2.5}$ [µg/m^3]**	**SO_2 [µg/m^3]**		**NOx [µg/m^3]**		**NH_3 [µg/m^3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL4 -1	01.09.2022	109	66	38	4.35	4.83	12.47	10.85	5.25	4.10
					6.89		9.70		2.76	
					3.26		10.39		4.28	
AL4 -2	05.09.2022	138	88	43	6.53	6.17	15.93	14.31	6.22	5.34
					7.62		13.16		4.70	
					4.35		13.85		5.11	
AL4 -3	08.09.2022	119	72	39	3.63	5.08	8.31	9.47	2.35	2.58
					6.16		10.39		1.93	
					5.44		9.70		3.45	
AL4 -4	12.09.2022	107	66	31	2.54	3.63	14.54	13.62	4.56	3.68
					4.71		12.47		3.59	
					3.63		13.85		2.90	
AL4 – 5	19.09.2022	142	94	45	1.81	2.66	11.08	11.31	5.39	4.14
					3.99		9.70		2.76	
					2.18		13.16		4.28	
AL4 – 6	22.09.2022	142	86	44	5.80	4.59	17.31	18.70	3.59	5.25
					3.63		20.78		6.91	
					4.35		18.01		5.25	
AL4 – 7	26.09.2022	149	95	49	2.90	3.99	12.47	14.08	2.49	3.55
					5.44		15.24		4.83	
					3.63		14.54		3.32	
AL4 – 8	29.09.2022	170	103	64	2.90	4.35	5.54	6.93	6.35	5.15
					5.44		6.93		5.66	
					4.71		8.31		3.45	
Monthly Average		135	84	44		4.41		12.41		4.22
Standard Deviation		22	14	10		1.04		3.58		0.98

Table 5 : Results of Air Pollutant Concentration at Gopalpuri Hospital					
Sampling Period	**Date**	**C_6H_6 [µg/m^3]**	***NMHC**	**CO [mg/m^3]**	**CO_2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL4 -1	01.09.2022	1	BDL	1.82	3689
AL4 -2	05.09.2022	1.076	BDL	1.64	7443
AL4 -3	08.09.2022	1.134	BDL	7.06	3193
AL4 -4	12.09.2022	1.066	BDL	1.61	459
AL4 – 5	19.09.2022	1.131	BDL	1.52	885
AL4 – 6	22.09.2022	1.029	BDL	1.58	879
AL4 – 7	26.09.2022	1.01	BDL	1.3	1643
AL4 – 8	29.09.2022	1.159	BDL	1.17	597
Monthly Average		**1.08**	**-**	**2.21**	**2348.50**
Standard Deviation		**0.06**	**-**	**1.97**	**2387.50**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 at Gopalpuri Hospital was attributed by vehicle emission produced from light motor vehicles of the colony residents. The mean TSPM values at Gopalpuri Hospital were 135 µg/m^3, the mean PM_{10} value was 84 µg/m^3 and $PM_{2.5}$ was 44 µg/m^3 which was within the permissible limit. The average values of SO_2, NO_2 and NH_3 were 4.41 µg/m^3, 12.41 µg/m^3 and 4.22 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Gopalpuri Hospital. The mean Benzene concentration was 1.08 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon monoxide concentration was 2.21 mg/m^3 which is well below the permissible limit of 4.0 mg/m^3.

Location 5: Coal Storage Area (AL-5)

Table 6 : Results of Air Pollutant Concentration at Coal Storage Area										
	Date	**TSPM [µg/m^3]**	**PM_{10} [µg/m^3]**	**$PM_{2.5}$ [µg/m^3]**	**SO_2 [µg/m^3]**		**NOx [µg/m^3]**		**NH_3 [µg/m^3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL6 – 1	01.09.2022	472	347	116	4.71	4.83	23.55	21.24	5.94	4.97
					3.63		20.78		4.01	
					6.16		19.39		4.97	
AL6 – 2	05.09.2022	392	292	95	2.90	4.47	15.93	17.08	8.15	6.77
					4.71		17.31		6.49	
					5.80		18.01		5.66	
AL6 – 3	08.09.2022	482	412	108	7.25	5.44	22.85	23.08	4.56	5.52
					3.99		24.93		7.04	
					5.08		21.47		4.97	
AL6 – 4	12.09.2022	386	288	92	2.54	3.50	19.39	17.31	3.18	4.05
					4.71		15.24		4.83	
					3.26		17.31		4.14	
AL6 – 5	19.09.2022	512	374	116	5.08	5.56	12.47	14.08	5.94	5.71
					7.25		15.24		4.70	
					4.35		14.54		6.49	
AL6 – 6	22.09.2022	552	409	139	6.89	5.68	21.47	21.24	6.22	5.34
					4.71		23.55		4.70	
					5.44		18.70		5.11	
AL6 – 7	26.09.2022	462	350	108	2.54	3.87	14.54	13.39	3.32	4.38
					3.63		12.47		5.25	
					5.44		13.16		4.56	
AL6 – 8	29.09.2022	588	434	144	4.71	4.59	20.78	18.70	6.91	6.58
					5.08		16.62		7.18	
					3.99		18.70		5.66	
Monthly Average		481	363	115		4.74		18.27		5.42
Standard Deviation		70	54	19		0.80		3.48		0.96

Table 6 : Results of Air Pollutant Concentration at Coal Storage Area					
Sampling Period	**Date**	**C_6H_6 [µg/m^3]**	***NMHC**	**CO [mg/m^3]**	**CO_2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL5 – 1	01.08.2022	01.09.2022	1.22	BDL	1.82
AL5 – 2	04.08.2022	05.09.2022	1.046	BDL	2.05
AL5 – 3	08.08.2022	08.09.2022	1.109	BDL	1.98
AL5 – 4	12.08.2022	12.09.2022	1.105	BDL	1.48
AL5 – 5	16.08.2022	19.09.2022	1.223	BDL	1.5
AL5 – 6	20.08.2022	22.09.2022	1.07	BDL	1.26
AL5 – 7	23.08.2022	26.09.2022	1.196	BDL	1.15
AL5 – 8	26.08.2022	29.09.2022	1.19	BDL	1.18
Monthly Average		**1.15**	**-**	**1.55**	**1796.13**
Standard Deviation		**0.07**	**-**	**0.36**	**1357.08**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 at Coal Storage Area was comparatively highest among all the locations of Air Quality monitoring in Kandla Port. High values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 at this location was due to lifting of coal with grab and other coal handling processes near Berth no. 6 & 7. Moreover, the traffic was also heavy around this place for transport of coal thus emissions produced from heavy vehicles. The mean TSPM values at Coal storage were 481 µg/m^3, the mean PM_{10} value was 363 µg/m^3, and the $PM_{2.5}$ value was 115 µg/m^3 which was above the permissible limit prescribed by NAAQS. The average values of SO_2, NO_2 and NH_3 were 4.74 µg/m^3, 18.27 µg/m^3 and 5.42 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Coal Storage Area. The mean Benzene concentration was1.15 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.55 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 6: Tuna Port (AL-6)

Table 7 : Results of Air Pollutant Concentration at Tuna Port										
	Date	**TSPM [µg/m^3]**	**PM_{10} [µg/m^3]**	**$PM_{2.5}$ [µg/m^3]**	**SO_2 [µg/m^3]**		**NOx [µg/m^3]**		**NH_3 [µg/m^3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL5 -1	01.09.2022	85	53	24	3.63	4.35	14.54	13.39	2.21	2.76
					5.08		12.47		2.90	
					4.35		13.16		3.18	
AL5 – 2	05.09.2022	104	67	27	2.18	2.42	10.39	9.00	6.08	5.39
					1.45		7.62		4.56	
					3.63		9.00		5.53	
AL5 – 3	08.09.2022	90	63	25	1.45	2.06	16.62	15.47	2.76	3.59
					2.18		14.54		3.87	
					2.54		15.24		4.14	
AL5 – 4	12.09.2022	89	57	27	4.71	4.32	9.70	11.31	6.22	5.30
					3.16		12.47		4.56	
					5.08		11.77		5.11	
AL5 – 5	19.09.2022	126	85	40	3.99	4.35	16.62	16.16	3.73	5.20
					4.71		14.54		6.91	
					4.35		17.31		4.97	
AL5 – 6	22.09.2022	112	78	31	1.81	1.69	19.39	21.47	8.56	7.64
					2.18		23.55		9.39	
					1.09		21.47		4.97	
AL5 – 7	26.09.2022	121	80	35	3.63	4.96	15.93	17.08	8.98	8.01
					5.44		18.70		7.74	
					5.80		16.62		7.32	
AL5 – 8	29.09.2022	129	88	40	3.26	3.38	9.70	12.01	5.25	5.52
					3.99		13.85		6.35	
					2.90		12.47		4.97	
Monthly Average		107	72	31		3.44		14.49		5.43
Standard Deviation		18	12	7		1.24		3.91		1.78

Table 7 : Results of Air Pollutant Concentration at Tuna Port					
	Date	C_6H_6 [µg/m^3]	*NMHC	CO [mg/m^3]	CO_2 [ppm]
Sampling Period		8 hr		Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m3		4.0 mg/m3	-
AL6 -1	01.09.2022	1.059	BDL	1.98	3416
AL6 – 2	05.09.2022	1.034	BDL	1.47	8217
AL6 – 3	08.09.2022	1.063	BDL	1.52	2598
AL6 – 4	12.09.2022	1.018	BDL	1.83	421
AL6 – 5	19.09.2022	1.114	BDL	1.31	744
AL6 – 6	22.09.2022	1.138	BDL	1.64	551
AL6 – 7	26.09.2022	1.135	BDL	1.77	1110
AL6 – 8	29.09.2022	1.116	BDL	1.53	952
Monthly Average		**1.08**		**1.63**	**2251.13**
Standard Deviation		**0.05**		**0.22**	**2634.12**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The mean TSPM values at Tuna Port was 107 µg/m^3, the mean PM_{10} value was 72 µg/m^3, the mean $PM_{2.5}$ value was 31 µg/m^3 which is within the permissible limit prescribed by NAAQS. The average values of SO_2, NO_2 and NH_3 were 3.44 µg/m^3, 14.49 µg/m^3 and 5.43 µg/m^3 respectively and were all within the permissible limit prescribed by NAAQS.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Tuna Port. The mean Benzene concentration was 1.08 µg/m3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.63 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 7: Admin Building (Vadinar) (AL-7)

Table 8 : Results of Air Pollutant Concentration at Admin Building										
	Date	**TSPM [µg/m^3]**	**PM_{10} [µg/m^3]**	**$PM_{2.5}$ [µg/m^3]**	**SO_2 [µg/m^3]**		**NOx [µg/m^3]**		**NH_3 [µg/m^3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL7 -1	01.09.2022	159	109	43	3.02	5.14	10.39	16.54	6.45	5.79
					5.44		14.43		4.83	
					2.72		11.54		8.17	
AL7 -2	05.09.2022	168	117	47	3.93	5.24	13.27	18.28	9.44	6.37
					4.84		10.97		7.94	
					3.02		15.00		7.02	
AL7 -3	08.09.2022	164	110	48	4.53	3.75	16.16	24.62	6.79	5.18
					3.32		18.47		7.60	
					2.72		13.27		5.99	
AL7 -4	12.09.2022	150	101	42	5.14	4.33	10.97	15.58	8.52	7.07
					6.65		10.39		7.94	
					3.93		7.50		8.06	
AL7 -5	15.09.202	134	95	34	3.32	4.23	11.54	19.43	6.79	4.34
					3.63		15.00		7.25	
					4.84		9.81		6.10	
AL7 -6	19.09.2022	147	97	43	3.02	4.84	10.97	15.00	9.32	2.76
					2.72		13.85		8.75	
					4.53		9.23		9.67	
AL1 -7	22.09.2022	160	106	50	3.63	4.33	8.66	16.35	5.87	5.22
					5.14		10.97		7.25	
					3.93		7.50		6.33	
AL1-8	26.09.2022	180	118	54	4.23	4.03	12.12	23.85	8.29	3.53
					2.72		14.43		6.91	
					5.44		16.16		5.99	
AL1-9	29.09.2022	134	95	37	3.32	4.73	11.54	19.04	8.63	6.91
					4.84		10.39		7.94	
					6.04		7.50		7.14	
Monthly Average		155	105	44		4.51		18.75		5.24
Standard Deviation		15	9	6		0.50		3.46		1.48

Table 8 : Results of Air Pollutant Concentration at Admin Building Vadinar					
Sampling Period	**Date**	**C_6H_6 [µg/m^3]**	***NMHC**	**CO [mg/m^3]**	**CO_2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL7 -1	01.09.2022	1.1	BQL	1.94	387
AL7 -2	05.09.2022	1.06	BQL	1.71	420
AL7 -3	08.09.2022	1.04	1.81	1.81	411
AL7 -4	12.09.2022	1.15	BQL	1.65	529
AL7 -5	15.09.2022	1.15	BQL	1.6	533
AL7 -6	19.09.2022	1.04	BQL	1.95	352
AL7 -7	22.09.2022	1.07	BQL	1.9	384
AL7 -8	26.09.2022	1.15	BQL	1.69	432
AL7 -9	29.09.2022	1.05	BQL	1.36	390
Monthly Average		**1.09**	**-**	**1.73**	**426**
Standard Deviation		**0.05**	**-**	**0.19**	**64**

*NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

At Admin Building, Vadinar the mean TSPM value was 155 µg/m^3, the mean PM_{10} value was 105 µg/m^3 which was slightly exceed the permissible limit, the mean $PM_{2.5}$ value was 44 µg/m^3 which was within the permissible limit. The average values of SO_2, NO_2 and NH_3 concentrations were 4.51 µg/m^3, 18.75 µg/m^3 and 5.24 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Vadinar Port. The mean Benzene concentration was 1.09 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.73 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 8: Signal Building (Vadinar) (AL-8)

Table 9 : Results of Air Pollutant Concentration at Signal Building Vadinar										
	Date	**TSPM [µg/m^3]**	**PM_{10} [µg/m^3]**	**$PM_{2.5}$ [µg/m^3]**	**SO_2 [µg/m^3]**		**NOx [µg/m^3]**		**NH_3 [µg/m^3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL8 -1	01.09.2022	137	97	37	3.93	5.64	14.43	14.81	5.29	7.10
					3.32		17.31		7.14	
					1.81		12.70		4.49	
AL8 -2	05.09.2022	153	103	42	2.42	4.10	10.97	27.70	5.76	5.45
					3.02		15.00		4.95	
					3.63		13.27		6.45	
AL8 -3	08.09.2022	146	99	38	4.23	3.88	15.00	16.35	8.29	6.27
					3.32		11.54		6.33	
					4.84		13.85		5.64	
AL8 -4	12.09.2022	142	97	35	2.72	4.63	9.81	17.31	5.06	4.83
					3.93		11.54		6.10	
					5.14		13.27		7.94	
AL8 -5	15.09.202	152	101	45	3.63	3.93	16.16	19.24	4.14	4.11
					5.44		11.54		5.29	
					6.04		9.23		6.56	
AL8 -6	19.09.2022	141	95	39	3.02	4.73	12.12	13.85	8.98	4.18
					2.72		15.58		7.14	
					4.84		17.31		8.17	
AL8 -7	22.09.2022	153	98	49	6.04	4.23	15.00	23.08	6.79	3.91
					5.44		12.70		7.60	
					3.93		10.39		7.02	
AL8-8	26.09.2022	158	101	48	5.14	4.23	9.23	18.28	6.22	5.68
					3.93		11.54		7.14	
					3.02		12.12		8.06	
AL8-9	29.09.2022	165	108	50	4.23	5.44	11.54	21.35	6.79	6.79
					5.14		13.27		8.17	
					6.35		10.97		6.33	
Monthly Average		150	100	43		4.54		19.11		5.37
Standard Deviation		9	4	6		0.64		4.36		1.19

Table 9 : Results of Air Pollutant Concentration at Signal Building Vadinar					
		C_6H_6 [µg/m^3]		CO [mg/m^3]	CO_2 [ppm]
Sampling Period	**Date**	**8 hr**	***NMHC**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL8 -1	01.09.2022	1.17	BQL	2.13	432
AL8 -2	05.09.2022	1.09	BQL	2.1	412
AL8 -3	08.09.2022	1.06	BQL	1.47	398
AL8 -4	12.09.2022	1.21	BQL	1.64	603
AL8 -5	15.09.2022	1.02	BQL	1.01	569
AL8 -6	19.09.2022	1.19	BQL	1.82	612
AL8 -7	22.09.2022	1.03	BQL	1.01	563
AL8 -8	26.09.2022	1.08	BQL	1.81	578
AL8 -9	29.09.2022	1.17	BQL	2.03	613
Monthly Average		**1.11**	**-**	**1.67**	**531**
Standard Deviation		**0.07**	**-**	**0.43**	**90**

* NMHC- Non- Methane Hydrocarbon
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

At Signal Building, Vadinar the mean TSPM value was 150 µg/m^3, the mean PM_{10} value was 100 µg/m^3 which was boundary line of the permissible limit, the mean $PM_{2.5}$ value was 43 µg/m^3 which was within the permissible limit. The average values of SO_2, NO_2 and NH_3 concentrations were 4.55 µg/m^3, 19.11 µg/m^3 and 5.37 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Vadinar Port. The mean Benzene concentration was 1.11 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.67 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Fig. No:-1 Average ambient air qulaity (PM) month of September-2022 at DPA and Vadinar Sampling Station

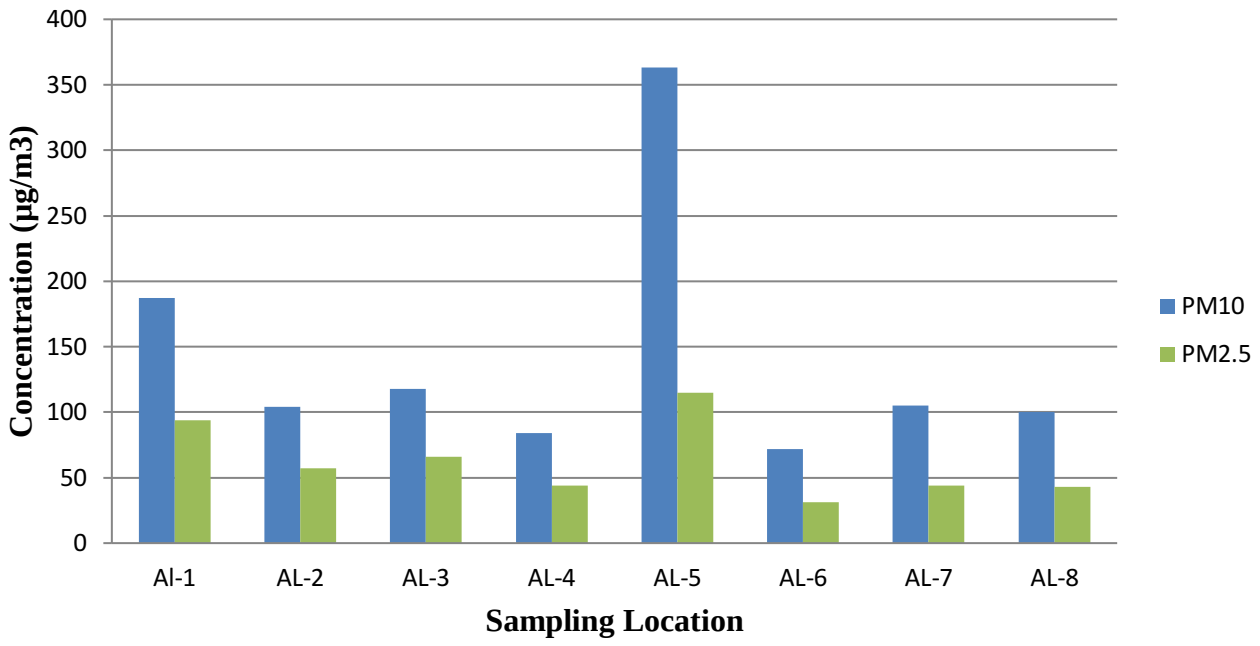


Fig. No:-2. Average ambient air qulaity (Gaseous) month of August-2022 at DPA and Vadinar sampling location

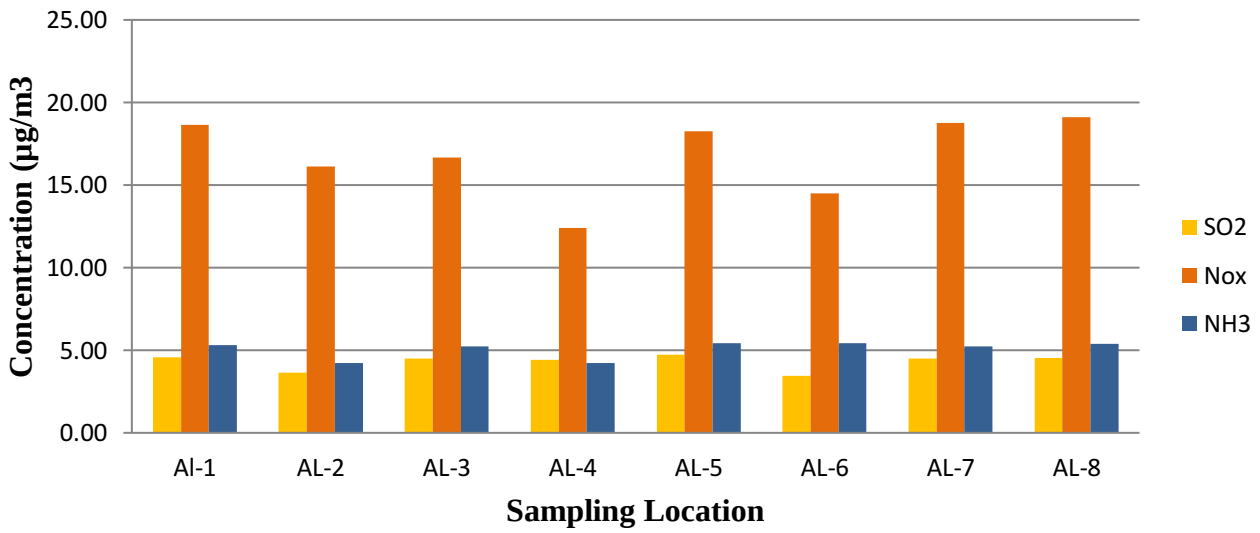


Fig. No:-3. Average ambient air qulaity (Gaseous) month of September-2022 at DPA and Vadinar sampling location

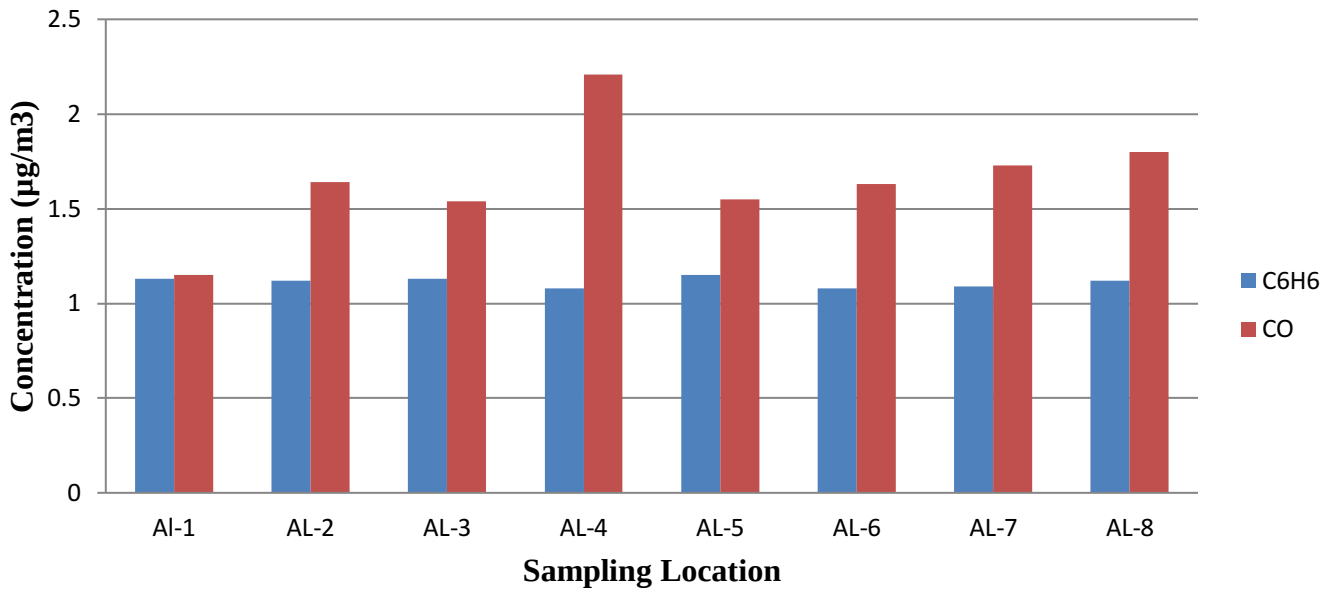
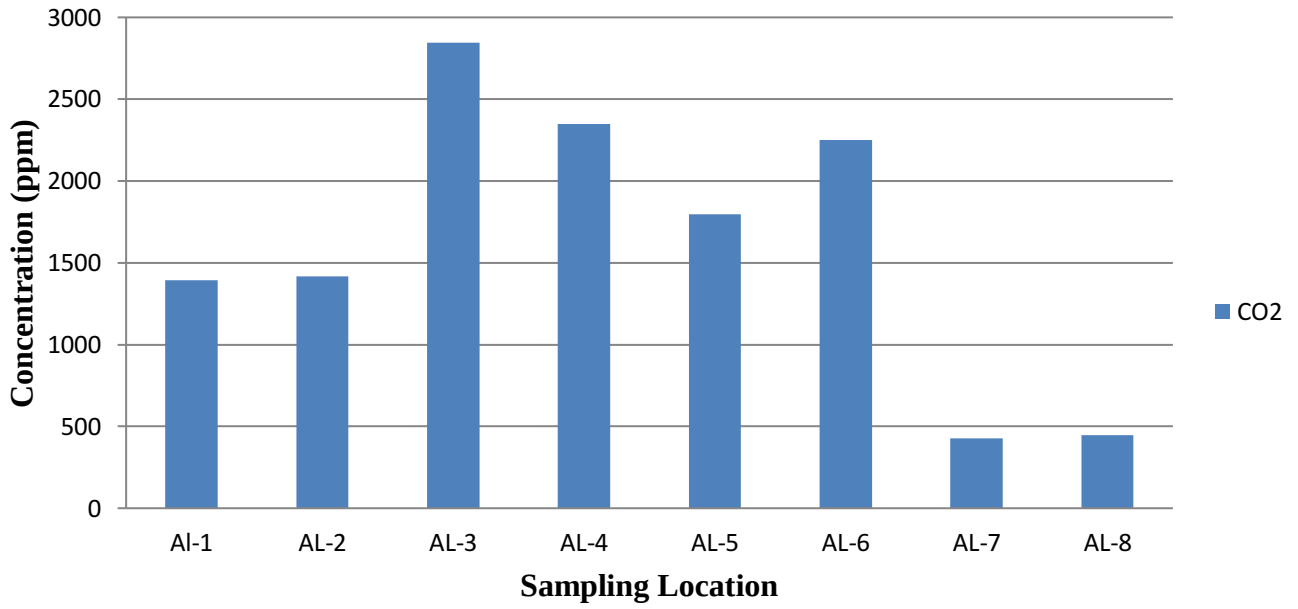


Fig. No:-4. Average ambient air qulaity (Gaseous) month of September-2022 at DPA and Vadinar sampling location



2.3 Observations and Conclusion

During the monitoring period, the overall Ambient Air Quality of the port area was found within permissible levels for various gaseous pollutants. However, Total Suspended Particulate matter as TSPM, Particulate matter as PM_{10} and $PM_{2.5}$ was found to exceed the limits at locations like Near Coal storage area, Marine Bhavan and Estate Office.

The concentration of PM_{10} was slightly exceeded at Oil Jetty while the mean concentration of $PM_{2.5}$ was within the limit. At Gopalpuri and Tuna Port location concentration of monitored parameters of ambient air quality were found within the limit.

The mean concentration of PM_{10} was slightly exceeded at Admin building Vadinar & at Signal building Vadinar was boundary line (100 $\mu g/m^3$) of permissible limit while the mean concentration at both location of $PM_{2.5}$ was found within permissible limit.

4.1 Meteorological Data

Automatic Weather station (ID KAZPHOEN424) have been installed in Seva Sadan-3 at the Deendayal Port which records the data on Temperature (°C), Relative Humidity (%),Wind speed (m/s),Wind Direction (°), Solar radiation (w/m²) and Rainfall mm.

Meteorological factors play an important role in environmental pollution studies particularly in pollutant transport irrespective of their entry into the environment. The wind speed and direction play a major role in dispersion of environment pollutants. Effects of pollution on receptors animate and inanimate depends on atmospheric condition.

Temperature

At Deendayal Port, the day time temperature was found range 24.9-34.4^{0}C. The average day time temperature was 29.11°C. The night time temperature was range from 24.6-32.3^{0}C. The mean night time temperature recorded was 27.51 °C.

Solar Radiation

The mean Solar Radiation in September month was 200.01 w/m^2. The maximum solar radiation was recorded 942.3 w/m^2 in 28th September, 2022 and the minimum solar radiation was recorded 0.93 w/m^2 in 12th September, 2022.

Rainfall

Rain fall of September month with an average rainfall was recorded 56.00 mm.

Relative Humidity

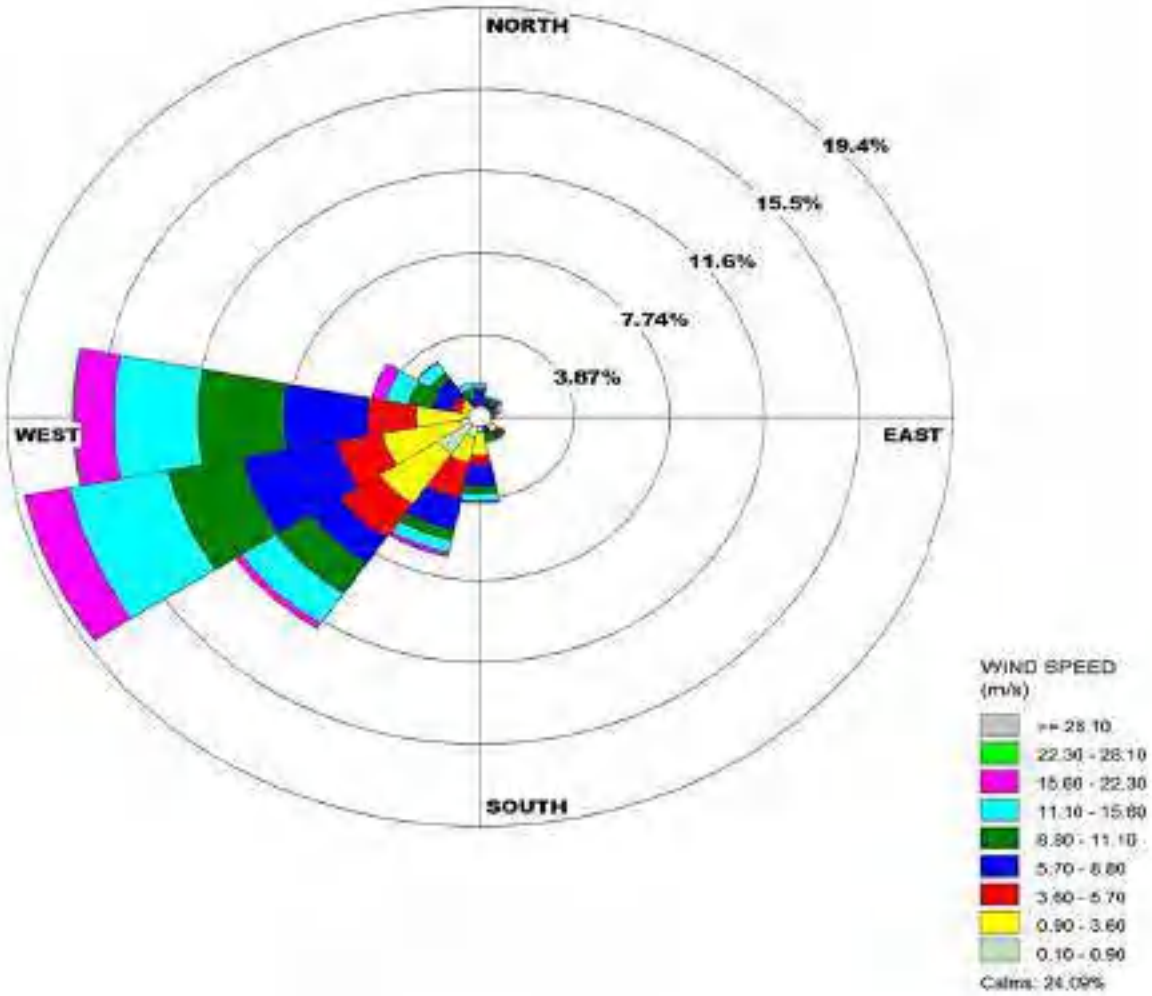
The mean Relative humidity was 84.81 % for the month of September. Maximum Relative humidity was recorded 99.0 % and minimum Relative humidity was recorded 64.0 %.

Wind Velocity and Wind Direction

Velocity and direction of wind have a significant role in the dispersion of air borne materials and therefore determines the air quality of the area. The average wind velocity for the entire month of September was 5.64 m/s. Maximum wind velocity was recorded 28.1 m/s. The wind direction was mostly West-South.

WIND ROSE PLOT:
M/s. Deendayal Port Authority (DPA)
Project Site, Sevasadan-3, Kandla Port

DISPLAY:
Wind Speed
Direction (blowing from)



COMMENTS:	DATA PERIOD:	COMPANY NAME:	
	Start Date: 01-09-2022 - 10:00 End Date: 30-09-2022 - 23:00	M/s. Deendayal Port Authority (DPA)	
		MODELER: M/s. Eco Chem Sales & Services	
	CALM WINDS: 24.09%	TOTAL COUNT: 1398 hrs.	
	AVG. WIND SPEED: 5.84 m/s	DATE: 06-10-2022	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

4.0 Drinking Water Quality Monitoring

Drinking Water Quality Monitoring was carried out at twenty stations at Kandla, Vadinar & Township Area of Deendayal Port.

Table No:-10. Drinking Water Sampling Location

Sr. No.	Name of Location	Location Code	Latitude	Longitude
1.	Nirman Building	DL-1	23° 0' 27"N	70° 13' 21"E
2.	P & C Building	DL-2	23° 0' 33"N	70° 13' 20"E
3.	North Gate	DL-3	23° 0' 26.97"N	70° 13' 21.87"E
4.	KPT-Canteen	DL-4	23° 2' 17.2674"N	70° 13'18.2814"E
5.	West Gate	DL-5	23° 59' 40.48"N	70° 12' 50.96"E
6.	Wharf Area	DL-6	22° 59' 52.2"N	70° 13' 22.95"E
7.	Sevasadan-3	DL-7	23° 0' 22.55"N	70° 13' 15.34"E
8.	Workshop	DL-8	23° 0' 33.74"N	70° 13' 20.05"E
9.	Custom Building	DL-9	23° 1' 8.70"N	70° 12' 52.0"E
10.	Kandla Colony	DL-10	23° 11' 14.9"N	70° 12' 48.4"E
11.	KPT Hospital	DL-11	23° 1' 5.02"N	70° 12' 44.38"E
12.	A.O. Building	DL-12	23° 3' 42.89"N	70° 8' 41.5"E
13.	Gopalpuri School	DL-13	23° 5' 1.03"N	70° 7' 55.42"E
14	Gopalpuri Guest House	DL-14	23° 4' 43.14"N	70° 7' 51.92"E
15.	E-Type Quarters	DL-15	23° 4' 59.90"N	70° 7' 56.72"E
16.	F-Type Quarters	DL-16	23° 4' 38.45"N	70° 8' 8.63"E
17.	Gopalpuri Hospital	DL-17	23° 4' 54.09"N	70° 8' 7.5"E
18.	Tuna Port	DL-18	23° 58' 23.06"N	70° 5' 35.6"E
19.	Vadinar Jetty	DL-19	22° 25' 51.73"N	69° 41' 36.62"E
20.	Vadinar Colony	DL-20	22° 30' 26.25"N	69° 39' 45.03"E

4.1 Drinking Water Monitoring Methodology

Samples for physico-chemical analysis were collected in 2 Carboys and samples for microbiological parameters were collected in sterilized bottles. These samples were then analyzed in laboratory for various drinking water parameters at Kandla Lab/Surat.

The Sampling was done as per IS: 3025 Part-1, analysis was done as per IS: 3025/APHA standard methods and, the analysis results compare with IS 10500:2012. The water samples were analyzed for various parameters, viz. Color , Odor, Turbidity , Conductivity , pH , Chlorides , TDS, Total Hardness, Iron , Sulphate, Salinity , DO, BOD, Na, K, Ca, Mg, F, NO_3, NO_2, Mn, Cr-6, Cu, Cd, As, Hg, Pb, Zn, Bacterial Count (CFU) .

4.2 Results

The Drinking Water Quality monitoring data for 20 stations are given in below from table No. 11 to Table No. 17

Table 11: Drinking Water Quality Monitoring Parameters for Nirman Building, P & C Building and Main Gate (North) at Kandla.

Sr. No.	Parameter	Unit	Nirman Building 1	P & C Building	Main Gate North	Acceptable Limits as per IS 10500 :2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.41	7.51	7.37	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved	mg/l	445	450	449	500	2000
3	Turbidity	NTU	1	0	1	1	5
4	Odor	-	-	-	-	Agreeable	Agreeable
5	Color	-	-	-	-	5	15
6	Conductivity	µs/cm	941	908	892	NS*	NS*
7	Biochemical Oxygen	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	175.39	150.33	145.32	250	1000
9	Ca as Ca	mg/l	38.48	36.07	40.08	75	200
10	Mg as Mg	mg/l	76.30	80.68	86.99	30	100
11	Total Hardness	mg/l	410	422	458	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	1.01	1.20	0.97	1	1.5
14	Sulphate as SO_4	mg/l	38.47	37.54	37.54	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	2.08	1.21	6.04	45	No Relaxation
17	Salinity	‰	0.32	0.27	0.26	NS*	NS*
18	Sodium as Na	mg/l	107.82	107.29	110.44	NS*	NS*
19	Potassium as K	mg/l	3.61	3.55	3.47	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100 ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe- 0.009 mg/l, Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu- 0.004 mg/l, Cd- 0.003 mg/l, As- 0.003mg/l, Hg- 0.001 mg/l, Pb- 0.006mg/l, Zinc- 0.021 mg/l).

Table 12: Drinking Water Quality Monitoring Parameters for Canteen, West Gate – I & Wharf Area at Kandla

Sr. No.	Parameter	Unit	Canteen	West Gate – I	Wharf Area	Acceptable Limits as per IS	Permissible Limits in the absence of Alternate Source as
1	pH	-	7.28	7.43	7.53	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	470	452	466	500	2000
3	Turbidity	NTU	0	0	1	1	5
4	Odor	-	-	-	-	Agreeable	Agreeable
5	Color	-	-	-	-	5	15
6	Conductivity	µs/cm	936	904	933	NS*	NS*
7	Biochemical Oxygen	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	190.42	155.35	180.40	250	1000
9	Ca as Ca	mg/l	41.68	37.68	42.48	75	200
10	Mg as Mg	mg/l	98.66	84.08	90.88	30	100
11	Total Hardness	mg/l	510	440	480	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	1.32	1.29	1.21	1	1.5
14	Sulphate as SO4	mg/l	40.43	37.31	41.35	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	37.72	2.55	6.17	45	No Relaxation
17	Salinity	‰	0.34	0.28	0.33	NS*	NS*
18	Sodium as Na	mg/l	113.91	109.93	111.24	NS*	NS*
19	Potassium as K	mg/l	5.02	3.37	5.06	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 13: Drinking Water Quality Monitoring Parameters for Sewa sadan–3, Workshop I and Custom Building at Kandla

Sr. No.	Parameter	Unit	Sewa Sadan – 3	Workshop	Custom Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.33	7.41	7.37	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	458	454	374	500	2000
3	Turbidity	NTU	1	0	0	1	5
4	Odor	-				Agreeable	Agreeable
5	Color	-				5	15
6	Conductivity	µs/cm	915	908	747	NS*	NS*
7	Biochemical	mg/l				NS*	NS*
8	Chloride as Cl	mg/l	140.31	185.41	170.38	250	1000
9	Ca as Ca	mg/l	39.28	40.08	36.87	75	200
10	Mg as Mg	mg/l	96.71	71.93	82.13	30	100
11	Total Hardness	mg/l	496	396	430	200	600
12	Iron as Fe	mg/l				0.3	No Relaxation
13	Fluorides as F	mg/l	1.38	1.43	1.07	1	1.5
14	Sulphate as SO_4	mg/l	37.43	35.69	37.07	200	400
15	Nitrite as NO_2	mg/l				NS*	NS*
16	Nitrate as NO_3	mg/l	3.49	1.28	1.34	45	No Relaxation
17	Salinity	‰	0.25	0.33	0.31	NS*	NS*
18	Sodium as Na	mg/l	108.70	93.00	110.12	NS*	NS*
19	Potassium as K	mg/l	3.45	3.34	3.22	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 14: Drinking Water Quality Monitoring Parameters for Port Colony Kandla, Hospital Kandla and A.O. Building at Gandhidham.

Sr. No.	Parameter	Unit	Port Colony Kandla	Hospital Kandla	A.O. Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 :
1	pH	-	7.28	7.31	7.42	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	454	400	411	500	2000
3	Turbidity	NTU	1	1	1	1	5
4	Odor	-				Agreeable	Agreeable
5	Color	-				5	15
6	Conductivity	µs/cm	911	800	823	NS*	NS*
7	Biochemical	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	195.43	165.37	140.31	250	1000
9	Ca as Ca	mg/l	43.29	44.09	37.68	75	200
10	Mg as Mg	mg/l	86.99	65.61	90.88	30	100
11	Total Hardness	mg/l	466	380	468	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	1.16	1.29	1.46	1	1.5
14	Sulphate as SO_4	mg/l	37.43	39.62	40.54	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	1.68	4.09	0.34	45	No Relaxation
17	Salinity	‰	0.35	0.30	0.25	NS*	NS*
18	Sodium as Na	mg/l	110.12	102.64	104.59	NS*	NS*
19	Potassium as K	mg/l	3.33	3.46	3.20	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 15: Drinking Water Quality Monitoring Parameters for School Gopalpuri, Guest House) and E - Type Quarter at Gopalpuri, Gandhidham

Sr. No.	Parameter	Unit	Gopalpuri School	Guest House	E - Type Quarter	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.45	7.55	7.42	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	407	420	459	500	2000
3	Turbidity	NTU	0	1	0	1	5
4	Odor	-				Agreeable	Agreeable
5	Color	-				5	15
6	Conductivity	µs/cm	814	846	908	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	155.35	180.40	135.30	250	1000
9	Ca as Ca	mg/l	38.48	39.28	40.88	75	200
10	Mg as Mg	mg/l	95.26	82.13	67.55	30	100
11	Total Hardness	mg/l	488	436	380	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	1.33	1.49	1.06	1	1.5
14	Sulphate as SO_4	mg/l	40.43	31.53	37.54	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	1.48	1.28	0.40	45	No Relaxation
17	Salinity	‰	0.28	0.33	0.24	NS*	NS*
18	Sodium as Na	mg/l	100.96	104.36	106.73	NS*	NS*
19	Potassium as K	mg/l	3.27	3.08	3.30	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100 ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 16: Drinking Water Quality Monitoring Parameters for F-Type Quarter, Hospital Gopalpuri and Tuna Port.

Sr. No.	Parameter	Unit	F - Type Quarter	Hospital Gopalpuri	Tuna Port	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.37	7.41	7.38	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	440	404	1473	500	2000
3	Turbidity	NTU	1	1	0	1	5
4	Odor	-				Agreeable	Agreeable
5	Color	-				5	15
6	Conductivity	µs/cm	880	805	2940	NS*	NS*
7	Biochemical Oxygen Demand	mg/l				NS*	NS*
8	Chloride as Cl	mg/l	130.29	175.39	651.45	250	1000
9	Ca as Ca	mg/l	41.68	42.48	101.80	75	200
10	Mg as Mg	mg/l	76.79	87.48	76.30	30	100
11	Total Hardness	mg/l	420	466	568	200	600
12	Iron as Fe	mg/l				0.3	No Relaxation
13	Fluorides as F	mg/l	1.41	1.31	1.48	1	1.5
14	Sulphate as SO_4	mg/l	38.70	39.16	296.00	200	400
15	Nitrite as NO_2	mg/l				NS*	NS*
16	Nitrate as NO_3	mg/l	1.41	1.74	6.71	45	No Relaxation
17	Salinity	‰	0.24	0.32	1.18	NS*	NS*
18	Sodium as Na	mg/l	107.30	102.85	365.00	NS*	NS*
19	Potassium as K	mg/l	3.09	3.11	4.48	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified, BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6-0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 17: Drinking Water Quality Monitoring Parameters for Vadinar Jetty and Port Colony at Vadinar.

Sr. No.	Parameter	Unit	Vadinar Jetty	Port Colony Vadinar	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.5	7.6	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	460	456	500	2000
3	Turbidity	NTU	1.00	1.00	1	5
4	Odor	-			Agreeable	Agreeable
5	Color	-			5	15
6	Conductivity	µs/cm	780	772	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	140.31	110.25	250	1000
9	Ca as Ca	mg/l	420	380	75	200
10	Mg as Mg	mg/l	84.17	72.14	30	100
11	Total Hardness	mg/l	0.25	0.20	200	600
12	Iron as Fe	mg/l	51.03	48.60	0.3	No Relaxation
13	Fluorides as F	mg/l	0.28	0.22	1	1.5
14	Sulphate as SO_4	mg/l	63.40	51.20	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	1.82	0.72	45	No Relaxation
17	Salinity	‰	BQL	BQL	NS*	NS*
18	Sodium as Na	mg/l	55.6	52.2	NS*	NS*
19	Potassium as K	mg/l	2.39	2.11	NS*	NS*
20	Manganese	mg/l	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

4.3 Results & Discussion

The colour of all drinking water samples was found Colourless and odour of the samples also agreeable. All parameters were found within the specified limit as per the Drinking water Standard.

pH

The pH is measure of the intensity of acidity or alkalinity and the concentration of hydrogen ion in water. At DPA the pH values for drinking water samples were ranges from 7.28-7.55 and mean value was 7.40 while at Vadinar pH range was7.5-7.6. All the sampling points showed pH values within the prescribed limit by Indian Standards.

Turbidity

The selected drinking water sample location turbidity range from 0-1NTU at all location of DPA and Vadinar in month of September. The Turbidity values were within the permissible limit at all sampling location prescribed limit by Indian standards.

Total Dissolved Solids (TDS)

Water has the ability to dissolve a wide range of inorganic and some organic minerals or salts such as potassium, calcium, sodium, bicarbonates, chlorides, magnesium, sulfates etc.

TDS values at DPA varied between 374-1473 mg/l. The average TDS value was found 493.63 mg/l. The minimum value for TDS was 374 mg/l at Custom Building and maximum was 1473 mg/l at Tuna Port while at Vadinar TDS ranged from 456-460 mg/l and mean was 458.0 mg/l. The TDS values were within the permissible limit at all sampling location prescribed limit by Indian standards.

Conductivity

Electrical Conductivity is the ability of a solution to transfer (conduct) electric current. Conductivity is used to measure the concentration of dissolved solids which have been ionized in a polar solution such as water. The conductivity in the samples collected during the month of September DPA ranged from 747 µs/cm at Custom building to 2940 µs/cm at Tuna Port and mean value was 989.50 µs/cm while at Vadinar ranged from 772-780 µs/cm and mean was 776 µs/cm.

BOD

BOD value in the studied area of DPA and Vadinar was found Below Quantification Limit (2.0 mg/l). IS 10500:2012 does not show any standard values for BOD in drinking water.

Chlorides

Excessive chloride concentration increase rates of corrosion of metals in the distribution system. This can lead to increased concentration of metals in the supply. The Chloride value in the studied area of DPA ranged from 130.29 mg/l at F-Type Quarters to 651.45 mg/l at Tuna Port and mean value was 190.15 mg/l while at Vadinar location chloride ranged from 145.32-150.33 and mean was 147.8 mg/l. The Chloride was found within the Permissible limit of the Drinking Water Standard.

Calcium

Calcium is most abundant element on the earth crust and is very important for human cell physiology and bones. About 95% calcium in human body stored in bones and teeth. The high deficiency of calcium in humans may caused rickets, poor blood clotting, bones fracture etc. and the exceeding limit of calcium produced cardiovascular diseases.

Calcium value in the studied area of DPA ranged from 36.07 mg/l at P& C building to 101.80 mg/l at Tuna Port and mean value was 43.46 mg/l while at Vadinar location calcium ranged from 32.87-34.47 mg/l and mean was 33.7 mg/l. The Calcium values were found to be within the Permissible limit of the Drinking Water Standard.

Magnesium

Magnesium value in the studied area of DPA ranged from 65.61 mg/l at DPA Hospital to 98.66 mg/l at DPA-Canteen and mean value was 83.19 mg/l while at Vadinar location magnesium ranged from 73.87-84.08 mg/l and mean was 79.0 mg/l. All the locations had Magnesium within the prescribed limits of 30-100 mg/L.

Total Hardness

Total Hardness value in the studied area of DPA ranged from 380.00 mg/l at DPA Hospital to 568.00 mg/l at Tuna Port and mean value was 450.78 mg/l while at Vadinar location total hardness ranged from 390.00-428.00 mg/l and mean was 409.00 mg/l. The values of total hardness were found within the Permissible limit of the Drinking Water Standard (200-600 mg/L). These results clear, that hardness of water is according to the IS standards and it is not harmful for local inhabitants.

Iron

Iron values in the studied area of DPA & Vadinar were Below Quantification Limit (0.009 mg/l) and hence well below the permissible limit as per Indian Standards are 0.3 mg/L.

Fluoride

Fluoride value in the studied area of DPA varied between 1.06-1.47 mg/l and mean was 1.26 mg/l. The minimum value was 0.11 mg/ at DPA Hospital and maximum was 2.42 mg/l at Tuna Port while at Vadinar location fluoride ranged from 1.20-1.41 mg/l and mean was 1.31 mg/l. The Fluoride values were well below the permissible limit as per Indian Standards is 1.0-1.5 mg/L. Moderate amounts lead to dental effects, but long-term ingestion of large amounts can lead to potentially severe skeletal problems.

Sulphate

Sulphate value in the studied area of DPA varied between 31.53–296.00 mg/l and mean was 52.43 mg/l. The minimum value was 31.53 mg/ at Gopalpuri Guest House and maximum was 296.00 mg/l at Tuna Port while at Vadinar location sulphate ranged from 39.39-42.97 mg/l and mean was 41.2 mg/l. All the sampling points showed sulphate values within the prescribed limits by Indian Standards (200-400 mg/L). Sulphate content in drinking water exceeding the 400 mg/L imparts bitter taste.

Nitrites (NO_2) and Nitrates (NO_3)

The all values of Nitrates were well within the permissible limit of the Drinking water Standard.

Salinity

Salinity in drinking water in the present samples collected at DPA ranged from 0.24 to 1.18 ‰ while at Vadinar sampling location salinity ranged from 0.26-0.27 ‰. There are no prescribed Indian standards for salinity in Drinking water**.**

Sodium and Potassium Salts

Sodium values in the samples collected at DPA ranged from 93.00- 365.00 mg/l and average was 120.94 mg/l while at Vadinar sodium ranged from 52.2- 55.6 mg/l. Potassium salts ranged at DPA ranged from 3.08 to 5.06 mg/l while average was 3.58 mg/l while at Vadinar

sampling location ranged from 2.11-2.39 mg/l and mean was 2.3 mg/l. There are no prescribed limits of Sodium and Potassium in Indian standards for Drinking water.

Heavy Metals in Drinking Water

In the present study period drinking water samples were analyzed for Mn, Cr, Cu, Cd, As, Hg, Pb and Zn. All these heavy metals were well Below the Quantification limits prescribed by the Indian Standards.

Bacteriological Study

Analysis of the bacteriological parameter (E-coli and total coliform) at all location shows that Bacteria were not detectable. This shows that drinking water samples were safe for human consumption as per tested parameters.

4.4 Conclusions

These results were compared with permissible limits as prescribed in IS 10500:2012 – Drinking Water Specification. It was seen from the analysis data that during the study period at selected sampling location the water was safe for human consumption as per analyzed parameters at all drinking water monitoring stations.

5.0 Noise Level Monitoring

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. Noise Monitoring was done at 13 stations at Kandla, Vadinar and Township area.

5.1 Method of Monitoring

Sampling was done at all stations for 24 hour period. Data was recorded using automated sound level meter. The intensity of sound was measured in sound pressure level (SPL) and common unit of measurement is decibel (dB).

5.2 Results

Table 18: Noise Monitoring data for ten locations of Deendayal Port and three locations of Vadinar Port

Sr. No.	Location	Day Time Average Noise Level (SPL) in dB(A)	Night Time Average Noise Level (SPL) in dB(A)
	Sampling Time	**6:00 am to 10:00 PM**	**10:00PM to 6:00 AM**
1	Marine Bhavan	74.2	65.1
2	Nirman Building 1	72.3	66.9
3	Tuna Port	58.7	55.9
4	Main Gate North	72.1	67.7
5	West Gate I	69.9	66.6
6	Canteen Area	73.3	65.6
7	Main Road	71.0	66.1
8	ATM Building	72.3	67.2
9	Wharf Area /Jetty Area	71.8	65.2
10	Port & Custom Office	68.1	62.2
Vadinar Port			
11	Entrance Gate of Vadinar Port	57.7	50.9
12	Nr. Port Colony, Vadinar	60.5	54.8
13	Nr. Vadinar Jetty	57.1	54.1

5.3 Conclusions

Transportation systems are the main source of noise pollution in urban areas. Construction of buildings, highways, and roads cause a lot of noise, due to the usage of air compressors, bulldozers, loaders, dump trucks, and pavement breakers. Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships.

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. The Day Time Noise Level (SPL) in all 10 locations at Deendayal Port Authority ranged from 58.7 dB(A) to 74.2 dB(A) while at Vadinar port 3 location ranged from 57.1 dB(A) to 60.5 dB(A) which was within the permissible limits of 75 dB(A) for the industrial area for the daytime. The Night Time Average Noise Level (SPL) in all locations of Deendayal Port Authority ranged from 55.9 dB to 67.7 dB(A) while at Vadinar port ranged from 50.9 dB (A) to 54.8 dB(A) which was within the permissible limits of 70 dB(A) for the industrial area for the night time.

6.0 Soil Monitoring

Sampling and analysis of soil samples were undertaken at six locations within the study area (Deendayal Port and Vadinar Port) as a part of EMP. The soil sampling locations are initially decided based on the locations as provided in the tender document of the Deendayal Port.

Table No.:-19. Soil Sampling Location

Sr. No.	Name of Location	Location Code	Latitude	Longitude	Remarks
1.	Tuna Port	SL-1	22° 58' 10.18"N	70° 6' 3.7"E	Near main gate of Port
2.	IFFCO Plant	SL-2	23° 26' 8.37"N	70° 13' 4.4"E	10 m away from main gate
3.	Khori creek	SL-3	22° 58' 10.18"N	70° 6' 3.7"E	Sand from creek after tide
4.	Nakti Creek	SL-4	23° 2' 1.10"N	70° 9' 33.6"E	
5.	DPA admin site	SL-5	22° 26' 30.9"N	69° 40' 37.03"E	Vadinar
6.	DPA colony	SL-6	22° 23' 57.09"N	69° 42' 49.42"E	

6.1 Methodology

The soil samples were collected in the month of September 2022. The samples collected from the all locations are homogeneous representative of each location. At random locations were identified at each location and soil was dug from 30 cm below the surface. It was uniformly mixed before homogenizing the soil samples. The samples were filled in polythene bags, labeled in the field with number and site name and sent to laboratory for analysis.

6.2 Results

Table-20: Chemical Characteristics of Soil in the Study Area for Tuna port, IFFCO, Khori Creek, Nakti Creek, DPA admin site, DPA colony.

Sr. No.	Parameter	Unit	Station Name					
			SL1	SL2	SL3	SL4	SL5	SL6
			Tuna Port	IFFCO Plant	Khori Creek	Nakti Creek	DPA Admin Site	DPA Colony
			Near main gate of Port	10 m away from main	Sand from creek after tide		Vadinar	
1	Texture		Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	pH	-	7.70	7.90	8.10	8.10	7.30	7.80
3	Electrical Conductivity	µs/cm	12400.0	2664.0	4,180.00	13,280.0	710.0	648.0
4	Phosphorus	mg/kg	10.1	9.69	12.52	20.50	8.79	7.68
5	Moisture	%	23.3	4.5	18.00	17.10	7.20	10.10
6	Total Organic	%	0.81	0.18	0.64	0.66	0.20	0.49
7	Alkalinity	mg/kg	400.0	600.0	400.0	200.0	300.0	400.0
8	Total Nitrogen	%	BQL	BQL	BQL	BQL	BQL	BQL
9	Sulphate	mg/kg	958.00	326.00	1,420.00	448.00	52.0	50.0
10	Chloride	mg/kg	2313.0	604.0	1,347.00	1,932.00	354.00	531.00
11	Calcium	mg/kg	1,302.00	1,202.00	1,503.00	4,809.00	1,304.00	1,155.00
12	Sodium	mg/kg	1902	868.0	1,060.00	3,108.00	118.14	236.64
13	Potassium	mg/kg	582	478	375.00	510.00	16.54	20.06
14	Copper as Cu	mg/kg	11	278.2	5.00	5.90	50.30	56.00
15	Lead as Pb	mg/kg	3.5	5	2.80	2.70	BDL	BDL
16	Nickel as Ni	mg/kg	17.10	45.30	11.60	17.50	17.20	26.20
17	Zinc as Zn	mg/kg	16.9	111.20	12.50	14.10	14.20	30.70
18	Cadmium as Cd	mg/kg	BQL	BQL	BQL	BQL	BDL	BQL

BQL- Below Quantification Limit, (TN: 0.001%, Cd: 1.0mg/kg)

6.3 Discussion

- DPA Kandla soil sampling data shows that value of pH ranges from 7.70 at Tuna port to 8.10 at Khori and Nakti Creek while the average value was 7.95. At Vadinar sampling location pH were 7.30 at DPA Admin site and 7.80 at DPA Colony. At all location of all soil samples were neutral to slight basic. Nakti Creek sample showed maximum
- The conductivity of DPA Kandla soil sample ranged from 2664.0 µs/cm at IFFCO Plant (10 m away from main Gate) to 13280 µs/cm at Nakti Creek (Sand from creek after tide) and mean was 8131 µs/cm while Vadinar soil sampling location conductivity were 648.0 µs/cm at DPA colony and 710 µs/cm at DPA Admin site.
- Total organic Carbon of DPA Kandla soil sample ranged from 0.18 % at IFFCO Plant to 0.81 % at Tuna Port (Near Main Gate) and mean was 0.50 % while Vadinar soil sample were 0.2% at DPA admin and 0.49 % at DPA Colony.
- The concentration of Phosphorus in the soil samples of DPA Kandla varies from 9.69 mg/kg at IFFCO plant (10 meter away from main gate) and 20.50 mg/kg at Nakti Creek and mean was 13.20 mg/kg while the Vadinar soil sample for Phosphorus were 7.68 mg/kg at DPA Colony and 8.79 mg at DPA Admin Site.
- Chloride in soil sample of DPA ranged from 604 mg/kg at IFFCO Plant to 2313 mg/kg at Tuna Port (Near Main Gate) while Vadinar soil sample were 354 mg/kg at DPA admin and 531mg/kg at DPA Colony.
- The concentration of Potassium in the soil samples of DPA Kandla ranged from 375 mg/kg at Khori creek and 582 mg/kg at Tuna Port and mean was 486.25 mg/kg while the Vadinar soil sample for Potassium were 16.54 mg/kg at DPA Admin Site and 20.06 mg/kg at DPA Colony.
- The concentration of Sodium in the soil samples of DPA Kandla ranged from 868 mg/kg at IFFCO Plant and 3108 mg/kg at Nakti Creek and mean was 1734.50 mg/kg while the Vadinar soil sample for Sodium were 118.14 mg/kg at DPA Admin Site and 236.64 mg/kg at DPA Colony.

These differences in NPK in soil at different locations are due to the dissimilar nature of soil at each of the locations. Samples SL3 & SL4 (Khori Creek & Nakti Creek) were coastal soil; where as other locations are inland locations and have different chemical properties.

Heavy Metals in the Soil

Traces of Copper, Lead, Nickel and Zinc were observed in the soil samples collected from all the four locations of Deendayal Port Authority Kandla and two locations of Vadinar Port. Cadmium metal was below detection limit in the Soil.

6.4 Conclusion

The soils of Deendayal Port Authority Kandla and Vadinar Port appears to be neutral to basic with varying levels of Chloride, Sulphate, NPK and Calcium. As the nature of soil at different locations are different with respect to its proximity to the sea, the samples showed high degree of variations in their chemical properties.

7.0 Sewage Treatment Plant Monitoring

This involves safe collection of waste water (spent/used water) from wash areas, bathroom, industrial units, etc., waste from toilets of various buildings and its conveyance to the treatment plant and final disposal in conformity with the requirement and guidelines of State Pollution Control Board and other statutory bodies.

7.1 Methodology for STP Monitoring

To monitor the working efficiency of Sewage Treatment Plant (STP), STP Inlet and Outlet Samples were collected once a week. Locations selected are namely Gopalpuri Township, Deendayal Port and Vadinar. Samples were collected in 1 lit. Carboys and were analyzed in laboratory for various parameters.

Table No. 21. Sewage Treatment Plant

Sr. No.	Location of STP	Types of Treatment	STP Capacity	Treated water Utilization
1.	Gopalpuri Township	MBBR	450 KLD	Plantation and Gardening
2.	Deendayal Port, Kandla	MBBR	600 KLD	Discharge to marine through pipeline, Plantation, Gardening
3.	Vadinar Port Colony	MBBR	1.5 MLD	Plantation and Gardening

7.2 Results

Table 22: Sewage Water Monitoring at Kandla STP (1st Week)

Date of Sampling	01.09.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.36	7.21	6.5 - 8.5
2	Total Suspended Solids	mg/l	121.8	50.4	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	90	40	100
5	BOD @ 27 °C	mg/l	26.0	12.0	30
Aeration Tank					
6	MLSS	mg/l	16.0		
7	MLVSS	%	92.0		

Table 23: Sewage Water Monitoring at Kandla STP (2nd Week)

Date of Sampling	06.09.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.45	7.24	6.5 - 8.5
2	Total Suspended Solids	mg/l	49.8	28.7	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	70	28.0	100
5	BOD @ 27 °C	mg/l	20.0	8.0	30
Aeration Tank					
6	MLSS	mg/l	20.0		
7	MLVSS	%	91.0		

Table 24: Sewage Water Monitoring at Kandla STP (3rd Week)

Date of Sampling	12.09.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.51	7.31	6.5 - 8.5
2	Total Suspended Solids	mg/l	97.4	46.2	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	60	26	100
5	BOD @ 27 °C	mg/l	18.0	8.0	30
Aeration Tank					
6	MLSS	mg/l	25.0		
7	MLVSS	%	86.0		

Table 25: Sewage Water Monitoring at Kandla STP (4th Week)

Date of Sampling	19.09.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.46	7.33	6.5 - 8.5
2	Total Suspended Solids	mg/l	98.2	46.3	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	110	26	100
5	BOD @ 27 °C	mg/l	30.0	8.0	30
Aeration Tank					
6	MLSS	mg/l	13.0		
7	MLVSS	%	85.0		

Table 26: Sewage Water Monitoring at Kandla STP (5th Week)

Date of Sampling	26.09.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.51	7.25	6.5 - 8.5
2	Total Suspended Solids	mg/l	82.8	44.9	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	70	30	100
5	BOD @ 27 °C	mg/l	21.0	10.0	30
Aeration Tank					
6	MLSS	mg/l	12.0		
7	MLVSS	%	88.0		

Table 27: Sewage Water Monitoring at Gopalpuri STP (1st Week)

Date of Sampling	01.09.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Gopalpuri STP I/L	Gopalpuri STP O/L	
1	pH	-	7.52	7.28	6.5 - 8.5
2	Total Suspended Solids	mg/l	94.6	31.9	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	80	20	100
5	BOD @ 27 °C	mg/l	24.0	6.0	30
Aeration Tank					
6	MLSS	mg/l	20.0		
7	MLVSS	%	90.0		

Table 28: Sewage Water Monitoring at Gopalpuri STP (2nd Week)

Date of Sampling	06.09.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Gopalpuri STP I/L	Gopalpuri STP	
1	pH	-	7.48	7.21	6.5 - 8.5
2	Total Suspended Solids	mg/l	109.6	34.4	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	92.0	30.0	100
5	BOD @ 27 °C	mg/l	26.0	8.0	30
Aeration Tank					
6	MLSS	mg/l	23.0		
7	MLVSS	%	88.0		

Table 29: Sewage Water Monitoring at Gopalpuri STP (3rd Week)

Date of Sampling	12.09.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Gopalpuri STP I/L	Gopalpuri STP O/L	
1	pH	-	7.48	7.23	6.5 - 8.5
2	Total Suspended Solids	mg/l	93	29	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	50	20	100
5	BOD @ 27 °C	mg/l	15.0	6.0	30
Aeration Tank					
6	MLSS	mg/l	12.0		
7	MLVSS	%	87.0		

Table 30: Sewage Water Monitoring at Gopalpuri STP (4th Week)

Date of Sampling	19.09.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Gopalpuri STP I/L	Gopalpuri STP O/L	
1	pH	-	7.54	7.42	6.5 - 8.5
2	Total Suspended Solids	mg/l	84.2	39.1	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	112	31	100
5	BOD @ 27 °C	mg/l	33.0	10.0	30
Aeration Tank					
6	MLSS	mg/l	5.0		
7	MLVSS	%	90.0		

Table 31: Sewage Water Monitoring at Vadinar STP (1st Week)

Date of Sampling	01.09.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar O/L	
1	pH	-	7.56	7.33	6.5 - 8.5
2	Total Suspended Solids	mg/l	86.2	43.4	100
3	Residual Chlorine	mg/	-	<0.5	-
4	COD	mg/l	80.0	50	100
5	BOD @ 27 °C	mg/l	23.0	14.0	30

Table 32: Sewage Water Monitoring at Vadinar STP (2nd Week)

Date of Sampling	06.09.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar O/L	
1	pH	-	7.38	7.21	6.5 - 8.5
2	Total Suspended Solids	mg/l	77.3	57.5	100
3	Residual Chlorine	mg/l	-	-	-
4	COD	mg/l	90	60	100
5	BOD @ 27 °C	mg/l	26.7	18.2	30

Table 33: Sewage Water Monitoring at Vadinar STP (3rd Week)

Date of Sampling	12.09.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar O/L	
1	pH	-	7.53	7.32	6.5 - 8.5
2	Total Suspended Solids	mg/l	95	49.8	100
3	Residual Chlorine	mg/l	-	-	-
4	COD	mg/l	61	20.2	100
5	BOD @ 27 °C	mg/l	16.0	6.0	30

Table 34: Sewage Water Monitoring at Vadinar STP (4th Week)

Date of Sampling	19.09.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar O/L	
1	pH	-	7.48	7.25	6.5 - 8.5
2	Total Suspended Solids	mg/l	94.2	47.1	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	40	30	100
5	BOD @ 27 °C	mg/l	12.2	8.0	30

Table 35: Sewage Water Monitoring at Vadinar STP (5th Week)

Date of Sampling	26.09.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar O/L	
1	pH	-	7.41	7.23	6.5 - 8.5
2	Total Suspended Solids	mg/l	96.2	38.5	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	40	20	100
5	BOD @ 27 °C	mg/l	12.0	6.0	30

Table No. 36. General Standards for discharge of Environmental Pollutant Part-A

Sr. No.	Parameter	Inland Surface Water	Land Irrigation	Marine Coastal Areas
1.	pH	5.5-9.0	5.5-9.0	5.5-9.0
2.	Total Suspended Solids (mg/l)	100	200	100
3.	Residual Chlorine (mg/l)	1.0	-	1.0
4.	BOD (mg/l)	30	100	100
5.	COD (mg/l)	250	-	250

Sources:-CPCB

7.3 Results & Discussion

The STP Sample carried out to evaluate the efficiency and performance of the wastewater treatment plant at Gopalpuri, Kandla and Vadinar STP. The performance of these plants is an essential parameter to monitor because the treated sewage water is discharged for irrigation purposes and discharge into marine. Wastewater samples were collected from different unit operations of the plant i.e, the inlet, aeration tank and the final treated outlet. These samples were analyzed for various physico-chemical characteristics such as pH, TSS, Residual Chlorine, COD, BOD, MLSS and MLVS.

- The final treated outlet observed pH values were within the allowed range at Gopalpuri, DPA Kandla & Vadinar ranged from 7.23 -7.42, 7.21-7.33 & 7.21-7.33 respectively. The wastewater treatment makes it suitable for irrigation. These values are below the allowed limit of the CPCB.
- The final treated outlet observed Total suspended solid values at Gopalpuri, DPA Kandla & Vadinar ranged from 24.60 -39.10 mg/l, 28.70-50.40 mg/l & 38.50-57.50 mg/l respectively. These values are below the allowed limit of the CPCB.
- The final treated outlet observed Residual Chlorine values were <0.5 at Gopalpuri, DPA Kandla & Vadinar. These values are below the allowed limit of the CPCB.
- The final treated outlet observed COD values were at Gopalpuri, DPA Kandla & Vadinar ranged from 20.0 -31.0 mg/l, 26.0-40.0 mg/l & 20.0-60.0 mg/l respectively. These values are below the allowed limit of the CPCB.

- The main focus of wastewater treatment plants is supposed to reduce the BOD in the effluent discharged to natural waters. Wastewater treatment plants are designed to function as bacteria farms, where bacteria are fed oxygen and organic waste. The observed BOD values were at Gopalpuri, DPA Kandla & Vadinar ranged from 6.0 -10.0 mg/l, 8.0-12.0 mg/l & 6.0-18.17 mg/l respectively. These values are below the allowed limit of the CPCB. .
- The final treated outlet observed BOD values were at Gopalpuri, DPA Kandla & Vadinar ranged from 6.0 -10.0 mg/l, 8.0-12.0 mg/l & 6.0-18.17 mg/l respectively. These values are below the allowed limit of the CPCB for irrigation water and discharge in marine coastal area.

7.4 Conclusions:

All parameters for STP outlet are within limit prescribed by CPCB. After the final treatment, it is found that the treated water is satisfactory.

8.0 Marine Water Monitoring

Marine Water Quality

The Forty Second Amendment to the Constitution in 1976 underscored the importance of 'green thinking'. Article 48A enjoins the state to protect and improve the environment and safeguard the forests and wildlife in the country. Further, Article 51A (g) states that the "fundamental duty of every citizen is to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures".

Policy Statement for Abatement of Pollution (1992) has suggested developing relevant legislation and regulation, fiscal incentives, voluntary agreements and educational programs and information campaigns. It emphasizes the need for integration by incorporating environmental considerations into decision making at all levels by adopting frameworks namely, pollution prevention at source, application of best practicable solution, ensure polluter pays for control of pollution, focus on heavily polluted areas and river stretches and involve public in decision-making. The National Conservation Strategy and Policy Statement on Environment and Development, (1992) aimed at "integrating environmental concerns with developmental imperatives to meet the challenges by redirecting the thrust of our developmental process so that the basic needs of our people could be fulfilled by making judicious and sustainable use of natural resources." The priorities mentioned in this policy document include the sustainable use of land and water resources, prevention and control of pollution and preservation of biodiversity.

The National Water Policy, (2002) contains provisions for developing, conserving, sustainable utilizing and managing this important water resources and need to be governed by national perspectives.

Sampling Stations

The monitoring of marine environment for the study of biological and ecological parameters was carried out on 05th & 06th September-2022 in harbor regions of DPA & Vadinar during Neap tide period of New moon phase of Lunar Cycle. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 12th & 16th September-2022 in harbor regions of DPA & Vadinar during Spring tide period first quarter of Lunar Cycle.

Plankton samples from sub surface layer was collected both during high tide period and low tide period from 3 water quality monitoring stations of DPA harbor area and two stations in Nakti creek and one station in Khori creek. The same sampling schedule was repeated during consecutive spring tide and neap tide in same month. Plankton samples from sub surface layer was collected both during high tide period and low tide period from 1 water quality monitoring stations near Vadinar jetty area during spring tide and neap tide in this month. Collected water samples were processed for estimation

of Chlorophyll- a, Pheophytin- a, qualitative & quantitative evaluation of phytoplankton, qualitative & quantitative evaluation zooplanktons (density and their population).

Sampling Locations

Offshore monitoring requirement	Number of locations
Offshore Installations	3 in Kandla creek 2 in Nakti creek 1 in Khori creek 1 near Vadinar Jetty 1 near 1st SBM
Total Number of locations	**8**

8.1 Marine Water Quality and Results

Marine water quality of marine waters of Deendayal Port Harbor waters, Khori & Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each month. The results of marine water quality from table no 37 to 44. During low tide DPA-6 Nakti-II location monitoring was not possible due to non-availability of marine water.

Table 37: Marine Water Quality Monitoring Parameters for Location Near DPA Colony

Sr. No.	Parameters	Unit	Kandla Creek Near DPA Colony (1)			
			23°0'58"N 70°13'22."E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.54	7.43	7.47	7.51
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	28.5	32.9	33.9	33
5	Turbidity	NTU	48	43	48	43
6	Total Dissolved Solids	mg/l	33482	28640	33482	28640
7	Total Suspended Solids	mg/l	499	692	499	692
8	Total Solids	mg/l	33981	29332	33981	29332
9	DO	mg/l	5.6	5.7	5.6	5.7
10	COD	mg/l	86	80	80	79
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	3.74	0.62	2.58	2.02
13	Phosphate	mg/l	0.04	0.63	0.12	0.14
14	Sulphate	mg/l	3465	3361	3199	2714
15	Nitrate	mg/l	4.69	1.47	2.61	2.82
16	Nitrite	mg/l	0.1	0.08	<0.05	<0.05
17	Calcium	mg/l	721.44	681.36	641.28	681.36
18	Magnesium	mg/l	1312	1555	1360	1215
19	Sodium	mg/l	7485	4308	10100	9770
20	Potassium	mg/l	330.2	346.2	340.1	326.4
21	Iron	mg/l	1.08	BQL	BQL	1.4
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	0.1	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 38: Marine Water Quality Monitoring Parameters for Location Near Passenger Jetty One at Kandla

Sr. No.	Parameters	Unit	Near passenger Jetty One (2)			
			23° 0'18 "N 70°13'31"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.61	7.48	7.43	7.38
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	35.8	36.5	32.6	33.5
5	Turbidity	NTU	45	47	45	47
6	Total Dissolved Solids	mg/l	33040	28420	33040	28420
7	Total Suspended Solids	mg/l	378	360	378	360
8	Total Solids	mg/l	33418	28780	33418	28780
9	DO	mg/l	5.5	5.1	5.5	5.1
10	COD	mg/l	78	70	88	84
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.84	1.38	1.18	1.66
13	Phosphate	mg/l	0.06	0.08	0.35	0.17
14	Sulphate	mg/l	2841	3511	2783	2691
15	Nitrate	mg/l	0.8	0.33	9.8	2.75
16	Nitrite	mg/l	0.05	0.03	<0.05	<0.05
17	Calcium	mg/l	601.2	641.28	560	601.2
18	Magnesium	mg/l	1312	1263	1190	1142
19	Sodium	mg/l	6255	7648	8399	7582
20	Potassium	mg/l	309.8	32.7	360.9	319.4
21	Iron	mg/l	BQL	BQL	0.3	0.4
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Nitrite: 0.05mg/lCu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 39: Marine Water Quality Monitoring Parameters for location Near Coal Berth

Sr. No.	Parameters	Unit	Near Coal Berth			
			22°59'12"N 70°13'40"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.35	7.28	7.41	7.32
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	30.4	33.9	34.4	34.9
5	Turbidity	NTU	46	40	46	40
6	Total Dissolved Solids	mg/l	27740	29210	27740	29210
7	Total Suspended	mg/l	393	484	393	484
8	Total Solids	mg/l	28133	29693	28133	29693
9	DO	mg/l	5.2	5.3	5.2	5.3
10	COD	mg/l	82	86	76	70
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.6	3.24	1.86	1.36
13	Phosphate	mg/l	0.07	0.13	0.33	0.64
14	Sulphate	mg/l	3234	2529	2529	1651
15	Nitrate	mg/l	0.8	3.48	6.04	3.82
16	Nitrite	mg/l	0.02	0.16	<0.05	<0.05
17	Calcium	mg/l	561.12	601.2	561.12	641.28
18	Magnesium	mg/l	1063	1020	1287	1080
19	Sodium	mg/l	4591	4658	8425	5768
20	Potassium	mg/l	32.2	23	364.3	188.1
21	Iron	mg/l	BQL	BQL	0.1	1.2
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 40: Marine Water Quality Monitoring Parameters for location Khori creek at Kandla

Sr. No.	Parameters	Unit	DPA 4			
			Near 15/16 Berth			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.51	7.45	7.28	7.33
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	38.9	35.5	33.9	33.5
5	Turbidity	NTU	42	45	42	45
6	Total Dissolved Solids	mg/l	32820	35470	32820	35470
7	Total Suspended Solids	mg/l	415	452	415	452
8	Total Solids	mg/l	33235	35922	33235	35922
9	DO	mg/l	4.9	4.7	4.9	4.7
10	COD	mg/l	90	88	85	82
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	1.24	1.1	1.72	2.54
13	Phosphate	mg/l	0.07	0.05	0.46	0.47
14	Sulphate	mg/l	3280	2483	1940	2344
15	Nitrate	mg/l	1.74	2.14	2.81	4.23
16	Nitrite	mg/l	0.04	0.09	<0.05	<0.05
17	Calcium	mg/l	721.44	681.36	681.36	601.2
18	Magnesium	mg/l	1628	1166	1117	1142
19	Sodium	mg/l	5027	6067	6525	7295
20	Potassium	mg/l	31.1	30.4	262.7	318.4
21	Iron	mg/l	BQL	BQL	0.1	1.4
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	0
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	33.9	33.5

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 41: Marine Water Quality Monitoring Parameters for location Nakti Creek near Tuna Port

Sr. No.	Parameters	Unit	Nakti Creek Near Tuna Port			
			22°57'49."N 70° 7'0.67"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.63	7.45	7.45	7.53
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	32.5	34.7	33	32.6
5	Turbidity	NTU	46	47	46	47
6	Total Dissolved Solids	mg/l	27050	32110	27050	32110
7	Total Suspended Solids	mg/l	380	430	380	430
8	Total Solids	mg/l	27430	32540	27430	32540
9	DO	mg/l	5	5.1	5	5.1
10	COD	mg/l	92	96	90	88
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.96	0.96	1.44	1.3
13	Phosphate	mg/l	0.08	0.06	0.42	0.12
14	Sulphate	mg/l	3176	2598	2494	2991
15	Nitrate	mg/l	4.16	1.07	2.28	2.21
16	Nitrite	mg/l	0.08	0.06	<0.05	<0.05
17	Calcium	mg/l	641.28	721.44	561.12	521.04
18	Magnesium	mg/l	1215	1312	990	1287
19	Sodium	mg/l	8423	6704	6981	8015
20	Potassium	mg/l	30.2	32	286.7	362
21	Iron	mg/l	BQL	BQL	BQL	0.1
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 42: Marine Water Quality Monitoring Parameters for location Nakti Creek Near NH-8A at Kandla

Sr. No.	Parameters	Unit	Nakti Creek Near NH-8A			
			23° 02'01"N 70° 09'31"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.61	Sampling not possible during Low Tide	7.61	Sampling not possible during Low Tide
2	Color	-	Agreeable		Agreeable	
3	Odor	-	Agreeable		Agreeable	
4	Salinity	‰	32.4		34.9	
5	Turbidity	NTU	48		48	
6	Total Dissolved Solids	mg/l	26130		26130	
7	Total Suspended Solids	mg/l	265		265	
8	Total Solids	mg/l	26395		26395	
9	DO	mg/l	5.4		5.4	
10	COD	mg/l	98		92	
11	BOD	mg/l	BQL		BQL	
12	Silica	mg/l	9.4		1.62	
13	Phosphate	mg/l	0.07		0.36	
14	Sulphate	mg/l	3303		3245	
15	Nitrate	mg/l	3.15		4.63	
16	Nitrite	mg/l	0.08		<0.05	
17	Calcium	mg/l	761.52		721.44	
18	Magnesium	mg/l	1312		1312	
19	Sodium	mg/l	5545		9075	
20	Potassium	mg/l	32.5		364.5	
21	Iron	mg/l	BQL		1.1	
22	Chromium	mg/l	BQL		BQL	
23	Copper	mg/l	BQL		BQL	
24	Arsenic	mg/l	BQL		BQL	
25	Cadmium	mg/l	BQL		0	
26	Mercury	mg/l	BQL		BQL	
27	Lead	mg/l	BQL		BQL	
28	Zinc	mg/l	BQL		BQL	

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 43: Marine Water Quality Monitoring Parameters for locations Nr. Vadinar Jetty

Sr. No.	Parameters	Unit	Nr.Vadinar Jetty			
			22°26'25.26"N 69°40'20.41"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.42	7.33	7.58	7.42
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	33	32.1	33	32.1
5	Turbidity	NTU	41	38	41	38
6	Total Dissolved Solids	mg/l	32030	37680	32030	37680
7	Total Suspended Solids	mg/l	395	319	395	319
8	Total Solids	mg/l	32425	37999	32425	37999
9	DO	mg/l	5.1	5.3	5.1	5.3
10	COD	mg/l	96	100	94	98
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.8	0.84	1.8	2
13	Phosphate	mg/l	0.7	2	0.74	0.82
14	Sulphate	mg/l	3017	1401	2256	2780
15	Nitrate	mg/l	1.4	2.02	3.86	4.89
16	Nitrite	mg/l	0.06	0.07	<0.05	<0.05
17	Calcium	mg/l	402	518	601.2	641.28
18	Magnesium	mg/l	1287	1578	1120	1380
19	Sodium	mg/l	7797	4468	6813	6965
20	Potassium	mg/l	326.9	328.4	326.9	328.4
21	Iron	mg/l	0.11	0.05	0.2	0.4
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	0.01	BQL	BQL	BQL
28	Zinc	mg/l	0.49	BQL	0.8	0.1

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 44: Marine Water Quality Monitoring Parameters for locations Nr. Vadinar SPM

Sr. No.	Parameters	Unit	Nr. Vadinar SPM			
			22°30'56.15"N 69°42'12.07"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.52	7.48	7.35	7.28
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	31.7	30.8	31.7	30.8
5	Turbidity	NTU	39	43	39	43
6	Total Dissolved Solids	mg/l	40100	36680	40100	36680
7	Total Suspended Solids	mg/l	490	510	490	510
8	Total Solids	mg/l	40590	37189	40590	37189
9	DO	mg/l	5.2	4.9	5.2	4.9
10	COD	mg/l	92	96	100	98
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.38	0.6	1.62	1.59
13	Phosphate	mg/l	0.23	0.76	0.92	0.9
14	Sulphate	mg/l	841.7	1908	2982	3012
15	Nitrate	mg/l	0.07	0.28	5.02	4.88
16	Nitrite	mg/l	0.03	0.03	<0.05	<0.05
17	Calcium	mg/l	490	430	681.36	561.12
18	Magnesium	mg/l	1297	1368	1192	1115
19	Sodium	mg/l	5883	4304	8589	5653
20	Potassium	mg/l	310.2	307.6	310.2	307.6
21	Iron	mg/l	BQL	BQL	BQL	BQL
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	0.28	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l)

8.2 Results & Discussion for Marine water samples

Marine water quality of Deendayal Port Harbor waters, Khori and Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each month. The Heavy metal analyzed and found below quantification limit.

pH

During spring tide the pH values was ranged from 7.28-7.63 at DPA Kandla and 7.33-7.52 at Vadinar while during Neap Tide pH values was ranged from 7.28-7.61 at DPA Kandla and 7.28-7.58 at Vadinar.

Color and Odor

All marine samples for Odor and Color were found agreeable at all sampling locations.

Turbidity

During spring tide the Turbidity values was ranged from 40-48 NTU at DPA Kandla and 38-43 NTU at Vadinar while during Neap Tide Turbidity values was ranged from 40-48 NTU at DPA Kandla and 38-43 NTU at Vadinar. Turbidity is the amount of particulate matter that is suspended in water. Turbidity measures the scattering effect that suspended solids have on light: the higher the intensity of scattered light, the higher the turbidity (Yap et al, 2011). Materials that cause water to be turbid include clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, plankton and microscopic organisms (Lawler, 2004).

Total Dissolved Solids (TDS)

TDS values in the studied area during Spring Tide varied between 26130- 35470 mg/l at DPA Kandla and 3203- 40100 mg/l at Vadinar while during Neap Tide TDS values was varied 26130-35470 mg/l at DPA Kandla and 32030-40100 mg/l at Near Vadinar.

Calcium

Calcium value in the studied area during Spring Tide varied between 561.12-761.52 mg/l at DPA Kandla and 402.0-518.0 mg/l at Vadinar while during Neap Tide calcium values between 521.0-721.44 mg/l at DPA Kandla and 561.12-681.36 at Vadinar.

Magnesium

Magnesium value in the studied area during Spring Tide varied between 1020-1628 mg/l at DPA Kandla and 1385.1 to 1530.9 mg/l at Vadinar while during Neap Tide magnesium

values between 1042-1360 mg/l at DPA Kandla and 1115 -1380 at Vadinar. Calcium and magnesium both play an important role in antagonizing the toxic effects of various ions and neutralizing the excess acid produced (Narayan R. et. al., 2007)

Nitrate

Nitrate value in the studied area during Spring Tide varied between 0.33-4.69 mg/l at DPA Kandla and 0.07-2.02 mg/l at Vadinar while during Neap Tide Nitrate values between 2.21-9.80 mg/l at DPA Kandla and 3.86-5.02 at Vadinar.

The variations were observed due to variation in phytoplankton excretion, oxidation of ammonia, reduction of nitrate and by recycling of nitrogen and bacterial decomposition of planktonic detritus (Asha and Diwakar, 2007).

Iron

Iron values in the studied area during Spring Tide was found below quantification limit (BQL) at DPA Kandla only at value observed 1.08 mg/l KPT-1 (DPA Kandla) and at Vadinar value ranged from 0.05-0.11 mg/l while during Neap Tide the iron values was varied 0.01-1.4 mg/l at DPA Kandla and 0.2 to 0.4 mg/l at Vadinar.

Sulphates

Sulphate values in the studied area during Spring Tide ranged from 2483.0-3511.0 mg/l at DPA Kandla and 841.7- 3017.0 mg/l at Vadinar while during Neap Tide the Sulphate values was varied 1651.0 to 3245.0 mg/l at DPA Kandla and 2256.0 to 3012.0 mg/l at Vadinar.

Salinity

Salinity values in the studied area during Spring Tide varied ranged 28.5 to 38.9 ‰ at DPA Kandla and 30.80 to 33.00 ‰ at Vadinar while during Neap Tide the Salinity values was varied 32.6 to 34.9 ‰ at DPA Kandla and 30.8 to 33.0 ‰ at Vadinar.

Sodium and Potassium Salts

During Spring Tide the Sodium values ranged from 4308.0-8423.0 mg/l at DPA Kandla & 4308.0-7797.0 mg/l at Vadinar and Potassium salts ranged from 23.0-346.0 mg/l at DPA Kandla & 307.60-328.40 mg/l at Vadinar while during Neap Tide the sodium values was ranges from 5768.0-10100.0 mg/l at DPA Kandla & 5653.0-8589 mg/l at Vadinar and Potassium salts ranged from 188.1-364.5 mg/l at DPA Kandla & 307.6-328.4 mg/l at Vadinar.

DO

The DO refers to the amount of oxygen dissolved in the water and it is particularly important in limnology (aquatic ecology) (Weiss 1970). The fate and behavior of DO is of critical importance to marine organisms in determining the severity of adverse impacts (Best et al. 2007). The major factor controlling dissolved oxygen concentration is biological activity: photosynthesis producing oxygen while respiration and nitrification consume oxygen (Best et al. 2007). From the studied samples, DO in marine water during Spring Tide was found in ranges from 4.7-5.7 mg/l at DPA Kandla and 4.90-5.30 mg/l at Vadinar while during Neap Tide 4.7-5.7 mg/l at DPA Kandla and 4.9-5.3 mg/l at Vadinar.

BOD

BOD in marine water at all sampling location in the studied samples were found <2.0 mg/l.

Heavy Metals in Marine Water

In the present study period marine water samples were analyzed for Cr, Cu, Cd, As, Hg, Pb and Zn. All these heavy metals were well Below the Quantification limits prescribed by the Indian Standards.

9.3 Conclusion

In the present study period marine water samples were analyzed and found inline as per Primary Water Quality criteria for class-IV WATERS (For Harbour Waters).

9.0 Marine Sediments

The deep-sea ocean floor is made up of sediment. This sediment is composed of tiny particles such as fine sand, silt, clay, or animal skeletons that have settled on the ocean bottom. Over long periods of time, some of these particles become compressed and form stratified layers. Scientists that study these layers look at particle size, particle composition, and origin to help them create historical records of the deep ocean floor. This process is called weathering. Weathering can be either mechanical or chemical. Mechanical weathering can occur as ice, wind, or water wears away the rock's surface. Chemical weathering can occur as rocks are dissolved by a chemical such as acid rain. The particles created as a result of weathering are called terrigenous sediments. These particles are transported to the ocean by wind and by rivers and streams. Once the particles enter the ocean, they are dispersed by waves, currents, and tides. The heaviest and largest particles that reach the oceans, such as sand, settle very quickly to the bottom as a result of gravity. Sand is deposited near the coast whereas the smaller silt and clay particles are transported farther distances offshore before they settle to the bottom. Sediments are an important component of aquatic ecosystems because they provide nutrients and habitat for aquatic organisms (Benhamed et al. 2016). However, human activities result in accumulation of toxic substances such as heavy metals in marine sediments. Heavy metals are well-known environmental pollutants due to their toxicity, persistence in the environment, and bioaccumulation. Metals affect the ecosystem because they are not removed from water by self-purification, but accumulate in sediments and enter the food chain (Astakhov et al. 2015).

Sediment samples were collected with Van Veen Grab from the six locations in Kandla Port Waters and two locations in Vadinar Port. Benthic surface grab samplers look like giant metal jaws. They dig into the bottom and take a bite of the sediment. These samplers are good for collecting softer, sandy or silty sediments that do not contain rocks. A box corer is a cross between a surface sampler and a sediment corer. It is a special device that is used to collect an undisturbed sample of the very top surface layers and the sediment underneath. Samples were collected and preserved in silver foil in ice box to prevent the contamination/decaying of the samples.

10.1 Results

The Sediment Quality results are given in below from table no. 45 & 46.

Table 45: Results of Analysis of Sediment of Kandla & Vadinar Port (Neap Tide)

Sr. No.	Parameters	Unit	DPA – 1	DPA - 2	DPA - 3	DPA - 4	DPA - 5	Jetty	SPM
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	0.52	0.88	0.96	0.78	0.92	0.45	1.24
3	Organic Carbon	mg/kg	0.30	0.51	0.56	0.45	0.53	0.26	0.72
4	Inorganic Phosphate	mg/kg	98.00	86.00	106.00	88.00	110.00	92.00	110.00
5	Moisture	%	12.50	16.20	15.60	11.62	14.60	18.40	17.30
6	Aluminum	mg/kg	ND	ND	ND	ND	ND	ND	ND
7	Silica	mg/kg	6.90	7.60	8.90	7.00	9.80	10.50	11.60
8	Phosphate	mg/kg	880.00	820.00	682.00	900.00	670.00	505.00	656.00
9	Sulphate	mg/kg	740.00	823.00	562.00	463.00	456.00	823.00	464.00
10	Nitrite	mg/kg	0.12	0.10	0.11	0.12	0.10	0.11	0.12
11	Nitrate	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
12	Calcium	mg/kg	1242.00	1202.00	1202.00	1162.32	1383.00	1422.84	1382.00
13	Magnesium	mg/kg	1677.00	1458.00	1215.00	1725.00	1349.00	1640.00	1409.40
14	Sodium	mg/kg	690.00	702.00	568.00	660.00	720.00	731.00	733.00
15	Potassium	mg/kg	210.00	189.00	166.00	198.00	146.00	388.00	367.00
16	Chromium	mg/kg	BQL	32.60	26.10	36.90	15.90	28.80	34.20
17	Nickel	mg/kg	BQL	16.20	12.90	18.10	7.50	13.20	16.60
18	Copper	mg/kg	BQL	7.20	5.80	10.00	BQL	139.00	22.80
19	Zinc	mg/kg	BQL	18.60	7.70	29.40	5.30	35.10	45.60
20	Cadmium	mg/kg	BQL	BQL	BQL	BQL	BQL	0.10	0.70
21	Lead	mg/kg	BQL	BQL	BQL	BQL	BQL	4.60	4.00
22	Mercury	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
23	Arsenic	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL

*ND - Not Detected, BQL: Below Quantification Limit (NO3:10.0mg/kg, Cd: 1.0mg/kg, Hg: 1.0mg/kg, As: 1.0mg/kg).

Table 46 : Results of Analysis of Sediment of Kandla & Vadinar Port (Spring Tide)

Sr. No.	Parameters	Unit	DPA – 1	DPA - 2	DPA - 3	DPA - 4	DPA - 5	Jetty	SPM
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	0.46	0.93	1.02	0.99	1.10	0.95	0.71
3	Organic Carbon	mg/kg	0.26	0.53	0.59	0.57	0.64	0.55	0.41
4	Inorganic Phosphate	mg/kg	110.00	100.00	82.00	88.00	116.00	78.00	100.00
5	Moisture	%	22.80	12.40	16.00	18.80	20.24	2.50	17.00
6	Aluminum	mg/kg	ND	ND	ND	ND	ND	ND	ND
7	Silica	mg/kg	6.60	8.10	8.62	6.52	8.90	10.20	18.00
8	Phosphate	mg/kg	930.00	868.00	820.00	989.00	720.00	474.00	7.47
9	Sulphate	mg/kg	740.00	823.00	590.00	463.00	496.00	842.00	480.00
10	Nitrite	mg/kg	0.12	0.10	0.11	0.12	0.11	0.11	0.11
11	Nitrate	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	11.02
12	Calcium	mg/kg	1623.00	1663.00	1560.00	1503.00	1420.00	1222.44	1863.00
13	Magnesium	mg/kg	1822.00	1445.00	1880.00	1834.00	890.00	2041.20	935.00
14	Sodium	mg/kg	539.00	708.00	710.00	685.00	620.00	736.00	1353.00
15	Potassium	mg/kg	239.00	342.00	280.00	316.00	240.00	358.00	335.00
16	Chromium	mg/kg	57.30	65.00	22.00	60.20	36.20	35.20	18.20
17	Nickel	mg/kg	27.20	30.30	10.60	21.10	14.50	16.00	8.00
18	Copper	mg/kg	14.30	19.20	BQL	12.40	5.90	10.10	6.90
19	Zinc	mg/kg	47.60	60.80	7.20	35.00	16.50	27.20	BQL
20	Cadmium	mg/kg	0.20	0.80	BQL	0.50	BQL	BQL	BQL
21	Lead	mg/kg	4.70	5.10	BQL	4.90	BQL	3.80	BQL
22	Mercury	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
23	Arsenic	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL

*ND - Not Detected, BQL: Below Quantification Limit (NO3:10.0 mg/kg,Cd: 1.0 mg/kg, Hg: 1.0mg/kg, As: 1.0mg/kg)

9.2 Discussion of Marine Sediment samples

Marine Sediments of Deendayal Port Harbor waters, Khori and Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each month. The Heavy metal analyzed and found below quantification limit.

9.3 Conclusion

The sediment types are majority Sandy loamy. Also all heavy metals found below Quantification limit wise Al, Pb, Cd, Hg , As and Nitrate for some locations.

10.0 INTRODUCTION:

10.1 Sampling Stations:

The monitoring of marine environment for the study of biological and ecological Parameters was carried out on 16th September 2022 in harbour region of DPA at Kandla Creek, and on 17th September 2022 in creeks near by the port during Neap tide. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 26th September, 2022 in harbour region of DPA at Kandla Creek and on 27th September, 2022 in creeks near by the port during spring tidal condition.

Plankton samples from sub surface layer was collected both during high tide period and low tide period from 3 water quality monitoring stations of KPT harbour area and two stations in Nakti creek and one station in Khori creek. Sampling at second sampling station of Nakti creek was possible only during high tide period.

Plankton samples from sub surface layer were collected during high tide period and low tide period from monitoring station near Vadinar jetty at Path Finder Creek during Neap tide on 06/09/2022 and Spring tide period on 10/09/2022. Collected water samples were processed for estimation of Chlorophyll- a, Pheophytin- a, qualitative and quantitative evaluation of phytoplankton, qualitative and quantitative evaluation of zooplankton density and their population.

TABLE:47 SAMPLING LOCATIONS

monitoring requirement	Number of locations
Kandla creek	3 in Kandla creek
Nakti creek	2 in Nakti creek
Khori Creek	1 in Khori creek
Vadinar jetty	1 near Vadinar Jetty
SPM	1 near I stSPM
Total Number of locations	**8**

Sampling methodology adopted:

A marine sampling is an estimation of the body of information in the population. The theory of the sampling design is depending upon the underlying frequency distribution of the population of interest. The requirement for useful water sampling is to collect a representative sample of suitable volume from the specified depth and retain it free from contamination during retrieval.

50 litres of the water sample were collected from Sub surface by using bucket. From the collected water sample 1 litres of water sample was taken in an opaque plastic bottle for chlorophyll estimation, thereafter plankton samples were collected by using filtration assembly with Nylon bolt cloth of 20µm mesh size. At Nakti Creek Near NH-8A Sampling was not possible during Low Tide.

Samples Processing for chlorophyll estimation:

Samples for chlorophyll estimation were preserved in ice box on board in darkness to avoid degradation in opaque container covered with aluminium foil. Immediately after reaching the shore after sampling, 1 litre of collected water sample was filtered through GF/F filters (pore size 0.45 µm) by using vacuum filtration assembly. After vacuum filtration the glass micro fiber filter paper was grunted in tissue grinder, macerating of glass fiber filter paper along with the filtrate was done in 90% aqueous Acetone in the glass tissue grinder with glass grinding tube. Glass fiber filter paper will assist breaking the cell during grinding and chlorophyll content was extracted with 10 ml of 90% Acetone, under cold dark conditions along with saturated magnesium carbonate solution in glass screw cap tubes. After an extraction period of 24 hours, the samples were transferred to calibrated centrifuge tubes and adjusted the volume to original volume with 90% aqueous acetone solution to make up the evaporation loss. The extract was clarified by using centrifuge in closed tubes. The clarified extracts were then decanted in clean cuvette and optical density was observed at wavelength 664, 665 nm. By using corrected optical density, Chlorophyll-a value was calculated as given in (APHA, 2017).

PLANKTON:

The entire area open water in the sea is the pelagic realm. Pelagic organisms live in the open sea. In contrast to the pelagic realm, the benthic realm comprises organisms and zone of the bottom of the sea. Vertically the pelagic realm can be dividing into two zones based on light penetration; upper photic or euphotic zone and lower dark water mass, aphotic zone below the photic zone.

The term plankton is a general term for organisms which have such limited powers of locomotion that they are at the mercy of the prevailing water movement. Plankton is subdivided to phytoplankton and zooplankton. Phytoplanktons are free floating organisms that are capable of photosynthesis and zooplanktons are the various free-floating animals.

Pelagic zone, represents the entire ocean water column from the surface to the deepest depths, is home to a diverse community of organisms. Differences in their locomotive ability categorize the organisms in the pelagic realm into two, ***plankton*** and ***nekton*** (Lalli and Parsons, 1997). ***Plankton*** consists of all organisms drifting in the water and is unable to swim against water currents, whereas ***Nekton*** includes organisms having strong locomotive power. Ecological studies on the plankton community, which form the base of the aquatic food chain, help in the better understanding of the dynamics and functioning of the marine ecosystem. The term 'Plankton' first coined by Victor Hensen (1887), Plankton, (Greek word: *planktos* meaning "passively drifting or wandering") is defined as drifting or free-floating organisms that inhabit the pelagic zone of water. Based on their mode of nutrition planktonic organisms are categorised into phytoplankton (organisms having an autotrophic mode of nutrition) and zooplankton (organisms having a heterotrophic mode of nutrition).

Phytoplankton in the marine environment:

Phytoplanktons are free floating unicellular, filamentous and colonial eutrophic organisms that grow in aquatic environments whose movement is more or less dependent upon water currents. These micro

flora acts as primary producers as well as the basis of food chain, source of protein, bio-purifier and bio-indicators of the aquatic ecosystems of which diverse array of the life depends .They are considered as an important component of aquatic flora, play a key role in maintaining equilibrium between abiotic and biotic components of aquatic ecosystem.

The phytoplankton includes a wide range of photosynthetic and phototrophic organisms. Marine phytoplankton is mostly microscopic and unicellular floating flora, which are the primary producers that support the pelagic food-chain. The two most prominent groups of phytoplankton are Diatoms (Bacillariophyceae) and Dinoflagellates (Dinophyceae).The phytoplankton those normally captured in the net from the Gulf of Kutch is normally dominated by these two major groups; Diatoms and Dinoflagellates. Phytoplankton also include numerous and diverse collection of extremely small, motile algae which are termed micro flagellates (naked flagellates) as well as and Cyanophytes (Blue-green algae).

Algae are an ecologically important group in most aquatic ecosystems and have been an important component of biological monitoring programs. Algae are ideally suited for water quality assessment because they have rapid reproduction rates and very short life cycles, making them valuable indicators of short-term impacts.

Aquatic populations are impacted by anthropogenic stress, resulting in a variety of alterations in the biological integrity of aquatic systems. Algae can serve as an indicator of the degree of deterioration of water quality, and many algal indicators have been used to assess environmental status.

Zooplankton in the marine environment:

Zooplankton includes a taxonomically and morphologically diverse community of heterotrophic organisms that drift in the waters of the world's oceans. Qualitative and quantitative studies on zooplankton community are a prerequisite to delineate the ecological processes active in the marine ecosystem. Zooplankton community plays a pivotal role in the pelagic food web as the primary consumers of phytoplankton and act as the food source for organisms in the higher trophic levels, particularly the economically essential groups such as fish larvae and fishes. They also function in the cycling of elements in the marine ecosystem. The dynamics of the zooplankton community, their reproduction, and growth and survival rate are all significant factors determining the recruitment and abundance of fish stocks as they form an essential food for larval, juvenile and adult fishes (Beaugrand et al., 2004). Zooplankton grazing in the marine environment controls the primary Production and helps in determining the pelagic ecosystem (Banse, 1995). Through grazing in surface waters and following the production of sinking faecal matters and also by the active transportation of dissolved and particulate matter to deeper waters via vertical migration, they help in the transport of organic carbon to deep ocean layers and thus act as key drivers of ‘biological pump’ in the marine ecosystem. Zooplankton grazing and metabolism also, transform particulate organic matter into

dissolved forms, promoting primary producer community, microbial demineralization, and particle export to the ocean's interior.

The categorization of zooplankton into various ecological groups is based on several factors such as duration of planktonic life, size, food preferences and habitat. As they vary significantly in size from microscopic to metazoic forms, the classification of zooplankton based on size has paramount importance in the field of quantitative plankton research.

Based on the duration of planktonic life, zooplankton are categorized into Holoplankton (organisms which complete their entire lifecycle as plankton) and Meroplankton (organisms which are planktonic during the early part of their lives such as the larval stages of benthic and nektonic organisms). Tychoplankton are organisms which live a brief planktonic life, such as the benthic crustaceans (Cumaceans, mysids, isopods) which ascend to the water column at night for feeding and certain ectoparasitic copepods, they leave the host and spend their life as plankton during their breeding cycle.

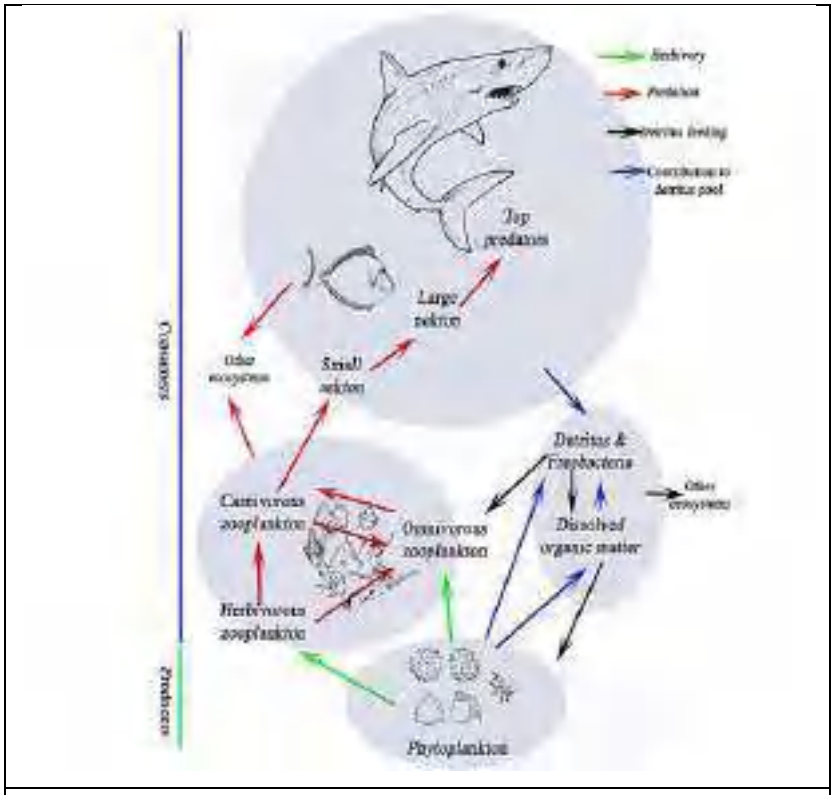
Zooplankton can be subdivided into holoplankton, i.e., permanent members of the plankton (e.g., Calanoid copepods), and meroplankton, i.e., temporary members in the plankton e.g., larvae of fish, shrimp, and crab). The meroplankton group consists of larval and young stages of animals that will adopt a different lifestyle once they mature. In contrast to phytoplankton which consist of a relatively smaller variety of organisms, Zooplankton are extremely divers, consist of a host of larval and adult forms representing many animal phylum.

Among the zooplankton one group always dominate than others; members of sub class copepods (Phylum Athropoda) and Tintinids (Phylum Protozoa) among the net planktons. These small animals are of vital importance in marine ecosystem as one of the primary herbivores animals in the sea, and it is they provide vital link between primary producer (autotrophs) and numerous small and large marine consumers.

As their community structure and function are highly susceptible to changes in the environmental conditions regular monitoring of their distribution as well as their interactions with various physicochemical parameters is inevitable for the sustainable management of the ecosystem (Kusum et al., 2014). Of all the marine zooplankton groups, copepods mainly Calanoid copepods are the dominant groups in marine subtropical and tropical waters and exhibit considerable diversity in morphology and habitats they occupy (Madhupratap, 1991 ;)

It has been well established that potential of pelagic fishes viz. finfishes, crustaceans, molluscs and marine mammals either directly or indirectly depend on zooplankton. The herbivorous zooplanktons are efficient grazers of the phytoplankton and are referred to as living machines transforming plant material into animal tissue. Hence they play an essential role as the intermediaries for nutrients/energy transfer between primary and tertiary trophic levels. Due to their large density, shorter lifespan, drifting nature, high group/species diversity and different tolerance to the stress, they used as the

indicator organisms for the physical, chemical and biological processes in the aquatic ecosystem (Ghajbhiye, 2002).



Simplified marine food web

Spatial distribution of Plankton:

A characteristic of plankton population is that they tend to occur in patches, which are varying spatially on a scale of few meters to far as few kilometres in distance. They also vary in time scale, season as well as vertically in the water column. It is this patchiness and its constant changes in time and spot, that has made it so difficult for plankton biologist to learn about the ecology of plankton. The biological factors that causes this patchiness is due to the ability of zooplankton to migrate vertically and graze out the phytoplankton at a rapid rate that can create patchiness. Similarly the active swimming ability by certain zooplankton organisms can cause to aggregate in dense group.

At its most extreme, because the water in which plankton is suspended is constantly moving, each sample taken by the plankton biologists remain a different volume of water, so each sample is unique and replicate does not exist.

Plankton in the month of SEPTEMBER also exhibit vertical patchiness. Physical factors contribute to this type of patchiness include light intensity, nutrients and density gradients in the water column.

Phytoplankton in particular tends to be unequally distributed vertically, which leads to the existence of different concentration of a chlorophyll value between photic zone and below the photic zone.

10.2 Methodology adopted for Plankton sampling:

Preservation and storage:

Both filtered plankton and those collected from the plankton net were preserved with 5% buffered formalin and stored in 1L plastic container for further processing in the laboratory.

Sample concentration:

The collected plankton samples were concentrated by using centrifuge and made up to 50 ml with 5% formalin -Glycerine mixture.

Taxonomic evaluation:

Before processing, the sample was mixed carefully and a subsample was taken with a calibrated Stempel-pipette. 1 ml of the concentrated plankton samples were transferred on a glass slide with automatic pipette. The plankton sample on the glass slides were stained by using Lugol's iodine and added glycerine to avoid drying while observation. The plankton samples were identified by using Labex triangular Research microscope with photographic attachment. Microphotographs of the plankton samples were taken for record as well as for confirming the identification. The bigger sized zooplankton was observed through dissecting stereomicroscope with magnification of 20-30 x. Plankton organisms in the whole slide were identified to the lowest taxon possible. A thorough literature search was conducted for the identification of the different groups of phytoplankton and zooplankton that were encountered

Cell counts by drop count method:

The common glass slide mounted with a 1ml of concentrated phytoplankton/zooplankton sample in glycerol and covered with cover slip 22 mm x 60 mm was placed under the compound microscope provided with a mechanical stage. The plankton was then counted from the microscopic field of the left top corner of the slide. Then slide is moved horizontally along the right side and plankton in each microscopic field was thus counted. When first microscopic field row was finished the next consecutive row was adjusted using the mechanical device of the stage. In this way all the plankton present in entire microscopic field are counted. From this total number in 1ml of the concentrated plankton, total amount of phytoplankton in the original volume of sample filtered was calculated as units/L and Zooplankton as N/m^3

BENTHIC ORGANISMS:

Benthos is those organisms that are associated with the sea bed or benthic habitats. Epi- benthic organisms live attached to a hard substratum or rooted to a shallow depth below the surface. In fauna organisms live below the sediment–water interface. Interstitial organisms live and move in pore water among sedimentary grains.

Because the benthic organisms are often collected and separated on sieves, a classification based on the overall size is used. Macro benthos include organisms whose shortest dimension is greater than or equal to 0.5 mm. Meio benthos are smaller than 0.5mm but larger than 42µ in size.

The terms such as macro fauna and Meio fauna generally have little relevance with taxonomic classification. The terms Meio fauna and macro fauna depend on the size. Meio fauna were considered as good bioassay of community health and rather sensitive indicators of environmental changes

SAMPLING METHODOLOGY ADOPTED FOR SUB TIDAL REGION:

Van veen sampler ($0.09m^2$) was used for sampling bottom sediments. Two sets of sediments were sampled from each location, one for macro fauna and other for Meio fauna. The macro fauna in the sediments were sieved on board to separate out the organisms. The fixation of Meio fauna is normally done by bulk fixation of the sediment sample. The bulk fixation is done by using 10% formalin (Buffered with borate). The organisms were preserved with seawater as diluting agent.

Sample sieving:

Sediments samples were sieved to extract the organisms. Sieving was performed carefully as possible to avoid any damage to the animals. The large portion of the sediment was split in to smaller portions and mixed with sea water in a bucket. The cohesive lumps were broken down by continuous stirring. The disaggregated sediments were then passed through the sieves.

Sample staining:

Sorting of the Meio fauna from the sieve is difficult task especially in the preserved material, because organisms are not easily detectable. To facilitate the animal detection the entire sample retained on the sieve after sieving operation were stained by immersing the sieve in a flat bottom tub with 1% Rose Bengal stain; a protein stain. A staining period of 10-30 minutes is sufficient for sample detection.

DIVERSITY INDICES:

On the whole, diversity indices provide more information about community composition than simply species richness (number of species present); they also, take the relative abundances of different species into account. Based on this fact, diversity indices therefore depend not only on species richness but on the evenness, or equitability, with which individuals are distributed among the different species (Magurram, A. E. (1988)

A diversity index is a measure of species diversity within a community that consists of co-occurring populations of several (two or more) different species. It includes two components: richness and evenness. Richness is the measure of the number of different species within a sample showing that more the types of species in a community, the higher is the diversity or greater is the richness. Evenness is the measure of relative abundance of the different species with in a community.

The basic idea of diversity index is to obtain a quantitative estimate of biological variability that can be used to compare biological entities composed of discrete components in space and time (Carol H.R. *etal*. 1998). Biodiversity is commonly expressed through indices based on species richness and species abundances (Whittaker 1972, Lande 1996, Purvis and Hector 2000). Biodiversity indices are

a non-parametric tool used to describe the relationship between species number and abundance. The most widely used bio diversity indices are Shannon Weiner index and Simpson's index.

A diversity Index is a single statistic that incorporates information on richness and evenness. Any study intended to interpret causes and effect of adverse impact on Biodiversity of communities require suitable measures to evaluate specie richness and Diversity. The former is number of species in community, while latter is a function of relative frequency of different species. Species richness is the iconic measure of biological diversity (Magurran, 2004). Several indices have been created to measure the diversity of species; however, the most widely used in the last decades are the Shannon (1948) and Simpson (1949) (Buzas and Hayek 1996; Gorelick 2006), with the components of diversity: richness (*S)* and evenness (*J)*

Simpson's diversity index

Simpson's index (**D**) is a measure of diversity, which takes into account both species richness, and evenness of abundance among the species present. The Simpson index is one of the meaningful and robust biodiversity measures available. (Magurran ,2004).

The formula for calculating D is presented as:

$$D = \frac{\sum n_i(n_i - 1)}{N(N-1)}$$

Where n_i = the total number of organisms of each individual species

N = the total number of organisms of all species

The value of D ranges from 0 to 1. With this index, 0 represents infinite diversity and, 1, no diversity. When D increases diversity decreases. Simpson's index is therefore usually expressed as 1-D or 1/D. (Magurran, 2004)

Low species diversity suggests:

- relatively few successful species in the habitat
- the environment is quite stressful with relatively few ecological niches and only a few organisms are really well adapted to that environment
- food webs which are relatively simple
- change in the environment would probably have quite serious effects

High species diversity suggests:

- a greater number of successful species and a more stable ecosystem
- more ecological niches are available and the environment is less likely to be hostile complex food webs
- environmental change is less likely to be damaging to the ecosystem as a whole

Species richness indices

The species richness***(S)*** is simply the number of species present in an ecosystem. Species richness Indices of species richness are widely used to quantify or monitor the effects of anthropogenic

disturbance. A decline in species richness in may be concomitant with severe or chronic human-induced perturbation .Species richness measures have traditionally been the mainstay in assessing the effects of environmental degradation on the biodiversity of natural assemblages of organisms (Clarke & Warwick, 2001)

Species richness is the iconic measure of biological diversity (Magurran, 2004). The species richness ***(S)*** is simply the number of species present in an ecosystem. This index makes no use of relative abundances. The term species richness was coined by McIntosh (1967) and oldest and most intuitive measure of biological diversity (Magurran, 2004).

Margalef's diversity index is a species richness index. Margalef's Species richness index (d), or indices that describe the evenness of the distribution of the numbers of individuals among species, were derived.

The value of a diversity index increases both when the number of types increases and when evenness increases. For a given number of types, the value of diversity index is maximized when all types are equally abundant [Rosenzweig, M. L. (1995)]

Shannon-Wiener's index:

An index of diversity commonly used in plankton community analyses is the Shannon-Wiener's index **(H),** which emphasizes not only the number of species (richness or variety), but also the apportionment of the numbers of individuals among the species (Odum 1971 and Reish 1984). Shannon-Wiener's index **(H**) reproduces community parameters to a single number by using an equation.

Shannon and Weiner index represents entropy. It is a diversity index taking into account the number of individuals as well as the number of taxa. It varies from 0 for communities with only single taxa to high values for community with many taxa each with few individuals. This index can also determine the pollution status of a water body. Normal values range from 0 to 4. This index is a combination of species present and the evenness of the species. Examining the diversity in the range of polluted and unpolluted ecosystems, Wilham and Dorris (1968) concluded that the values of the index greater than 3 indicate clean water, values in the range of 1 to 3 are characterized by moderate pollution and values less than 1 are characterized as heavily polluted

$$H' = -\sum_{i=1}^{s} \frac{n_i}{N} \ln\left(\frac{n_i}{N}\right)$$

10.3 RESULTS:

CHLOROPHYLL-a:

In the sub surface water chlorophyll-a was varying from 0.323 -0.667 mg/m^3 with an average value 0.508 mg/m^3 in harbour region of DPA in Kandla Creek during sampling done in spring tide period of September 2022. In the nearby creeks chlorophyll-a was varying from 0.237 - 0.764 mg/m3. with an average value 0.567 mg/m^3 Pheophytin –a level was below detectable limit- the all the sampling stations during spring tide.

In the sub surface water chlorophyll-a was varying from 0.347- 0.631 mg/m^3 with an average value 0.541mg/m^3.in harbour region of DPA in Kandla Creek during sampling done in Neap tide period of September 2022. In the nearby creeks chlorophyll-a was varying from 0.496- 0.613 mg/m^3 with an average value 0.545 mg/m^3.Pheophytin –a level was below detectable limit- at the all the sampling stations.

In the sub surface water chlorophyll-a was varying from 0.448 - 0.630 mg/m^3 in harbour region of DPA OOT in path finder Creek during sampling done in spring tide period of September 2022. In the sub surface water chlorophyll-a was varying from 0.460 - 0.732 mg/m^3 in harbour region of DPA OOT in path finder Creek during sampling done in Neap Tide period of September 2022

TABLE 48 VARIATIONS IN CHLOROPHYLL –a PHEOPHYTIN- a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPA HARBOUR AREA IN KANDLA CREEK ,NEAR BY CREEKS AND DPA OOT JETTY IN PATH FINDER CREEK AND SPM NEAR VADINAR DURING SPRING TIDE IN SEPTEMBER 2022

Sr. No.	Station	Tide	Chlorophyll-a ($mg/m^{3)}$	Pheophytin- a ($mg/m^{3)}$	Algal Biomass (Chlorophyll method) mg/m^3
DPA HARBOUR AREA KANDLA CREEK					
1	KPT1	High tide	0.564	BDL	37.79
		Low tide	0.323	BDL	21.67
2	KPT 2	High tide	0.647	BDL	43.35
		Low tide	0.441	BDL	29.55
3	KPT 3	High tide	0.667	BDL	44.69
		Low tide	0.409	BDL	27.40
CREEKS					
4	KPT-4 Khori-I	High tide	0.748	BDL	50.22
		Low tide	0.440	BDL	29.48
5	KPT-5 Nakti-I	High tide	0.764	BDL	51.19
		Low tide	0.645	BDL	43.22
6	KPT-6 Nakti-II	High tide	-	--	--
PATHFINDER CREEK VADINAR					
7	VADINAR-I jetty	High tide	0.452	BDL	30.28
8		Low tide	0.630	BDL	42.21
9	SPM	High tide	0.448	BDL	30.02
10	SPM	Low tide	0.530	BDL	35.51

BDL: Below Detectable Limit.

TABLE 49 VARIATIONS IN CHLOROPHYLL –a PHEOPHYTIN- a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPA HARBOUR AREA, NEAR BY CREEKS AND DPA OOT JETTY IN PATH FINDER CREEK AND SPM NEAR VADINAR DURING NEAP TIDE IN SEPTEMBER 2022

Sr. No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPA HARBOUR AREA KANDLA CREEK					
1	KPT1	High tide	0.631	BDL	42.28
		Low tide	0.516	BDL	34.57
2	KPT 2	High tide	0.617	BDL	41.34
		Low tide	0.347	BDL	23.25
3	KPT 3	High tide	0.630	BDL	42.21
		Low tide	0.510	BDL	34.17
CREEKS					
4	KPT-4 Khori-I	High tide	0.548	BDL	36.72
		Low tide	0.526	BDL	35.24
5	KPT-5 Nakti-I	High tide	0.613	BDL	41.07
		Low tide	0.496	BDL	33.23
6	KPT-6 Nakti-II	High tide	-	-	-
PATHFINDER CREEK VADINAR					
7	VADINAR-I jetty	High tide	0.542	BDL	36.31
8		Low tide	0.460	BDL	30.82
9	SPM	High tide	0.662	BDL	44.35
10	SPM	Low tide	0.732	BDL	49.04

BDL: Below Detectable Limit.

PHYTOPLANKTON POPULATION:

For the evaluation of the Phytoplankton population in DPA harbour area and within the immediate surroundings of the port, sampling was conducted from 5 sampling locations (3 in harbour area and two in Nakti creek) during high tide period and low tide period of spring tide and neap tide.

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by, Diatoms, Blue Green Algae algae and Dinoflagellates during spring tide period. Diatoms were represented by 25 genera, Blue Green Algae algae were represented by 3 genera and Dinoflagellates were represented by 3 genera during the sampling conducted in spring tide in September, 2022. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 46-312 units/ L during high tide period and 164-213 units/ L during low tide of Spring Tide.

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by Diatoms, Blue Green Algae algae and Dinoflagellates during Neap tide period. Diatoms were represented by 27 genera, Blue Green Algae algae were represented 4 genera and Dinoflagellates with 3 genera during the sampling conducted in Neap tide in September, 2022. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 47-225 units/ L during high tide period and 132-196 units/ L during low tide of Neap Tide.

For the evaluation of the Phytoplankton population in DPA OOT jetty area in Path Finder creek sampling was conducted from two sampling locations; jetty area during high tide period and low tide of spring tide and Neap tide period.

The phytoplankton community of the sub surface water in the path finder creeks was represented by Diatoms, Blue Green Algae algae and Dinoflagellates during spring tide period. Diatoms were represented by 19 genera, Blue Green Algae algae by 2 genera and Dinoflagellates by 5 genera during the sampling conducted in spring tide in September, 2022. Phytoplankton of the sampling stations at sub surface layer in the harbour area was 95 units/ L during high tide period and 114 units/ L during low tide of Spring Tide. Phytoplankton of the sampling stations at sub surface layer in the *SPM area* was varying from 92 units/ L during high tide period and 156 units/ L during low tide of Spring Tide.

The phytoplankton community of the sub surface water in the path finder creeks was represented by Diatoms, Blue Green Algae and Dinoflagellates during Neap tide period. Diatoms were represented by 19 genera and Blue Green Algae algae by 3 genera and Dinoflagellates by 5 genera during the sampling conducted in Neap tide in September, 2022. Phytoplankton of the sampling stations at sub surface path finder creek near OOT Jetty was varying from 105 units/ L during high tide period and 90 units/ L during low tide of Neap Tide. Phytoplankton of the sampling stations at sub surface path finder creek near SPM area was varying from 87 units/ L during high tide period and 68 units/ L during low tide of Neap Tide.

Species Richness Indices and Diversity Indices:

Margalef's diversity index (Species Richness) S

Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek and nearby creeks sampling stations was varying from 2.873- 3.94 with an average of 3.302 during the sampling conducted in High tide period of spring tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek region and nearby creeks was varying from 2.873- 3.233 with an average of 3.084 during the consecutive low tide period.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations in Kandla creek and nearby creeks was varying from 3.117- 4.431 with an average of 3.852 during the sampling conducted in High tide period of Neap tide. While Margalef's diversity index (Species Richness) of phytoplankton communities in the Kandla creek region and nearby creeks was varying from 3.072- 4.463 with an average of 3.817 during consecutive low tide.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations was 4.392 at OOT jetty area and 3.981 at SPM area during the sampling conducted in High tide period of spring tide. While Margalef's diversity index (Species Richness) of phytoplankton communities in the path finder creek near OOT jetty was 4.012 and 3.762 at SPM during the consecutive low tide period.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations was 4.942 at OOT jetty area and 4.702 at SPM area during the sampling conducted in High tide period of Neap tide. While Margalef's diversity index (Species Richness) of phytoplankton communities in the path finder creek near OOT jetty was 4.889 and SPM area was 4.029 during the consecutive low tide period.

Shannon-Wiener's index:

Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.868- 0.965 between selected sampling stations with an average value of 0.922 during high tide period of spring tide at Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.850-0.951 between selected sampling stations with an average value of 0.899 during consecutive low tide at Kandla creek and nearby creeks.

Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.863– 1.011 between selected sampling stations with an average value of 0.945 during high tide period of neap tide at Kandla creek and nearby creeks. Shannon-Wiener's Index of phytoplankton communities in the sampling stations was in the range of 0.886- 0.985 between selected sampling stations with an average value of 0.933 during consecutive low tide at Kandla creek and nearby creeks.

Shannon-Wiener's Index (H) of phytoplankton communities in the stations was 1.132 at OOT jetty area and 1.071 at SPM area during the sampling conducted in High tide period of spring tide. While Shannon-Wiener's Index (H) of phytoplankton communities in the path finder creek near OOT jetty was 1.064 and 0.889 at SPM during the consecutive low tide period of spring tide.

Shannon-Wiener's Index (H) of phytoplankton communities in the stations was 1.121 at OOT jetty area and 1.143 at SPM area during the sampling conducted in High tide period of Neap tide. While Shannon-Wiener's Index (H) of phytoplankton communities in the path finder creek near OOT jetty was 1.163 and at SPM area was 1.008 during the consecutive low tide period.

Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon-Wiener's index increases as both the richness and the evenness of the community increase. This result indicates that diversity of phytoplankton of Kandla Harbour region and nearby creeks is less but with abundant population of few, with relatively few ecological niches and only very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson's diversity index:

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks, which was varying from 0.779- 0.867 between selected sampling stations with an average of 0.827 during high tide period of spring tide. Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks except few, which was varying from 0.799- 0.852 between selected sampling stations with an average of 0.820 during consecutive low tide.

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations except few in Kandla Harbour region and nearby creeks, during high tide period and low tide period during Neap tide also, which was varying from 0.754- 0.881 with an average value of 0.830 between selected sampling stations during high tide period and 0.799- 0.853 varying from with an average value of 0.828 between selected sampling stations during consecutive low tide period Low species diversity suggests a relatively few successful species in this habitat.

Simpson diversity index (1-D) of phytoplankton communities in the stations was 0.908 at OOT jetty area and 0.894 at SPM area during the sampling conducted in High tide period of spring tide at Path finder creek. While Simpson diversity index (1-D) of phytoplankton communities in the path finder creek near OOT jetty was 0.878 and 0.802 at SPM during the consecutive low tide period in the path finder creek.

Simpson diversity index (1-D) of phytoplankton communities in the stations was 0.886 at OOT jetty area and 0.901 at SPM area during the sampling conducted in High tide period of Neap tide at Path finder Creek. While Simpson diversity index (1-D) of phytoplankton communities in the path finder creek near OOT jetty was 0.911 and at SPM area was 0.871 during the consecutive low tide period.

Low species diversity suggests a relatively few successful species in this habitat. The environment is quite stressful with relatively few ecological niches and only a few organisms are really well adapted to that environment. Any change in the environment would probably have quite serious effects.

Table 50 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND ,NEAR BY CREEKS DURING SPRING TIDE IN SEPTEMBER 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% Of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	266	23/31	74.19	3.94	0.9655	0.8335
	2	271	18/31	58.06	3.035	0.9079	0.8265
	3	312	19/31	61.29	3.134	0.8683	0.7787
	4	247	19/31	61.29	3.267	0.913	0.8179
	5	273	21/31	67.74	3.565	0.946	0.8389
	6	46	12/31	38.71	2.873	0.9315	0.8667
LOW TIDE	1	185	16/31	51.61	2.873	0.8496	0.7989
	2	205	18/31	58.06	3.194	0.8789	0.8064
	3	192	18/31	58.06	3.233	0.924	0.8256
	4	164	17/31	54.84	3.137	0.9512	0.8519
	5	213	17/31	54.84	2.984	0.8931	0.8181

Table 51 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND ,NEAR BY CREEKS DURING NEAP TIDE IN SEPTEMBER 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	225	25/34	73.53	4.431	1.002	0.8524
	2	201	23/34	67.65	4.148	1.011	0.8571
	3	180	19/34	55.88	3.466	0.8852	0.8044
	4	216	23/34	67.65	4.093	0.8626	0.754
	5	179	21/34	61.76	3.856	0.9338	0.8298
	6	47	13/34	38.24	3.117	0.9729	0.8807
LOW TIDE	1	196	23/34	67.65	4.168	0.9087	0.7995
	2	132	16/34	47.06	3.072	0.9348	0.8489
	3	165	20/34	58.82	3.721	0.8862	0.8
	4	173	24/34	70.59	4.463	0.985	0.8382
	5	179	20/34	58.82	3.663	0.9498	0.8535

Table 52 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND, NEAR BY CREEKS DURING SPRING TIDE IN SEPTEMBER 2022

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	DIATOMS	34-307	25/31	80.64
			BLUE GREEN ALGAE ALGAE	3-12	3/31	9.68
			DINOFLAGELLATES	0-3	3/31	9.68
			TOTAL PHYTO PLANKTON	**46-312**	**31**	
LOW TIDE	Sub surface	5	DIATOMS	162-209	25/31	80.64
			BLUE GREEN ALGAE ALGAE	1-5	3/31	9.68
			DINOFLAGELLATES	1-3	3/31	9.68
			TOTAL PHYTO PLANKTON	**164-213**	**31**	

TABLE 53 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND, NEAR BY CREEKS DURING NEAP TIDE IN SEPTEMBER 2022

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	DIATOMS	44-210	27/34	79.42
			BLUE GREEN ALGAE ALGAE	3-11	4/34	11.76
			DINOFLAGELLATES	0-4	3/34	8.82
			TOTAL PHYTO PLANKTON	**47-225**	**34**	
LOW TIDE	Sub surface	5	DIATOMS	120-185	27/34	79.42
			BLUE GREEN ALGAE ALGAE	5-22	4/34	11.76
			DINOFLAGELLATES	1-6	3/34	8.82
			TOTAL PHYTO PLANKTON	**132-196**	**34**	

TABLE # 8 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING SPRING TIDE IN SEPTEMBER 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	95	21/26	80.77	4.392	1.132	0.908
	SPM	92	19/26	73.08	3.981	1.071	0.894
LOW TIDE	Jetty	114	20/26	76.92	4.012	1.064	0.878
	SPM	156	20/26	76.92	3.762	0.889	0.802

TABLE 54 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING NEAP TIDE IN SEPTEMBER 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	105	24/27	88.89	4.942	1.121	0.886
	SPM	87	22/27	81.48	4.702	1.143	0.901
LOW TIDE	Jetty	90	23/27	85.19	4.889	1.163	0.911
	SPM	68	18/27	66.67	4.029	1.008	0.871

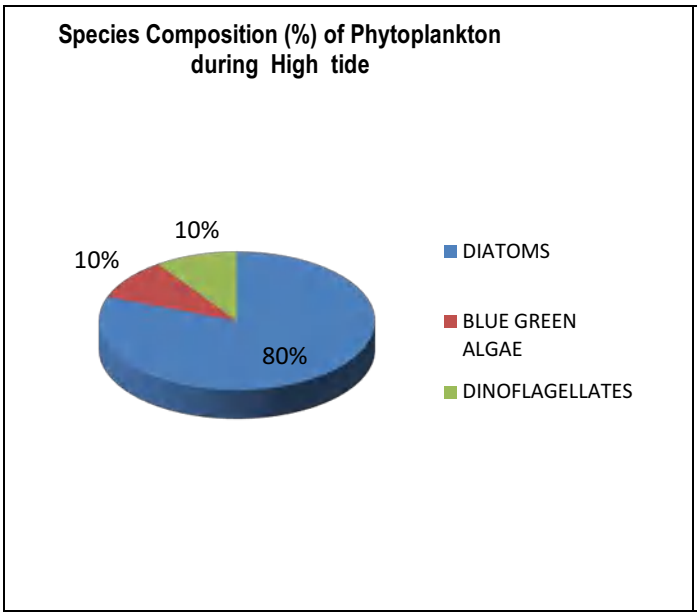
TABLE 55 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPAOOT AT PATH FINDER CREEK, VADINAR & NEAR BY SPM, DURING SPRING TIDE IN SEPTEMBER 2022

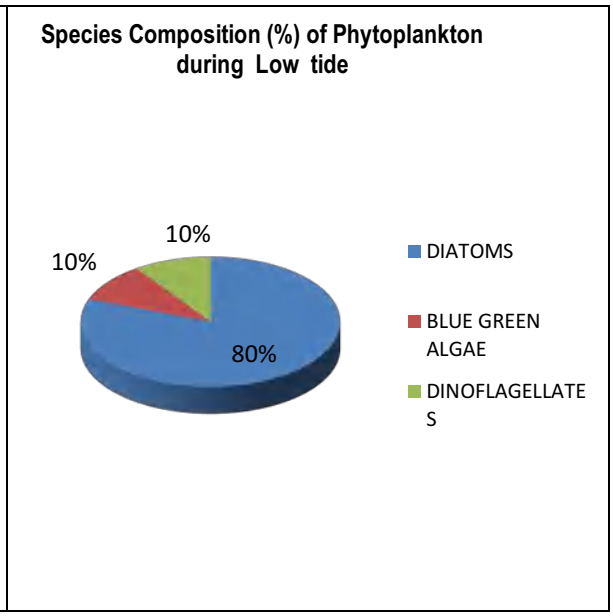
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	DIATOMS	79-80	19/26	73.08
			BLUE GREEN ALGAE ALGAE	2-6	2/26	7.69
			DINOFLAGELLATES	9-11	5/26	19.23
			TOTAL PHYTO PLANKTON	**92-95**	**26**	
LOW TIDE	Sub surface	2	DIATOMS	102-147	19/26	73.08
			BLUE GREEN ALGAE ALGAE	2-5	2/26	7.69
			DINOFLAGELLATES	7	5/26	19.23
			TOTAL PHYTO PLANKTON	**114-156**	**26**	

Table 56 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPAOOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING NEAP TIDE IN SEPTEMBER 2022

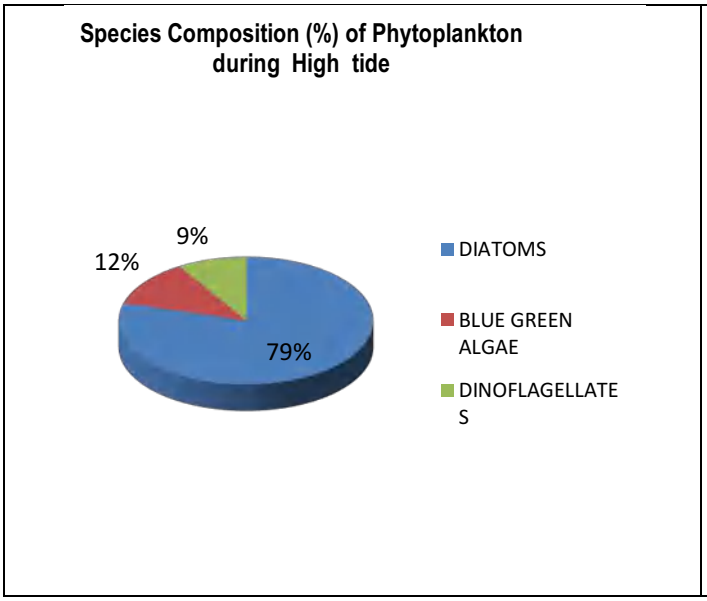
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	DIATOMS	70-93	19/27	70.37
			BLUE GREEN ALGAE ALGAE	6-8	3/27	11.11
			DINOFLAGELLATES	6-9	5/27	18.52
			TOTAL PHYTO PLANKTON	**87-105**	**27**	
LOW TIDE	Sub surface	2	DIATOMS	59-74	19/27	70.37
			BLUE GREEN ALGAE ALGAE	4-12	3/27	11.11
			DINOFLAGELLATES	4-5	5/27	18.52
			TOTAL PHYTO PLANKTON	**68-90**	**27**	

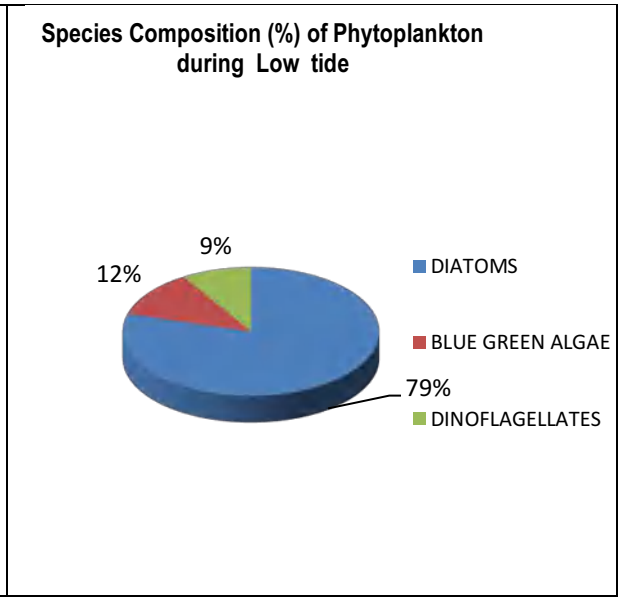
Species Composition (%) of Phytoplankton during High tide and Low tide period during spring tide in Kandala creek and nearby creeks



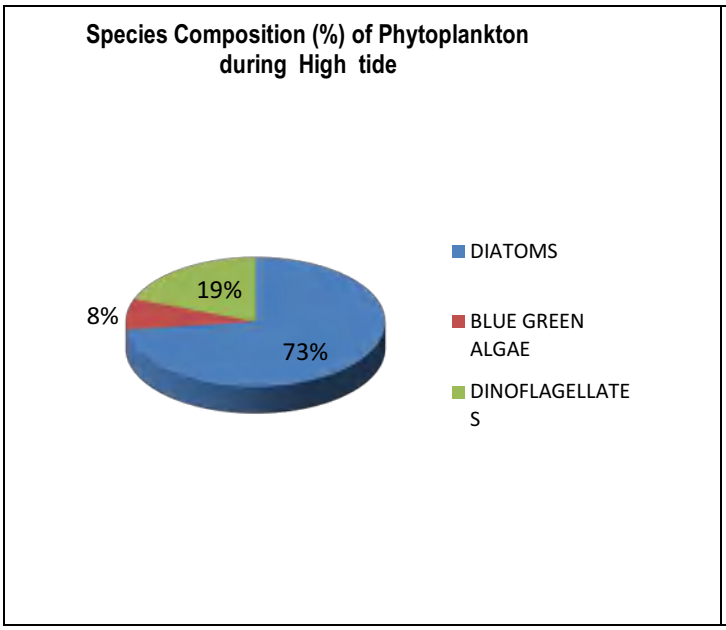


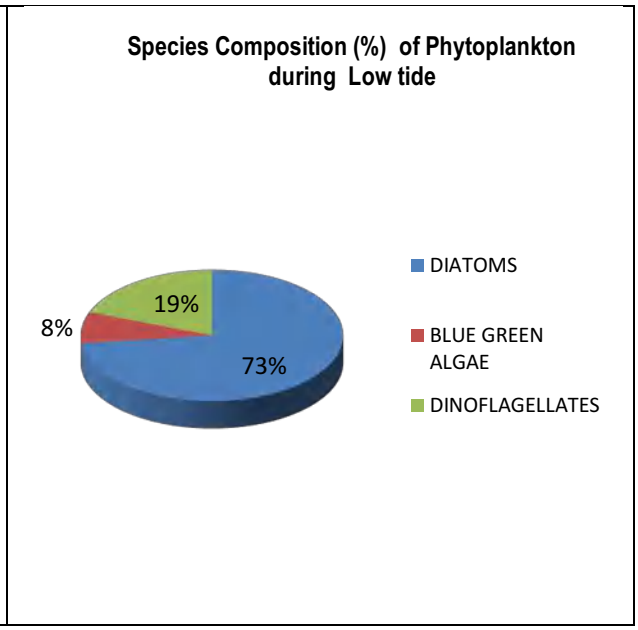
Species Composition (%) of Phytoplankton during High tide and Low tide period during Neap tide in Kandala creek and nearby creeks



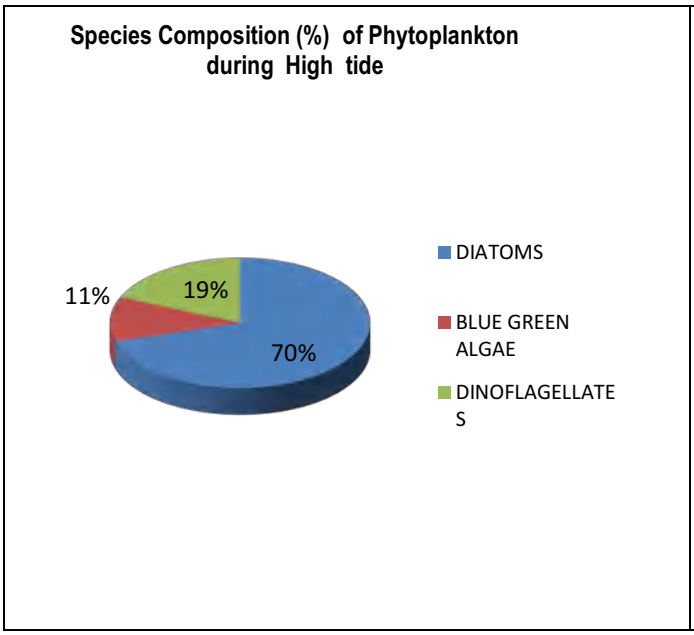


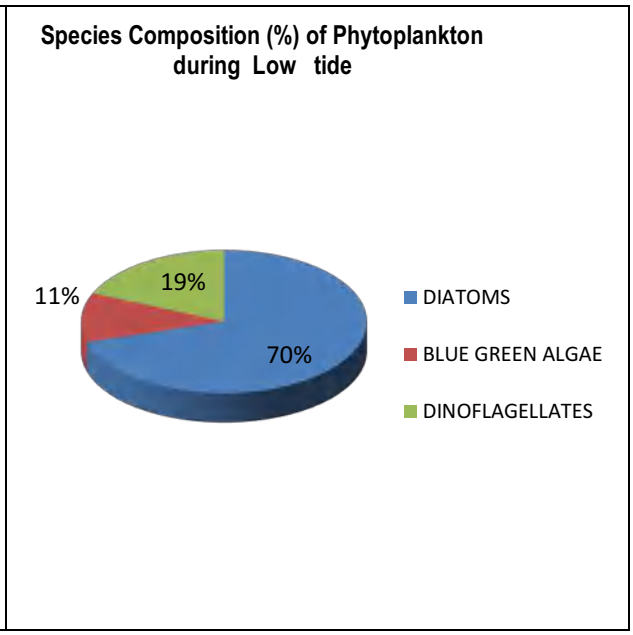
Species Composition (%) of Phytoplankton during High tide and Low tide period during spring tide in Path Finder Creek, Vadinar





Species Composition (%) of Phytoplankton during High tide and Low tide period during Neap tide in Path Finder Creek, Vadinar





ZOOPLANKTON POPULATION:

For the evaluation of the Zooplankton population in DPA harbour area and within the immediate surroundings of the port sampling was conducted from 6 sampling locations (3 in harbour area and two in Nakti creek and one in Khori creek) during high tide period and low tide period of spring tide and Neap tide in September, 2022. The Zooplankton community of the sub surface water in the harbour and nearby creeks during spring tide was represented by mainly seven groups; Tintinids, Copepods, Rotifers, Arrow worms, Urochordata, Ciliates, Nematodes and 6 larval forms. The Zooplankton community of the sub surface water in the harbour and nearby creeks during neap tide was represented by mainly eight groups; Tintinids, Copepods, Rotifers, Mysids, Urochordata, Arrow worms, Ciliates, Nematode and 7 larval forms.

Zooplankton of the sampling stations at sub surface layer in the DPA harbour area and nearby creek was varying from 34-85 $x10^3$ N/ m^3 during high tide and 35-54 $x10^3$ N/ m^3 during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPA harbour area and nearby creek was varying from 43-145 $x10^3$ N/ m^3 during high tide and 95-118 $x10^3$ N/ m^3 during low tide of Neap Tide period.

For the evaluation of the Zooplankton population in DPA OOT jetty area in Path Finder creek and SPM in Vadinar selected 2 sampling locations (1 in jetty area and one near SPM).
During spring tide sampling plankton sample were collected at Jetty area and near SPM during consecutive high tide period and low tide period. During Neap tide sampling Plankton samples were collected from jetty area and SPM during consecutive high tide period and low tide period.
The Zooplankton community of the sub surface water in the path finder creek during spring tide was represented by mainly five groups Titinids, Copepods, Arrow worms, Urochordata, Mysids and 5 larval forms.

The Zooplankton community of the sub surface water in the path Finder creeks at Jetty region and SPM during neap tide was represented by mainly Seven groups, Titinids, Copepods, Arrow worms, Mysids, Urochordata, Medusa, Nematode and 8 larval forms.

Zooplankton of the sampling stations at sub surface layer in the DPA OOT Jetty area of path finder creek was 102 $x10^3$ N/ m^3 during high tide and 106 $x10^3$ N/ m^3 during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPA SPM area of path finder creek was 60 $x10^3$ N/ m^3 during high tide and 124 $x10^3$ N/ m^3 during low tide of spring Tide period.

Zooplankton of the sampling stations at sub surface layer in the DPA OOT jetty area in path finder creek was recorded 150 $x10^3$ N/ m^3 during high tide and 147 $x10^3$ N/ m^3 during consecutive low tide period of Neap tide. Zooplankton of the sampling stations at sub surface layer in the DPA SPM area

in path finder creek was recorded $108x10^3$ N/ m^3during high tide and 117 $x10^3$ N/ m^3 during consecutive low tide period of Neap Tide.

Species Richness Indices and Diversity Indices:

Margalef's diversity index (Species Richness)

Margalef's diversity index (Species Richness) of Zooplankton communities in the stations Kandla creek region and nearby creeks were varying from 1.701- 3.95 with an average of 2.924 during the sampling conducted in High tide period. Margalef's diversity index (Species Richness) of Zooplankton communities varying from 1.688- 3.834 with an average of 2.582 during the sampling conducted in low tide period during Spring tide.

Margalef's diversity index (Species Richness) of Zooplankton communities in the Kandla creek region and nearby creeks sampling stations were varying from 2.393- 4.996 with an average of 3.85 during the sampling conducted in high tide and varying from 3.272 - 4.942 with an average of 3.903 during the sampling conducted in low tide during Neap tide period.

Margalef's diversity index (Species Richness) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 4.324 and 4.503 respectively. Margalef's diversity index (Species Richness) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 3.419 and 3.527 respectively.

Margalef's diversity index (Species Richness) of Zooplankton communities near Jetty at Path finder creek were varying from 5.189 and 3.607 respectively during the sampling conducted in consecutive High tide period and Low tide period of Neap tide. While Margalef's diversity indexes (Species Richness) of Zooplankton communities near SPM at Path finder creek were varying from 4.272- 3.15 respectively during the consecutive High tide and low tide period.

Shannon-Wiener's index:

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.624-1.049 between selected sampling stations with an average value of 0.884 during high tide period of spring tide. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.584- 0.977 between selected sampling stations with an average value of 0.762 during consecutive low tide period.

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.893-1.103 between selected sampling stations with an average value of 0.99' during high tide period of Neap tide. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was

in the range 0.939- 1.138 of between selected sampling stations with an average value of 1.020 during consecutive low tide period.

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 1.073-1.05 respectively. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.897-0.863 respectively.

Shannon-Wiener's Index (H) of Zooplankton communities near jetty at Path finder creek was varying from 1.023-0.996 respectively during the sampling conducted consecutive High tide period and Low tide period of Neap tide. While Shannon-Wiener's Index (H) of Zooplankton communities near SPM at Path finder creek was varying from 1.064-0.898 during the consecutive High tide and low tide period.

Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon-Wiener's index increases as both the richness and the evenness of the community increase. This result indicates that diversity of Zooplankton of Kandla Harbour region and nearby creeks stations is slightly high with very minimum diverse population but very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson's diversity index:

Simpson diversity index (1-D) of Zooplankton communities was below 0.9 most of sampling stations in the Kandla Harbour region and nearby creeks during high tide and low tide of spring tide period except few stations, which was varying from 0.709-0.885 between selected sampling stations with an average of 0.835 during high tide period and was varying from 0.672 - 0.859 with an average value of 0.761 between selected sampling stations during low tide.

Simpson diversity index (1-D) of Zooplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks during high tide and low tide period of Neap tide except few, which was varying from 0.781- 0.898 between selected sampling stations with an average of 0.849 during high tide period and was varying from 0.840--0.901 with an average value of 0.867 between selected sampling stations during consecutive low tide .This species diversity suggests a relatively few successful species in this habitat during September ,2022 sampling.

Simpson diversity index (1-D) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.876 and 0.868 respectively. Simpson diversity index (1-D) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.818 and 0.789 respectively.

Simpson diversity index (1-D) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of Neap tide was recorded as 0.851- 0.867 respectively. Simpson diversity index (1-D) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.889 and 0.843 respectively.

TABLE 57 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND NEAR BY CREEKS DURING SPRING TIDE IN SEPTEMBER 2022

Tide	Sampling Station	Abundance In Nx10^3/ m^3	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	74	18/27	66.67	3.95	1.049	0.8852
	2	59	13/27	48.15	2.943	0.8943	0.8533
	3	85	17/27	62.96	3.601	0.9974	0.8731
	4	61	14/27	51.85	3.162	0.9681	0.8765
	5	39	9/27	33.33	2.184	0.7723	0.8097
	6	34	7/27	25.93	1.701	0.6237	0.7094
LOW TIDE	1	50	12/27	44.44	2.812	0.7838	0.7657
	2	50	16/27	59.26	3.834	0.9769	0.8588
	3	35	7/27	25.93	1.688	0.5843	0.6723
	4	54	11/27	40.74	2.507	0.7574	0.7428
	5	48	9/27	33.33	2.067	0.7083	0.7668

TABLE 58 ZOOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA HARBOUR AREAAT KANDLA CREEK AND NEAR BY CREEKS DURING NEAP TIDE IN SEPTEMBER 2022

Tide	Sampling Station	Abundance In No x10^3/ m^3	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	122	25/32	78.13	4.996	1.079	0.8675
	2	132	18/32	56.25	3.482	0.9421	0.8241
	3	145	21/32	65.63	4.019	1.033	0.8575
	4	145	20/32	62.50	3.818	0.8926	0.781
	5	95	21/32	65.63	4.392	1.103	0.8983
	6	43	10/32	31.25	2.393	0.8945	0.8682
LOW TIDE	1	105	24/32	75.00	4.942	1.138	0.9013
	2	95	16/32	50.00	3.294	0.9387	0.8396
	3	98	16/32	50.00	3.272	0.9756	0.8586
	4	118	22/32	68.75	4.402	1.067	0.8812
	5	112	18/32	56.25	3.603	0.9797	0.8554

Table 59 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND NEAR BY CREEKS DURING SPRING TIDE IN SEPTEMBER 2022

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^3/m^3$ Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinids	1-8	5/27	18.53
			Copepods	3-39	11/27	40.75
			Rotifers	0-16	1/27	3.70
			Arrow worms	0-2	1/27	3.70
			Urochordata	0-2	1/27	3.70
			Ciliates	0-2	1/27	3.70
			Larval forms	10-35	6/27	22.22
			Nematode	0-1	1/27	3.70
			TOTAL ZOOPLANKTON N/ M^3	**34-85**	**27**	
LOW TIDE	Sub surface	5	Tintinids	0-5	5/27	18.53
			Copepods	11-28	11/27	40.75
			Rotifers	0	1/27	3.70
			Arrow worms	0-2	1/27	3.70
			Urochordata	0-1	1/27	3.70
			Ciliates	0-1	1/27	3.70
			Larval forms	14-32	6/27	22.22
			Nematode	0-1	1/27	3.70
			TOTAL ZOOPLANKTON N/M^3	**35-54**	**27**	

TABLE 60 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA HARBOUR AREA IN KANDLA CREEK AND, NEAR BY CREEKS DURING NEAP TIDE IN SEPTEMBER 2022

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^{3/}/m^3$ Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinids	0-11	7/32	21.86
			Copepods	14-55	12/32	37.50
			Rotifers	0-10	1/32	3.13
			Arrow worms	0-2	1/32	3.13
			Mysids	0-2	1/32	3.13
			Urochordata	0-2	1/32	3.13
			Ciliates	1-4	1/32	3.13
			Larval forms	17-90	7/32	21.86
			Nematode	0-1	1/32	3.13
			TOTAL ZOOPLANKTON N/M^3	**43-145**	**32**	
			Tintinids	7-12	7/32	21.86

LOW TIDE	Sub surface	5	Copepods	26-50	12/32	37.50
			Rotifers	0	1/32	3.13
			Arrow worms	0-2	1/32	3.13
			Mysids	0-2	1/32	3.13
			Urochordata	0-2	1/32	3.13
			Ciliates	1-5	1/32	3.13
			Larval forms	45-56	7/32	21.86
			Nematode	0-4	1/32	3.13
			TOTAL ZOOPLANKTON N/M^3	**95-118**	**32**	

Table 61 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING SPRING TIDE IN SEPTEMBER 2022

Tide	Sampling Station	Abundance In x10^{3}N / m^3	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	102	21/26	80.77	4.324	1.073	0.876
	SPM	60	15/26	57.69	3.419	0.897	0.818
LOW TIDE	Jetty	106	22/26	84.62	4.503	1.05	0.868
	SPM	124	18/26	69.23	3.527	0.863	0.789

TABLE 62 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING NEAP TIDE IN SEPTEMBER 2022

Tide	Sampling Station	Abundance In Nx10^3/ m^3	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	150	27/32	84.38	5.189	1.023	0.851
	SPM	108	21/32	65.63	4.272	1.064	0.889
LOW TIDE	Jetty	147	19/32	59.38	3.607	0.996	0.867
	SPM	117	16/32	50.00	3.15	0.898	0.843

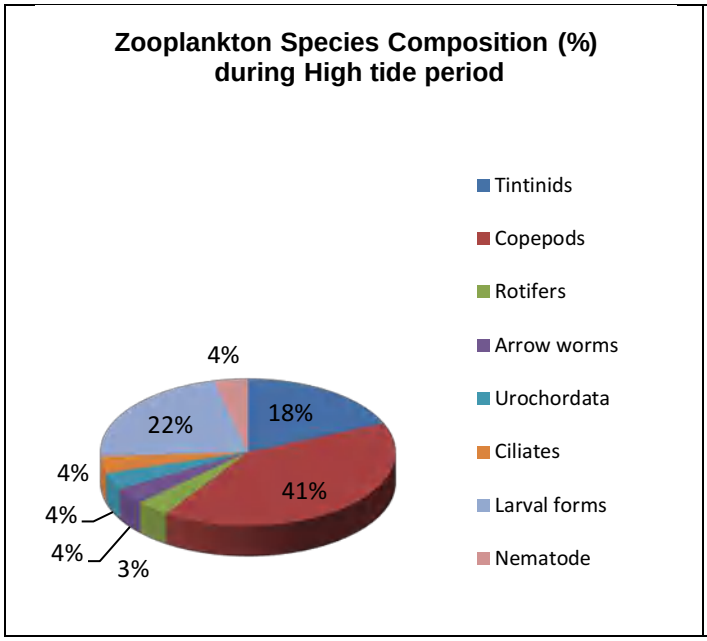
Table 63 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA OOT AREA AND PATH FINDER CREEK AND NEAR BY SPM DURING SPRING TIDE IN SEPTEMBER 2022

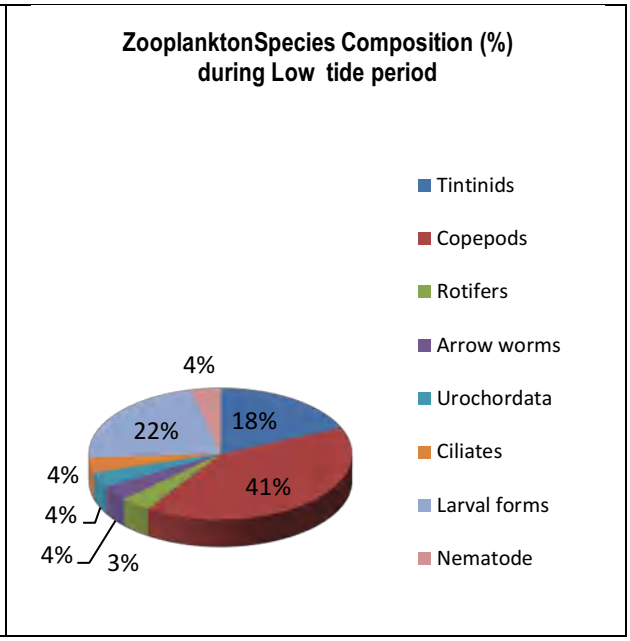
Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^{3/}$ m^3 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	Tintinids	12-28	8/26	30.77
			Copepods	23-34	10/26	38.46
			Arrow worms	1-2	1/26	3.85
			Mysids	1-2	1/26	3.85
			Urochordata	1	1/26	3.85
			Larval forms	22-35	5/26	19.22
			TOTAL ZOOPLANKTON NO/L	**60-102**	**26**	
LOW TIDE	Sub surface	2	Tintinids	32-37	8/26	30.77
			Copepods	32-35	10/26	38.46
			Arrow worms	0-1	1/26	3.85
			Mysids	0-1	1/26	3.85
			Urochordata	0-2	1/26	3.85
			Larval forms	37-53	5/26	19.22
			TOTAL ZOOPLANKTON NO/L	**106-124**	**26**	

TABLE 64 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING NEAP TIDE IN SEPTEMBER 2022

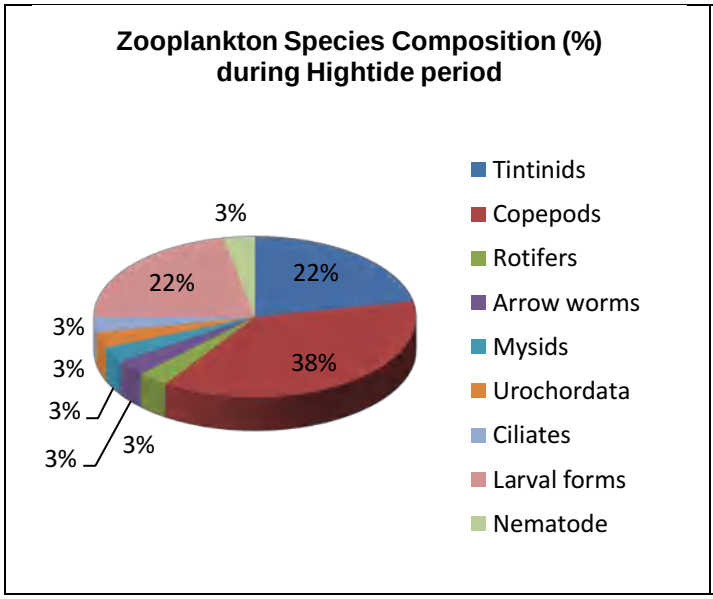
Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^3$/ m^3 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	Tintinids	27-30	6/32	18.73
			Copepods	53-61	13/32	40.62
			Arrow worms	1	1/32	3.13
			Mysids	0-2	1/32	3.13
			Urochordata	0	1/32	3.13
			Medusa	0-1	1/32	3.13
			Larval forms	25-55	8/32	25.00
			Nematode	1	1/32	3.13
			TOTAL ZOOPLANKTON	**108-150**	**32**	
LOW TIDE	Sub surface	2	Tintinids	27-37	6/32	18.73
			Copepods	55-61	13/32	40.62
			Arrow worms	0	1/32	3.13
			Mysids	0	1/32	3.13
			Urochordata	0-2	1/32	3.13
			Medusa	0	1/32	3.13
			Larval forms	35-47	8/32	25.00
			Nematode	0	1/32	3.13
			TOTAL ZOOPLANKTON	**117-147**	**32**	

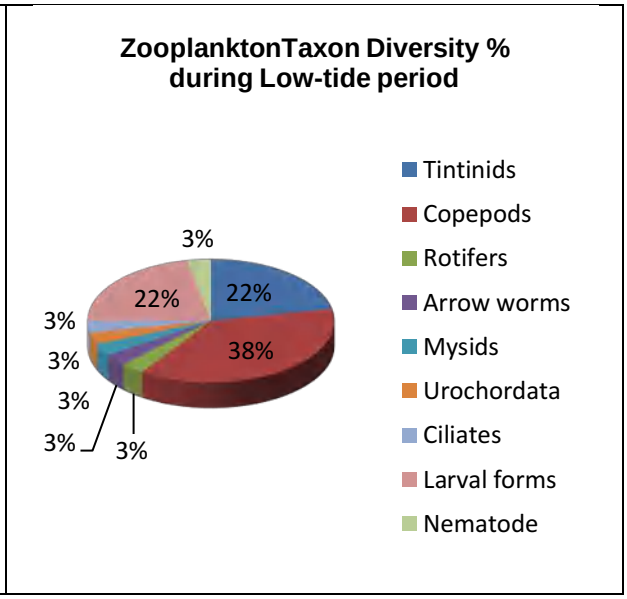
Species Composition (%) of Zooplankton during High tide and Low tide period of Spring tide In Kandla Creek and nearby Creeks



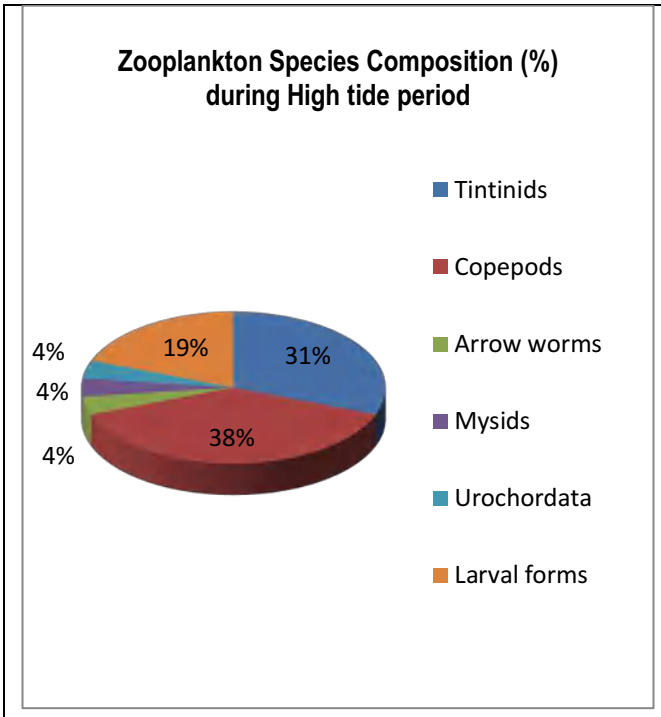


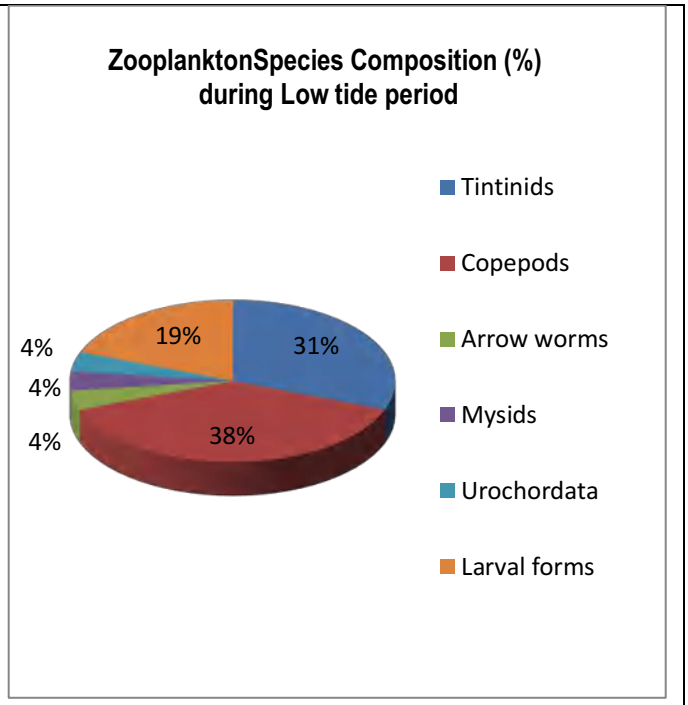
Species Composition (%) of Zooplankton during High tide and Low tide period of Neap tide In Kandla Creek and nearby Creeks



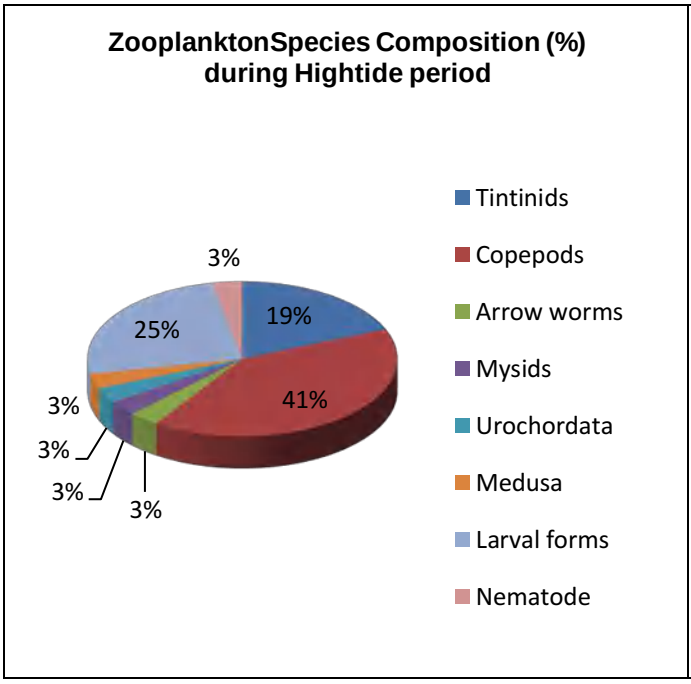


Species Composition (%) of Zooplankton during High tide and Low tide period of Spring tide In Path Finder Creek and near Jetty





Species Composition (%) of Zooplankton during High tide and Low tide period of Neap tide In Path Finder Creek near jetty and nearby SPM



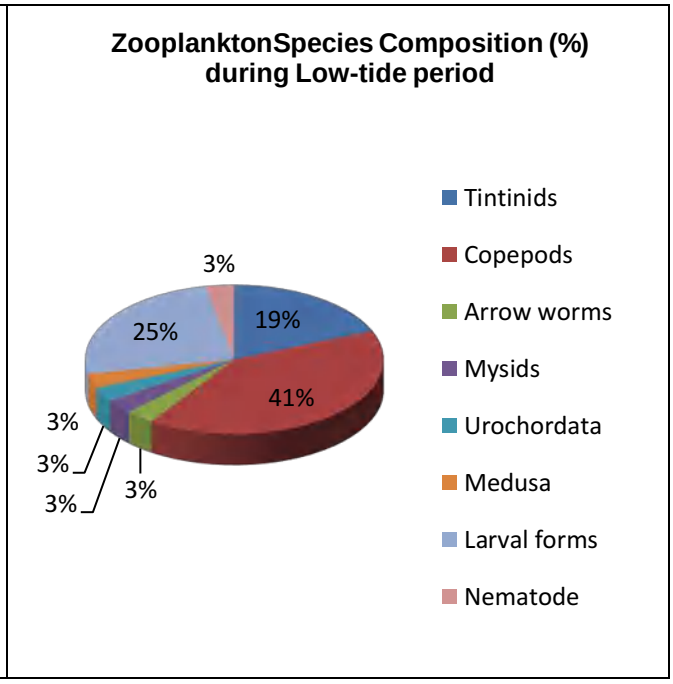


TABLE 65 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS OF DPA HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING NEAP TIDE OF SEPTEMBER 2022

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
Cyanophyceae	Nostocales	Oscillatoriaceae	*Arthrospira sp.*	B1	Very sparse
			Lyngbya sp.	B2	Very sparse
			Oscillatoria sp.	B3	Very sparse
	Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B4	Very sparse
Coscinodiscophyceae	Biddulphiales	Biddulphiaceae	*Biddulphia* sp.	D1	Dominant
	Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp	D2	Sparse
	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D3	Scattered
	Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D4	Very sparse
		Hemiaulaceae	*Cerataulina sp.*	D5	Very sparse
	Leptocylindrales	Leptocylindraceae	*Leptocylindrus sp*	D6	Very sparse
	Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D7	Abundant
	Melosirales	Melosiraceae	*Melosira sp*	D8	Very sparse
	Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D9	Very sparse
	Thalassiosirales	Skeletonemataceae	*Skeletonema sp.*	D10	Very sparse
		Lauderiaceae	*Lauderia sp*	D11	Very sparse
		Thalassiosiraceae	*Planktoniella sp*	D12	Very sparse
	Triceratiales	Triceratiaceae	*Odontella* sp.	D13	Scattered
			Triceratium sp.	D14	Sparse
Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria* sp.	D15	Very sparse
			Nitzschia sp	D16	Very sparse
			Pseudo-ntzschia sp	D17	Very sparse
	Naviculales	Naviculaceae	*Navicula* sp	D18	Very sparse
		Pleurosigmataceae	*Pleurosigma* sp	D19	Very sparse
		Pinnulariaceae	*Pinnularia sp*	D20	Very sparse
	Surirellales	Surirellaceae	*Campylodiscus* sp	D21	Very sparse
			Surirella sp	D22	Very sparse
Fragilariophyceae	Fragilariales	Fragilariaceae	*Asterionellopsis sp.*	D23	Scattered
			Fragilaria sp	D24	Very sparse
			Synedra sp	D25	Sparse
	Thalassionematales	Thalassionemataceae	*Thalassionema sp.*	D26	Very sparse
			Thalassiothrix sp.	D27	Scattered
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Very sparse
	Gonyaulacales	Ceratiaceae	*Ceratium furca*	DF2	Very sparse
			Ceratium tripos	DF3	Very sparse

TABLE 66 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPA HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING SPRING TIDE OF SEPTEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
Cyanophyceae	Nostocales	Oscillatoriaceae	*Arthrospira sp.*	B1	Sparse
			Oscillatoria sp.	B2	Very sparse
	Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B3	Very sparse
Coscinodiscophyceae	Biddulphiales	Biddulphiaceae	*Biddulphia* sp	D1	Abundant
	Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp.	D2	Scattered
	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D3	Scattered
	Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D4	Very sparse
		Hemiaulaceae	*Cerataulina sp.*	D5	Sparse
			Eucampia sp	D6	Very sparse
	Rhizosoleniales	Rhizosoleniaceae	*Dactyliosolen sp.*	D7	Very sparse
			Rhizosolenia sp.	D8	Very sparse
	Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D9	Dominant
	Thalassiosirales	Thalassiosiraceae	*Planktoniella* sp	D10	Very sparse
		Lauderiaceae	*Lauderia* sp	D11	Very sparse
		Skeletonemataceae	*Skeletonema* sp	D12	Scattered
	Triceratiales	Triceratiaceae	*Odontella* sp.	D13	Scattered
			Triceratium sp.	D14	Very sparse
Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria* sp.	D15	Very sparse
			Nitzschia sp	D16	Very sparse
			Pseudo-nitzschia sp.	D17	Sparse
	Naviculales	Naviculaceae	*Navicula* sp.	D18	Very sparse
		Pleurosigmataceae	*Pleurosigma* sp.	D19	Very sparse
	Surirellales	Surirellaceae	*Surirella sp.*	D20	Very sparse
Fragilariophyceae	Fragilariales	Fragilariaceae	*Asterionellopsis sp*	D21	Abundant
			Fragilaria sp	D22	Sparse
			Synedra sp	D23	Very sparse
	Thalassionematales	Thalassionemataceae	*Thalassionema sp.*	D24	Sparse
			Thalassiothrix sp.	D25	Scattered
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Very sparse
	Gonyaulacales	Ceratiaceae	*Ceratium furca*	DF2	Very sparse
			Ceratium tripos	DF3	Very sparse

TABLE 67 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPA OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINARDURING NEAP TIDE OF SEPTEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
Cyanophyceae	Chroococcales	Chroococcaceae	*Merismopedia sp.*	B1	Very sparse
	Nostocales	Oscillatoriaceae	*Oscillatoria sp.*	B2	Very sparse
	Stigonematales	Stigonemataceae	*Stigonema sp.*	B3	Very sparse
Coscinodiscophyceae	Biddulphiales	Biddulphiaceae	*Biddulphia* sp	D1	Very sparse
	Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp	D2	Scattered
	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D3	Scattered
			Palmeria sp.	D4	Very sparse
	Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D5	Sparse
		Hemiaulaceae	*Cerataulina sp.*	D6	Very sparse
	Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D7	Scattered
	Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D8	Sparse
	Thalassiosirales	Thalassiosiraceae	*Planktoniella* sp	D9	Very sparse
	Triceratiales	Triceratiaceae	*Odontella sp*	D10	Very sparse
			Triceratium sp	D11	Very sparse
Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria* sp.	D12	Sparse
			Cylindrotheca sp	D13	Very sparse
			Nitzschia sp	D14	Sparse
			Pseudo-nitzschia sp	D15	Very sparse
	Naviculales	Pinnulariaceae	*Pinnularia sp*	D16	Very sparse
		Pleurosigmataceae	*Pleurosigma* sp	D17	Very sparse
Fragilariophyceae	Fragilariales	Fragilariaceae	*Synedra sp.*	D18	Very sparse
	Thalassionematales	Thalassionemataceae	*Thalassiothrix sp.*	D19	Very sparse
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Very sparse
	Gonyaulacales	Pyrophacaceae	*Pyrophacus sp.*	DF2	Very sparse
		Ceratiaceae	*Ceratium furca*	DF3	Very sparse
			Ceratium fusus	DF4	Very sparse
			Ceratium tripos	DF5	Very sparse

TABLE 68 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPA OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING AND SPRING TIDE OF SEPTEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
Cyanophyceae	Nostocales	Oscillatoriaceae	*Oscillatoria sp.*	B1	Very sparse
	Stigonematales	Stigonemataceae	*Stigonema sp.*	B2	Very sparse
Coscinodiscophyceae	Biddulphiales	Biddulphiaceae	*Biddulphia* sp	D1	Very sparse
	Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp	D2	Sparse
	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D3	Dominant
	Hemiaulales	Bellerocheaceae	*Bellerochea* sp.	D4	Scattered
		Hemiaulaceae	*Cerataulina sp.*	D5	Very sparse
	Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D6	Abundant
	Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D7	Sparse
	Thalassiosirales	Lauderiaceae	*Lauderia* sp	D8	Very sparse
	Triceratiales	Triceratiaceae	*Odontella* sp.	D9	Very sparse
			Triceratium sp.	D10	Very sparse
Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria* sp.	D11	Sparse
			Nitzschia sp	D12	Very sparse
			Pseudo-nitzschia sp	D13	Very sparse
	Naviculales	Pleurosigmataceae	*Pleurosigma* sp	D14	Very sparse
		Pinnulariaceae	*Pinnularia sp*	D15	Very sparse
Fragilariophyceae	Climacospheniales	Climacospheniaceae	*Climacosphenia sp.*	D16	Very sparse
	Fragilariales	Fragilariaceae	*Synedra sp.*	D17	Very sparse
	Thalassionematales	Thalassionemataceae	*Thalassionema sp.*	D18	Very sparse
			Thalassiothrix sp.	D19	Sparse
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Very sparse
	Dinophysales	Dinophysaceae	*Dinophysis sp.*	DF2	Very sparse
	Gonyaulacales	Pyrophacaceae	*Pyrophacus sp.*	DF3	Very sparse
		Ceratiaceae	*Ceratium furca*	DF4	Sparse
			Ceratium tripos	DF5	Sparse

TABLE 69 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPA HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKSDURING NEAP TIDE OF SEPTEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnus sp.*	T1	Sparse
		Codonellidae	*Tintinnopsis acuminata*	T2	Very sparse
			Tintinnopsis dadayi	T3	Sparse
			Tintinnopsis failakkaensis	T4	Very sparse
			Tintinnopsis gracilis	T5	Very sparse
			Tintinnopsis radix	T6	Very sparse
		Xystonellidae	*Favella sp.*	T7	Very sparse
Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Scattered
			Parvocalanus sp.	C2	Very sparse
		Acartiidae	*Acartia sp.*	C3	Very sparse
		Clausocalanidae	*Clausocalanus sp.*	C4	Very sparse
		Centropagidae	*Centropages sp.*	C5	Very sparse
		Eucalanidae	*Subeucalanus sp.*	C6	Very sparse
		Temoridae	*Temora sp.*	C7	Very sparse
	Cyclopoida	Oithonidae	*Oithona sp.*	C8	Abundant
	Harpacticoida	Ectinosomatidae	*Microsetella* sp.	C9	Scattered
		Euterpinidae	*Euterpina sp.*	C10	Sparse
	Poicilostomatatoida	Corycaeidae	*Corycaeus sp.*	C11	Very sparse
		Oncaeidae	*Oncaea sp.*	C12	Very sparse
Rotifera Subclass: Eurotatoria	Superorder: Monogononta Order:Ploimida	Brachionidae	*Brachionus plicatilis*	R1	Sparse
Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse
Malacostraca	Mysida, Decapoda	Solenoceridae	*Solenocera sp.*	M1	Very sparse
Appendicularia		Fritillariidae	*Fritillaria sp.*	U1	Very sparse
Oligohymenophorea	Sessilida	Zoothamniidae	*Zoothamnium sp.*	CI1	Sparse
Copepoda			Nauplius larvae of copepods	L1	Dominant
Malacostraca Decapoda			Brachyuran zoea larvae	L2	Very sparse
Maxillopoda Thecostraca			Cirripede larvae	L3	Sparse
			Cyphonautes larvae	L4	Sparse
			Ophiopluteus larvae	L5	Very sparse
Polychaeta			Trochophore larvae	L6	Abundant
Pelecypoda			Veliger larvae of bivalves	L7	Very sparse
			Unidentified nematodes	N1	Sparse

TABLE 70 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING OF DPA HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING SPRING TIDE OF SEPTEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnus sp.*	T1	Very sparse
		Codonellidae	*Tintinnopsis failakkaensis*	T2	Very sparse
			Tintinnopsis gracilis	T3	Very sparse
			Tintinnopsis radix	T4	Very sparse
		Xystonellidae	*Favella sp.*	T5	Very sparse
Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Sparse
			Parvocalanus sp.	C2	Very sparse
		Acartiidae	*Acartia sp.*	C3	Very sparse
		Clausocalanidae	*Clausocalanus sp.*	C4	Very sparse
		Centropagidae	*Centropages sp.*	C5	Very sparse
		Eucalanidae	*Subeucalanus sp.*	C6	Very sparse
		Temoridae	*Temora sp.*	C7	Very sparse
	Cyclopoida	Oithonidae	*Oithona sp.*	C8	Scattered
	Harpacticoida	Canthocamptidae	*Canthocamptus sp*	C9	Very sparse
		Ectinosomatidae	*Microsetella* sp.	C10	Sparse
		Euterpinidae	*Euterpina sp.*	C11	Very sparse
Rotifera Subclass: Eurotatoria	Superorder: Monogononta Order:Ploimida	Brachionidae	*Brachionus plicatilis*	R1	Scattered
Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse
Appendicularia		Fritillariidae	*Fritillaria sp.*	U1	Very sparse
Oligohymenophorea	Sessilida	Zoothamniidae	*Zoothamnium sp.*	CI1	Very sparse
Copepoda			Nauplius larvae of copepods	L1	Abundant
Malacostraca Decapoda			Brachyuran zoea larvae	L2	Very sparse
Maxillopoda Thecostraca			Cirripede larvae	L3	Very sparse
			Cyphonautes larvae	L4	Very sparse
Polychaeta			Trochophore larvae	L5	Scattered
Pelecypoda			Veliger larvae of bivalves	L6	Very sparse
			Unidentified nematodes	N1	Very sparse

TABLE 71 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPA OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING NAEP TIDE OF SEPTEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnus sp.*	T1	Dominant
		Codonellidae	*Tintinnopsis failakkaensis*	T2	Very sparse
			Tintinnopsis gracilis	T3	Very sparse
			Tintinnopsis radix	T4	Sparse
		Dictyocystidae	*Luminella sp.*	T5	Very sparse
		Xystonellidae	*Favella* sp.	T6	Very sparse
Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Abundant
			Parvocalanus sp.	C2	Very sparse
		Centropagidae	*Centropages sp.*	C3	Very sparse
		Clausocalanidae	*Clausocalanus sp.*	C4	Very sparse
		Eucalanidae	*Subeucalanus sp.*	C5	Very sparse
		Temoridae	*Temora sp.*	C6	Very sparse
		Tortanidae	*Tortanus sp.*	C7	Very sparse
	Cyclopoida	Oithonidae	*Oithona sp.*	C8	Abundant
	Harpacticoida	Clytemnestridae	*Clytemnestra sp.*	C9	Very sparse
		Euterpinidae	*Euterpina sp.*	C10	Scattered
		Ectinosomatidae	*Microsetella* sp.	C11	Very sparse
	Poicilostomatatoida	Corycaeidae	*Corycaeus sp.*	C12	Very sparse
		Oncaeidae	*Oncaea sp.*	C13	Sparse
Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse
Malacostraca	Mysida, Decapoda	Penaeidae	*Metapenaeus sp.*	M1	Very sparse
Appendicularia		Oikopleuridae	*Oikopleura sp.*	U1	Very sparse
Hydrozoa			Unidentified medusa	ME1	Very sparse
Copepoda			Nauplius larvae of copepods	L1	Dominant
Malacostraca Decapoda			Brachyuran zoea larvae	L2	Very sparse
Maxillopoda Thecostraca			Cirripede larvae	L3	Very sparse
			Cyphonautes larvae	L4	Very sparse
			Ophiopluteus larvae	L5	Very sparse
Gastropoda Streptoneura			Opisthobranchia larvae	L6	Very sparse
Polychaeta			Trochophore larvae	L7	Very sparse
Pelecypoda			Veliger larvae of bivalves	L8	Very sparse
			Unidentified nematodes	N1	Very sparse

TABLE 72 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPAOOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING SPRING TIDE OF SEPTEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnus sp.*	T1	Abundant
		Codonellidae	*Tintinnopsis failakkaensis*	T2	Very sparse
			Tintinnopsis gracilis	T3	Very sparse
			Tintinnopsis mortensenii	T4	Very sparse
			Tintinnopsis radix	T5	Scattered
			Tintinnopsis tocantinensis	T6	Very sparse
		Dictyocystidae	*Luminella sp.*	T7	Very sparse
		Tintinnidae	*Eutintinnus* sp.	T8	Very sparse
Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Scattered
			Parvocalanus sp.	C2	Very sparse
		Centropagidae	*Centropages sp.*	C3	Very sparse
		Clausocalanidae	*Clausocalanus sp.*	C4	Very sparse
	Cyclopoida	Oithonidae	*Oithona sp.*	C5	Scattered
	Harpacticoida	Clytemnestridae	*Clytemnestra sp.*	C6	Very sparse
		Euterpinidae	*Euterpina sp.*	C7	Sparse
		Ectinosomatidae	*Microsetella* sp.	C8	Sparse
	Poicilostomatatoida	Corycaeidae	*Corycaeus sp.*	C9	Very sparse
		Oncaeidae	*Oncaea sp.*	C10	Very sparse
Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse
Malacostraca	Mysida, Decapoda	Penaeidae	*Metapenaeus sp.*	M1	Very sparse
Appendicularia		Oikopleuridae	*Oikopleura sp.*	U1	Very sparse
Copepoda			Nauplius larvae of copepods	L1	Dominant
Malacostraca Decapoda			Brachyuran zoea larvae	L2	Very sparse
Gastropoda Streptoneura			Opisthobranchia larvae	L3	Very sparse
Polychaeta			Trochophore larvae	L4	Very sparse
Pelecypoda			Veliger larvae of bivalves	L5	Very sparse

BENTHIC ORGANISMS:

Few Benthic organisms were observed in the collected sediments by using the Van-veen grabs during the sampling conducted during spring tide period and Neap tide period from DPA harbour region and nearby creek. The meio-benthic organisms during spring tide and Neap tide were represented by Polychaetes *Heteromastus sp.* and *Notomastus*. Population of benthic fauna was varying from 10-60-N/m^2 during spring tide and 20-40 N/m^2 during Neap tide. The benthic communities at path finder Creek were represented by Polychaetes *Tharyx* sp., *Paraonis* sp. and *Dasybranchus* sp. Their population was varying as 30 N/m^2 at OOT jetty premises and 40 N/m^2 near the SPM area during spring tide and 70 N/m^2 at OOT jetty premises and 40 N/m^2 near the SPM area during Neap tide period.

Table 73 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPA HARBOUR AREA CREEKS DURING SPRING TIDE IN SEPTEMBER 2022

ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS						
REPRESENTATION BY GROUP	DPA HARBOUR			CREEKS		
Benthic fauna						
POLYCHAETES	KPT-1	KPT-2	KPT-3	KPT-4	KPT-5	KPT-6
Family : CAPITELLIDAE *Heteromastus* sp.	10	20	40	10	20	NS
Family : Capit*ellidae* *Notomastus* sp.	0	10	20	0	0	NS
Total Polychaetes N/M^2	10	30	60	10	20	NS
TOTAL Benthic Fauna NUMBER/ M^2	10	30	60	10	20	NS

NS : No sample

Table 74 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPA HARBOUR AREA CREEKS DURING NEAP TIDE IN SEPTEMBER 2022

ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS						
REPRESENTATION BY GROUP	DPA HARBOUR			CREEKS		
Benthic fauna						
POLYCHAETES	KPT-1	KPT-2	KPT-3	KPT-4	KPT-5	KPT-6
Family : CAPITELLIDAE *Heteromastus* sp.	30	20	NS	20	NS	NS
Family : Capit*ellidae* *Notomastus* sp.	0	0	NS	0	NS	NS
Total Polychaetes N/M^2	30	20	NS	20	NS	NS
TOTAL Benthic Fauna NUMBER/ M^2	30	20	NS	20	NS	NS

NS: No sample

Table 75 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPA OOT JETTY AREA, VADINAR DURING SPRING TIDE IN SEPTEMBER 2022

ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS		
REPRESENTATION BY GROUP	OOT Jetty Area	SPM area
POLYCHAETES		
Family : Cirratulidae *Tharyx* sp.	10	0
Family : Capit*ellidae* *Dasybranchus* sp.	20	40
Total Polychaetes N/M^2	30	40
TOTAL Benthic Fauna NUMBER/ M^2	30	40

Table 76 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPA OOT JETTY AREA, VADINAR DURING NEAP TIDE IN SEPTEMBER 2022

ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS		
REPRESENTATION BY GROUP	OOT Jetty Area	SPM area
POLYCHAETES		
Family : Cirratulidae *Tharyx* sp.	20	20
FAMILY: PARAONIDAE *Paraonis sp.*	10	0
Family : Capit*ellidae* *Dasybranchus* sp.	40	20
Total Polychaetes N/M^2	70	40
TOTAL Benthic Fauna NUMBER/ M^2	70	40

11.0 Conclusive Summary and Remedial measures Suggested

- The AAQ monitoring of six locations at Deendayal Port Kandla indicates that the mean PM_{10} and $PM_{2.5}$ values for three locations viz. Marine Bhavan, Estate Office and Coal storage area were found higher than the permissible limit (standards100 µg/m^3, 60 µg/m^3). The higher concentration of Particulate matter at Marine Bhavan may be due to vehicles emissions during loading-unloading of food grains and timbers; at Estate office due to construction work, vehicles emission produced from trucks, heavy duty vehicles that pass through the road outside Kandla port and Oil jetty area; while at Coal Storage area lifting of coal from grab yard and other coal handling processes. Moreover, the transportation of coal produces pollution from heavy vehicles. At Oil Jetty location, concentration of PM_{10} varied from 81-128 µg/m^3 and mean value was observed 104 µg/m^3 which was slightly exceed the prescribed standard limit, concentration of $PM_{2.5}$ was ranged from 49-67 µg/m^3 and mean was found 57 µg/m^3 which was within the prescribed limit. At Gopalpuri and Tuna port PM_{10} and $PM_{2.5}$ were found within permissible limit prescribed by NAAQS.
- The AAQ monitoring signal building concentration of PM_{10} exceed the permissible limit and $PM_{2.5}$ was found within limit while at admin building had PM_{10} concentration was exceed the permissible limit and $PM_{2.5}$ shown slight increased.
- At Vadinar, the average concentration of PM_{10} was found 105 µg/m^3 slightly exceed at Vadinar Colony and 100 µg/m^3 at Signal Building which was boundary line of standard limit (Standard Limit 100 µg/m^3). The average concentration of $PM_{2.5}$ at Admin building was 44 µg/m^3 and Signal building was 43 µg/m^3 which was within standard limit (60 µg/m^3).
- Further, precautionary measures and management strategies to minimize the effect of particulate as well as gaseous pollutants have also been suggested for achieving its ambient levels in and around Kandla Port and Vadinar Port, Gujarat, India.

- Drinking water at all the twenty locations was found potable and it was found within in line of BIS standards (IS 10500-2012).
- Transportation systems are the main source of noise pollution in project areas. Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. All sampling location were within the permissible limit day time 75 dB(A) and night time 70 dB (A) for the industrial area.

- The treated sewage water of Kandla STP, Deendayal Port Colony (Gopalpuri) and Vadinar were in line with the standards set by the Central Pollution Control Board.
- It was suggested to monitor the STP performance on regular basis to avoid flow of contamination / Polluted water into the sea.
- Good species diversity suggests a relatively successful species in this habitat. A greater number of successful species and a more stable ecosystem. More ecological niches are available and the environment is less likely to be hostile complex food webs environmental change is less likely to be damaging to the ecosystem as a whole.
- The results obtained from the study for biological and ecological parameters in marine water for Arabian Sea at surrounding area of Deendayal Port Authority (DPA) Kandla and Vadinar were not affected by Port activities.
- The mean day time temperature at Deendayal Port was 29.11 °C. The day-time maximum temperature was 34.4°C and minimum was 24.9 °C. The mean night time temperature recorded was 27.51 °C. The mean Solar Radiation in September month was 199.87 w/m^2. The maximum solar radiation was recorded 942.3 w/m^2 in 28th September, 2022 and the minimum solar radiation was recorded 0.93 w/m^2 in 12th September, 2022. The mean Relative humidity was 84.81 % for the month of September. Maximum Relative humidity was recorded 99.0 % and minimum Relative humidity was recorded 64.0 %. The average wind velocity for the entire month of September was 5.64 m/s. Maximum wind velocity was recorded 28.1 m/s. The wind direction was mostly West-South.

Reasons for higher Values of PM_{10}

- The unloading of coal directly in the truck, using grabs cause coal to spread in air as well as coal dust to fall on ground. This settled coal dust again mixes with the air while trucks travel through it.
- Also, the coal loaded trucks were not always covered with tarpaulin sheets and these results in spillage of coal from trucks/dumpers during its transit from vessel to yard or storage site. This also increased PM values around marine Bhavan & Coal storage area.

Remedial Measures

The values of PM_{10} & $PM_{2.5}$ during the month of September, 2022 were beyond the permissible limit at 3 locations (Coal Storage, Marine Bhavan and Estate office) except Gopalpuri and Tuna Port. At Oil Jetty location the concentration of PM_{10} was slightly exceeding from the standard limit. Given below are the remedial measures suggest to minimize the Air pollution.

- During September, 2022 overall ambient air quality of the DPA was within CPCB permissible limits except TSPM, PM_{10}, $PM_{2.5}$ at Coal storage area, Marine Bhavan, Estate Office. To improve air quality the port was using number of precautionary measures, such as maintained a wide expanse of Green zone, initiated Inter-Terminal Transfer (ITT) of tractor-trailers, Centralized Parking Plaza, providing shore power supply to tugs and port crafts, the use of LED lights at DPA area helps in lower energy consumption and decreases the carbon foot prints in the environment, time to time cleaning of paved and un paved roads, use of tarpaulin sheets to cover dumpers at project sites etc. are helping to achieve the cleaner and green future at port.

Solution towards the Green port:

Today, it is increasingly recognized that air pollution hurts human health. Consequently, efficient mitigation strategies need to be implementation for substantial environmental and health co-benefits.

The guidelines can be considered a basis for governments for the implementation of a strategic plan focused on the reduction of multi pollutant emission, as well as of the overall air pollution related risk.

- The plantation should be all along the periphery of the port and inside and outside the port along with the road. Trees having high dust trapping efficiency (*Azadirachta indica, Cassia fistula, Delonix regia, Ficus religiosa, Pterocarpus marsupium*) are to be grown alongside the roads.
- The water sprinkling should be use at each and every stage of transporting coal up the loading of truck to avoid generation of coal dust.
- The vehicles should be covered during transportation and the vehicle carrying the coal should not be overloaded by raising the height of carriage.
- The water sprinklers should be use during transportation of loaded heavy vehicles on raw road.
- It should be ensure that regular sweeping of coal internal, main road and space a free circulation.
- Practice should be initiated for using mask as preventative measure, to avoid Inhalation of dust particle- Mask advised in sensitive areas.
- Department for use maintenance should have a routine checkup noise level by replacing bearings, tights of all loose parts that can vibrate.

- Speed control is also an effective way to mitigate noise pollution, the lowest sound emission arise from vehicles moving smoothly.
- Use of renewable energy like solar energy should be optimal and ensure to work continuously.
- Keep neat and clean public transport and all basic items at public interaction places as much as possible.
- Technology like Electric cart, Inter-Terminal Transfer (ITT) are worthy selection to reduce Port operation efficiency and fuel cost.
- Conventional RTGCs should be altered as E-RTGCs counting inside the port completely.
- Initiate Natural Gas (CNG) as fuel by all buses and trucks.

Green Ports Initiative

- Deendayal Port is committed to sustainable development and adequate measures are being taken to maintain the Environmental well-being of the Port and its surrounding environs. Weighing in the environmental perspective for sustained growth, the Ministry of Shipping had started "Project Green Ports" which will help in making the Major Ports across India cleaner and greener. "Project Green Ports" will have two verticals - one is "Green Ports Initiatives" related to environmental issues and second is "Swachh Bharat Abhiyaan".

- The Green Port Initiatives include twelve initiatives such as preparation and monitoring plan, acquiring equipments required for monitoring environmental pollution, acquiring dust suppression system, setting up of waste water treatment plants/ garbage disposal plant, setting up Green Cover area, projects for energy generation from renewable energy sources, completion of shortfalls of Oil Spill Response (OSR) facilities (Tier-I), prohibition of disposal of almost all kind of garbage at sea, improving the quality of harbour wastes etc.

- Deendayal port has also appointed GEMI as an Advisor for "Making Deendayal Port a Green Port - Intended Sustainable Development under the Green Port Initiatives.

- Deendayal Port has also signed MOU with Gujarat Forest Department in September 2019 for Green Belt Development in an area of 31.942 Ha of land owned by Deendayal Port Trust. The plantation is being carried out by the Social Forestry division of Kachchh.

ENVIRONMENTAL MONITORING REPORT FOR DEENDAYAL PORT AUTHORITY

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Mont	:	October 01
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ENVIRONMENTAL MONITORING PLAN FOR DEENDAYAL PORT ENVIRONMENTALMONITORING REPORT- OCTOBER, 2022

1. EXECUTIVE SUMMARY

Monitoring of various environmental aspects of the Deendayal port by M/s Detox Corporation Pvt. Ltd. has been carried out through collection of samples, analysis of the same, comparing results with respect to the national standards and any other relevant standards by GBCB/CPCB/MoEF & CC to understand status of various parameters in the Environment of the Deendayal Port. The results shall address the identified impacts and suggest measures to minimize the environmental impact due to various operations at Deendayal Port.

A) Ambient Air

The monitoring of Ambient Air quality at 6-locations at Deendayal Port Authority Kandla and 2- location at Vadinar Port on 24 hourly basis for TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2, NH_3, CO_2, CO, C_6H_6 and NMHC in twice a week 24 hourly at uniform intervals (as per NAAQS) at Gopalpuri, Tuna Port, Marine Bhavan Building, Coal storage area, Estate building, Oil jetty and at Vadinar port, Vadinar Jetty and Vadinar colony area using respirable dust sampler, Fine particulate sampler and gaseous sampler.

The Maximum TSPM values in month of October 2022 were found 983 µg/m^3 at Coal Storage area on 23.10.2022 and minimum 71 µg/m^3 at Tuna Port on 03.10. 2022. The Maximum PM_{10} values were 713µg/m^3 at Coal Storage area on 23.10.2022 and minimum was 42 µg/m^3 at Tuna Port on 03.10. 2022. The maximum $PM_{2.5}$ values were found 267 µg/m^3 at Coal Storage area on 23.10.2022 and minimum was 23 µg/m^3 at Tuna Port on 03.10. 2022. The PM_{10} and $PM_{2.5}$ values were found for four locations (Marine Bhavan Building, Oil Jetty, Coal Storage Area and Estate Office Building) to exceed the permissible limit.

At Tuna Port location the mean concentration of PM_{10} was found slightly exceed the permissible limit, the mean concentration of $PM_{2.5}$ was 60 µg/m^3 within the permissible limit. At Gopalpuri sampling location all parameters of ambient air quality were found within the limit.

The AAQ monitoring for Vadinar at Admin building mean value of PM_{10} and $PM_{2.5}$ were slightly exceed while at signal building the concentration of PM_{10} and $PM_{2.5}$ was within the limit.

The overall values of October for Gaseous SO_2, NO_2, NH_3, CO_2, CO, C_6H_6 concentration were within the permissible limit at all location and NMHC were found BQL (Below Quantification Limit).

B) Weather

The mean day time temperature at Deendayal Port was 29.87 °C. The day-time maximum temperature was 35.1°C and minimum was 23.2 °C. The mean night time temperature recorded was 27.91 °C. The night-time maximum temperature was 32.5°C and minimum was 23.4 °C. The mean Solar Radiation in October month was 185.99 w/m^2. The maximum solar radiation was recorded 856.7 w/m^2 in 1st October, 2022 and the minimum solar radiation was recorded 1.106 w/m^2 in 29th October, 2022. The mean Relative humidity was 74.90 % for the month of October. Maximum Relative humidity was recorded 98.0 % and minimum Relative humidity was recorded 30.0 %. The average wind velocity for the entire month of October was 1.22 m/s. Maximum wind velocity was recorded 6.50 m/s. The wind direction was mostly West-South.

C) Marine Ecology (Flora and Fauna) / Marine Water / Sediments:

The results obtained from the study for the month of October 2022 for biological and ecological parameters in marine water for Arabian Sea at surrounding area of Deendayal Port Authority (DPA) Kandla and Vadinar were not affected by Port activities.

D) Drinking Water Quality

The drinking water being supplied to Deendayal Port was safe for drinking purpose. At all drinking water monitoring stations around port area were in line with the standard limit as per the drinking water specifications given in IS 10500:2012 as per tested parameters only.

The average results for 20 locations were as: pH were found Min 7.28 and maximum 7.6, TDS were found min 374.0 mg/l and Max found 1473.0 mg/l, Chloride were found Min 130.29 mg/l and Max 651.45 mg/l, Total Hardness were found Min 380.0 mg/l and Max 568.0 mg/l and Calcium were found Min 36.07 mg/l and Max101.80 mg/l, color were colorless and odor were odorless. In all water samples BOD, Heavy metal like manganese, Hexavalent chromium, Copper, Cadmium, Arsenic, Mercury, Lead, zinc all are found BQL (Below Quantification Limit). The bacterial count (E-coli & Coliform) is absent in all drinking water samples.

E) Monitoring Performance of Sewage Treatment Plant

It was seen that the performance of STP at Deendayal Township Gopalpuri, DPA STP Plant Kandla and Vadinar STP plant was satisfactory by overall. The treatment plant was well maintained during [October 2022] with considerable removal efficiency achieving the standards prescribed for final disposal. At Gopalpuri STP, the pollutant removal efficiency for TSS, BOD and COD was ranged from 58-62%, 50% and 48-51% respectively. At Kandla STP, removal efficiency for TSS, BOD and COD was ranged from 49-62%, 63-68% and 63-72% respectively & at Vadinar STP removal efficiency for TSS, BOD and COD was ranged from 58-61%, 40-73% and 33-75% respectively. At all STP location treated waste water the pH were ranged from 7.21-7.45,Total Suspended Solids were found 41.8-59.9 mg/l , Residual Chlorine were below Detection Limit (< 0.5) , COD were found 20-60 mg/l and 3day BOD @ 27 °C were found 6.0-18.0 mg/l.

F) Noise

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. The Day Time Noise Level (SPL) in all 10 locations at Deendayal Port Authority ranged from 63.8 dB(A) to 72.8 dB(A) while at Vadinar port 3 location ranged from 57.2 dB(A) to 58.4 dB(A) which was within the permissible limits of 75 dB(A) for the industrial area for the daytime. The Night Time Average Noise Level (SPL) in all locations of Deendayal Port Authority ranged from 53.9 dB to 64.7 dB(A) while at Vadinar port ranged from 53.6 dB (A) to 57.5 dB(A) which was within the permissible limits of 70 dB(A) for the industrial area for the night time.

1.0 Introduction

About Deendayal Port

The Deendayal Port is situated in the Kandla Creek and is 90 Kms. From the mouth of Gulf of Kachchh. Latitude: 23° 01" N Longitude: 70° 13"E. Deendayal Port's journey began in 1931 with construction of RCC Jetty by Maharao Khengarji. After partition, Deendayal Port's success story has continued and it rise to the No. 1 Port in India in the year 2007-08 and since then retained the position for the 15 consecutive year. On 31.03.2016, Deendayal Port created history by handling 100 MMT cargoes in a year, the first Major Port to achieve the milestone. Kandla, also known as the Deendayal Port Authority is a seaport in Kutch District of Gujarat state in western India, near the city of Gandhidham. Located on the Gulf of Kutch, it is one of major ports on west coast. Kandla was constructed in the 1950s as the chief seaport serving western India, after the partition of India from Pakistan left the port of Karachi in Pakistan. The Port of Deendayal is located on the Gulf of Kutch on the northwestern coast of India some 256 nautical miles North West of the Port of Karachi in Pakistan and over 430 nautical miles north-northwest of the Port of Mumbai (Bombay). It is the largest port of India by volume of cargo handled. Kandla history Deendayal Port Authority, India's busiest major port in recent years, is gearing to add substantial cargo handling capacity with private sector participation. Deendayal port Authority creates a new record by handling 127.10 million metric tons of cargo during the FY 2021-22, as against 117.566 million metric tons in FY 2020-21. Showing a growth of 8.11 %. Incidentally, DPA is the only major Indian port of handle more than 127 MMT cargo throughout and it has also registered the highest cargo throughput in its history. While the port has flagged off several projects related to infrastructure creation, DPA has successfully awarded the work of augmentation of liquid cargo handling capacity by revamping the existing pipeline network at the oil jetty area in Sept. 2021. Even as much of this growth has come from handling of crude oil imports, mainly for Essar Oil's Vadinar refinery in Gujarat, the port is also taking measures to boost non-POL cargo. Last fiscal, POL traffic accounted for 63 per cent of the total cargo handled at Deendayal Port, as against 59% in 2007-08. The Deendayal Port Authority had commissioned the Off-shore Oil Terminal facilities at Vadinar in the year 1978, for which M/s. Indian Oil Corporation Limited (IOCL) provided Single Bouy Mooring (SBM) system, having a capacity of 54 MMTPA, which was first of its kind in India. Further, significant. Quantum of infrastructural up-gradation has been affected & excellent maritime infrastructure been created at Vadinar for the 32 MMTPA Essar Oil Refinery in Jamnagar District. Monitoring of various environmental aspects of the Deendayal port by M/s Detox Corporation Pvt. Ltd. has been carried out through collection of samples, analysis of the same, comparing results with respect to the prescribed standards by GPCB/CPCB/MoEF& CC. The results shall address the identified impacts and suggest measures to minimize the environmental impact due to various operations at Deendayal Port. The environmental monitoring is carried out as per the Environment Management and Monitoring Plan submitted by Detox Corporation Pvt. Ltd.

2. Introduction

Air pollutants are added in the atmosphere from variety of sources that change the composition of atmosphere and affect the biotic environment. The concentration of air pollutants depend not only on the quantities that are emitted from air pollution sources but also on the ability of the atmosphere to either absorb or disperse these emissions. The air pollution concentration vary spatially and temporarily causing the air pollution pattern to change with different locations and time due to changes in meteorological and topographical condition. Air pollution occurs when harmful substances including particulates and biological molecules are introduced into earth's atmosphere. It may cause diseases, allergies or death of humans; it may also cause harm to other living organisms such as animals and food crops, and may damage the natural or built environment. Human activity and natural processes can both generate air pollution. A physical, biological or chemical alteration to the air in the atmosphere can be termed as pollution. It occurs when any harmful gases, dust, smoke enters into the atmosphere and makes it difficult for plants, animals and humans to survive as the air becomes dirty. The consequences of industrialization and the demand for improved quality of life has been increased exposure to air pollution (Vallero, 2014). An air pollutant is a substance in the air that can have adverse effects on humans and the ecosystem. The substance can be solid particles, liquid droplets, or gases. A pollutant can be of natural origin or man-made. Pollutants are classified as primary or secondary. Any gas could qualify as pollution if it reached a high enough concentration to do harm. Theoretically, that means there are dozens of different pollution gases. In practice, about ten different substances cause most concern. Heavy metals represent a class of omnipresent pollutants, with toxic potential, in some cases even at low exposure levels. They concentrate in each tropic level because of their weak mobility, so the concentration in plants is higher than in soil, in herbivore animals higher than in plants, in carnivores' tissues higher than in herbivore, the highest concentration being reached at the end of the tropic chain, at big predacious and human bodies.

Globally, one of the main contributors to emissions of atmospheric pollutants and a significant user of energy is the industrial sector (Conti et al. 2015).

The concentration of air pollutants depends not only on the quantities that are emitted from the polluting sources, but also on the ability of the atmosphere to either absorb or disperse such emissions (USEPA, 2008).

Nowadays, the shipping sector provides low-cost and reliable delivery services in the economic field (Arunachalam et al. 2015). Nevertheless, shipping-related activities have a considerable impact on air pollution, especially in coastal areas but also globally (Buccolieri et al. 2016). The primary air pollutants are PM, VOCs, NOx, O3, SO2, and CO (Bailey and Solomon 2004). As a consequence, a wide range of options toward "greener" seaports is needed (Bailey and Solomon 2004). Some of these measures are easy to adopt such as the regulation of fuel quality (by using low-sulfur alternative fuels), the speed reduction (Lack et al. 2011), and the use of alternative transportation equipment (Lai et al. 2011).

Clean air is the basic requirement of all living organisms. In recent times, due to population growth, urban sprawl, industrial development, and vehicular boom, the quality of air is deteriorating and being polluted. Pollutants of major public health concerns include particulate matter, carbon monoxide, ozone, nitrogen dioxide, and sulfur dioxide, which pose serious threats to human health and hygiene. In the present study, prime particulate pollutants (PM_{10}, $PM_{2.5}$), and gaseous pollutants (SO_2, and NO_2) were estimated at seven stations in and around Dahej Port, Gujarat, India (Soni and Jagruti Patel, 2017).

Among particulate pollutants, particulate matter (PM) is a ubiquitous entity, and is especially a grave problem due to its higher suspension rate into the atmosphere, and adverse health effects on plants, animals, humans, and materials in the form of visibility reduction, soiling of buildings, etc. (Horaginamani and Ravichandran, 2010; Chaurasia *et al*., 2013).

The sources of air pollutants include vehicles, industries, domestic sources and natural sources. Because of the presence of high amount of air pollutants in the ambient air, the health of the population and property is getting adversely affected. In order to arrest the deterioration in air quality, Govt. of India has enacted Air (Prevention and Control of Pollution) Act in 1981. The responsibility has been further emphasized under Environment (Protection) Act, 1986. It is necessary to assess the present and anticipated air pollution through continuous air quality survey/monitoring programs. Therefore, Central Pollution Control Board had started National Ambient Air Quality Monitoring (NAAQM) Network during 1984 - 85 at national level. The programme was later renamed as National Air Quality Monitoring Programme (NAMP).

2.1 Ambient Air Quality Monitoring

As per the Environmental Monitoring Plan of Deendayal Port Authority, Air monitoring was carried out at six identified locations at Deendayal Port and two locations at Vadinar Port.

Table: 1. Ambient Air Sampling Location

Sr. No.	Name of Location	Location Code	Latitude	Longitude	Remarks
1.	Marine Bhavan	AL-1	23° 0' 26.524"N	70° 13' 22.414"E	**DPA-Kandla**
2.	Oil Jetty	AL-2	23° 1' 45.613"N	70° 13' 11.052"E	
3.	Estate Office	AL-3	23° 1' 11.273"N	70° 12' 48.657"E	
4.	Gopalpuri Hospital	AL-4	23° 4' 53.551"N	70° 8' 7.047"E	
5.	Coal Storage Area	AL-5	22° 59' 31.812"N	70° 13' 9.979"E	
6.	Tuna Port	AL-6	22° 59' 15.291"N	70° 58' 57.018"E	
7.	Signal Building	AL-7	22° 26' 26.750"N	69° 40' 22.127"E	**DPA-Vadinar**
8.	Admin Building	AL-8	22° 26' 25.223"N	69° 40' 19.358"E	

- **Air Quality Monitoring Methodology**

Air quality is measured in all the stations, for 24 hour for Total Suspended Particulate Matter (TSPM), PM_{10}, $PM_{2.5}$, SO_2, NO_2, NH_3 & Benzene and Grab-sampling for CO & CO_2 measurements. The Air samplers are operated for a period of 24 hours and after a continuous operation of 8 hours for gaseous parameters. The absorbing reagents for $SO_{2:-}$ Absorbing Reagent TCM (Potassium Tetrachloromercurate 0.04M): Mercuric Chloride, Potassium Chloride and EDTA used. For NO_2:- Absorbing Reagent Sodium Hydroxide (NAOH): Sodium Hydroxide and Sodium Arsenite used. For NH_3 need Conc. Sulphuric Acid and Distilled water was used. By replacing 3 times the reagents per day for each parameter namely, SO_2, $NO_{2,}$ NH_3. The GFA filter paper and PTFE Membrane bound filter paper are used for a period of 24 hours to obtain one sample each of TSPM, PM_{10} & $PM_{2.5}$. The AAQ samples are collected two consecutive days a week as per CPCB guidelines, from all the eight locations as mentioned in the EMP.

2.2 Results

The ambient air quality monitoring data for six stations, viz. Marine Bhavan, Oil Jetty, Port Colony, Gopalpuri Hospital, Tuna Port and Nr. Coal Storage Area for the month of October 2022 are given in Tables 2 to 7. The ambient air quality monitoring data for two stations at Vadinar (Nr. Admin Building & Nr. Signal Building) are given in Tables 8 to 9.

The Movement of heavy transport with uncovered coal transportation, raw road around ambient location may be causes fugitive dust emission from dry conditions. Particulate Matter then enters the atmosphere through the action of wind, vehicular movement, or other activities. The dust produces tends to float in air and spread all around the vicinity. Direction and speed of wind affect the dispersion of the dust particulate matter. Humidity of air also has strong effect on the spreading of particulate matter. With increasing humidity, moisture particles eventually grow in size to a point where ‘dry deposition’ occurs, reducing PM_{10} concentrations in the atmosphere.

Location 1: Marine Bhavan (AL1)

Table 2 : Results of Air Pollutant Concentration at Marine Bhavan										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL1 – 1	03.10.2022	350	226	112	3.32	3.53	5.77	11.93	4.14	5.68
					2.72		17.89		7.25	
					4.53		12.12		5.64	
AL1 – 2	06.10.2022	372	235	127	4.53	4.33	14.43	14.81	4.83	5.60
					5.74		12.12		7.02	
					2.72		17.89		4.95	
AL1 – 3	11.10.2022	397	257	135	4.61	5.09	30.59	23.85	5.87	4.11
					6.05		24.24		2.88	
					4.61		16.74		3.57	
AL1 – 4	14.10.2022	496	339	153	2.72	6.55	20.20	13.66	4.72	4.45
					7.55		8.66		5.87	
					9.37		12.12		2.76	
AL1 – 5	17.10.2022	543	362	175	4.23	4.73	24.24	19.62	3.91	4.37
					6.95		16.74		4.72	
					3.02		17.89		4.49	
AL1 - 6	20.10.2022	580	378	192	9.37	5.64	17.89	14.43	4.37	4.22
					2.72		15.58		4.95	
					4.84		9.81		3.34	
AL1 - 7	23.10.2022	600	393	202	6.35	4.53	14.43	18.66	7.02	5.33
					4.53		23.66		4.95	
					2.72		17.89		4.03	
AL1 – 8	28.10.2022	459	326	125	3.93	4.43	29.43	25.20	4.72	3.41
					6.65		20.20		3.80	
					2.72		25.97		1.73	
Monthly Average		475	315	153		4.85		17.77		4.65
Standard Deviation		96	66	33		0.92		4.89		0.81

Table 2 : Results of Air Pollutant Concentration at Marine Bhavan					
	Date	**C6H6 [µg/m3]**	**HC**	**CO [mg/m3]**	**CO2 [ppm]**
Sampling Period		**8 hr**		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**	**ppm**	**4.0 mg/m3**	**-**
AL1 – 1	03.10.2022	1.22	BQL	1.46	1010
AL1 – 2	06.10.2022	1.14	BQL	1.46	912
AL1 – 3	11.10.2022	1.08	BQL	1.16	1042
AL1 – 4	14.10.2022	1.05	BQL	1.17	1392
AL1 – 5	17.10.2022	1.1	BQL	1.2	888
AL1 - 6	20.10.2022	1.16	BQL	1.26	650
AL1 - 7	23.10.2022	1.15	BQL	1.13	454
AL1 - 8	28.10.2022	1.17	BQL	1.43	364
Monthly Average		**1.13**	**-**	**1.28**	**839**
Standard Deviation		**0.05**	**-**	**0.14**	**337**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

At Marine Bhavan, the overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 is attributed mainly by motor vehicle emission produced from various types of automobiles (both diesel and petrol driven). Moreover, the loading and unloading of Food Grains and Timber at Jetty no. 1 and 2 also contributes to the high levels of TSPM and PM_{10}. The mean TSPM value at Marine Bhavan was 475 µg/m^3, the mean PM_{10} value was 315 µg/m^3, and $PM_{2.5}$ value was 153 µg/m^3 which is above the permissible limit prescribed by NAAQS. The average values of SO_2, NO_2 and NH_3 were 4.85 µg/ m^3, 17.77 µg/ m^3 & 4.65 µg/ m^3 respectively; these values were within the permissible limit prescribed by NAAQS.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Marine Bhavan. The mean Benzene concentration was 1.13 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.28 mg/m^3, well below the permissible limit of 4.0 mg/m^3 prescribed by NAAQS.

Location 2: Oil Jetty (AL2)

Table 3 : Results of Air Pollutant Concentration at Oil Jetty										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL2 -1	03.10.2022	137	92	40	4.23	3.53	10.39	14.43	4.95	5.64
					2.72		15.00		7.02	
					3.63		17.89		4.95	
AL2 -2	06.10.2022	140	89	41	3.32	3.63	8.66	9.43	2.19	4.45
					4.53		7.50		5.29	
					3.02		12.12		5.87	
AL2 -3	11.10.2022	207	131	70	4.61	3.84	36.36	24.82	2.88	15.58
					2.59		24.24		39.14	
					4.32		13.85		4.72	
AL2 -4	14.10.2022	234	142	69	9.07	6.35	13.85	19.04	1.61	2.38
					6.35		24.82		4.14	
					3.63		18.47		1.38	
AL2 – 5	17.10.2022	137	91	40	4.84	5.34	10.97	14.43	4.03	3.15
					8.76		20.20		3.34	
					2.42		12.12		2.07	
AL2 – 6	20.10.2022	671	461	209	6.35	6.45	17.89	14.62	4.03	4.91
					7.25		10.97		4.83	
					5.74		15.00		5.87	
AL2 – 7	23.10.2022	209	135	64	2.12	4.13	24.24	19.62	4.95	4.68
					3.93		16.74		5.87	
					6.35		17.89		3.22	
AL2 -8	28.10.2022	207	130	62	2.12	4.33	17.89	18.28	2.76	4.49
					6.35		23.66		4.83	
					4.53		13.27		5.87	
Monthly Average		243	159	74		4.70		16.83		5.66
Standard Deviation		177	124	56		1.19		4.63		4.14

Table 3 : Results of Air Pollutant Concentration at Oil Jetty					
	Date	**C_6H_6 [µg/m^3]**	***NMHC**	**CO [mg/m^3]**	**CO2 [ppm]**
Sampling Period		**8 hr**		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL2 -1	03.10.2022	1.09	BQL	1.31	849
AL2 -2	06.10.2022	1.12	BQL	1.19	870
AL2 -3	11.10.2022	1.07	BQL	1.43	1280
AL2 -4	14.10.2022	1.07	BQL	1.47	1032
AL2 – 5	17.10.2022	1.12	BQL	1.32	862
AL2 – 6	20.10.2022	1.11	BQL	1.19	555
AL2 -7	23.10.2022	1.15	BQL	1.13	454
AL2 -8	28.10.2022	1.17	BQL	1.43	364
Monthly Average		**1.11**	**-**	**1.31**	**783**
Standard Deviation		**0.04**	**-**	**0.13**	**308**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

Oil Jetty Area, the overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 was mainly by motor vehicle emission produced from various types of vehicles at Oil Jetty Area. The mean TSPM value at Oil Jetty was 243 µg/m^3. The mean PM_{10} value was 159 µg/m^3 and mean $PM_{2.5}$ value was 74 µg/m^3 which was above the permissible limit. The average values of SO_2, NO_2 and NH_3 were within the permissible limit prescribed by NAAQS. The mean concentration of SO_2, NO_2 and NH_3 were 4.70 µg/m^3, 16.83 µg/m^3 and 5.66 µg/m^3 respectively.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Oil Jetty. The mean Benzene concentration was 1.11 µg/m^3 which was well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.31 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 3: Kandla Colony – Estate Office (AL-3)

Table 4 : Results of Air Pollutant Concentration at Estate Office										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL3 – 1	03.10.2022	160	100	50	1.81	2.72	13.85	10.97	4.83	6.29
					4.84		10.39		6.68	
					1.51		8.66		7.37	
AL3 – 2	06.10.2022	247	154	78	3.32	3.42	13.27	11.16	4.83	3.91
					4.53		8.08		3.57	
					2.42		12.12		3.34	
AL3 – 3	11.10.2022	362	237	118	4.32	5.09	23.66	16.35	3.91	3.07
					6.05		14.43		1.73	
					4.90		10.97		3.57	
AL3 – 4	14.10.2022	413	271	133	4.53	6.85	20.78	12.70	0.46	2.65
					6.35		12.12		4.83	
					9.67		5.19		2.65	
AL3 – 5	17.10.2022	535	421	112	2.72	4.23	24.24	24.43	4.83	3.80
					3.63		29.43		4.14	
					6.35		19.62		2.42	
AL3 – 6	20.10.2022	314	216	95	6.35	4.43	20.20	19.62	4.83	3.68
					2.12		12.12		3.57	
					4.84		26.55		2.65	
AL3 – 7	23.10.2022	436	318	117	3.63	5.34	23.66	16.16	5.18	4.18
					7.55		13.85		4.14	
					4.84		10.97		3.22	
AL3 – 8	28.10.2022	451	332	114	4.53	4.53	12.70	15.00	4.83	3.57
					6.35		17.89		3.22	
					2.72		14.43		2.65	
Monthly Average		365	256	102		4.58		15.80		3.89
Standard Deviation		121	103	27		1.25		4.55		1.08

Table 4 : Results of Air Pollutant Concentration at Estate Office					
Sampling Period	**Date**	**C_6H_6 [µg/m^3]**	***NMHC**	**CO [mg/m^3]**	**CO_2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL3 -1	03.10.2022	1.09	BQL	1.36	785
AL3 -2	06.10.2022	1.21	BQL	1.21	573
AL3 -3	11.10.2022	1.01	BQL	1.08	795
AL3 -4	14.10.2022	1.19	BQL	1.34	1037
AL3 – 5	17.10.2022	1.22	BQL	1.22	742
AL3 – 6	20.10.2022	1.1	BQL	1.31	555
AL3 – 7	23.10.2022	1.15	BQL	1.13	454
AL3 – 8	28.10.2022	1.17	BQL	1.43	364
Monthly Average		**1.14**	**-**	**1.26**	**663**
Standard Deviation		**0.07**	**-**	**0.12**	**218**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 at Kandla Port Colony (Estate Office) was attributed by vehicle emission produced from trucks and heavy duty vehicles that pass through the road outside Kandla Port Colony. The mean TSPM values at Kandla port Colony were 265 µg/m^3, the mean PM_{10} value was 256 µg/m^3, and $PM_{2.5}$ value was 102 µg/m^3 which was above the permissible limit prescribed by NAAQS. The average values of SO_2, NO_2 and NH_3 were 4.58 µg/m^3, 15.80 µg/m^3 and 3.89 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Kandla Port Colony. The mean Benzene concentration was 1.14 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide was 1.26 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 4: Gopalpuri Hospital (AL-4)

Table 5 : Results of Air Pollutant Concentration at Gopalpuri Hospital										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL4 -1	03.10.2022	138	93	41	2.72	2.22	5.19	6.73	3.80	2.92
					2.12		8.66		2.76	
					1.81		6.35		2.19	
AL4 -2	06.10.2022	118	73	32	2.42	2.92	6.93	9.23	2.88	3.45
					3.63		8.66		3.57	
					2.72		12.12		3.91	
AL4 -3	11.10.2022	136	87	39	2.59	2.21	12.12	11.93	2.42	1.73
					1.15		15.00		1.73	
					2.88		8.66		1.04	
AL4 -4	14.10.2022	171	104	56	2.42	2.32	8.08	12.89	2.42	2.42
					3.02		12.70		1.27	
					1.51		17.89		3.57	
AL4 – 5	17.10.2022	140	95	44	1.51	2.72	10.39	14.04	3.57	3.84
					3.02		12.12		4.83	
					3.63		19.62		3.11	
AL4 – 6	20.10.2022	118	64	38	2.72	2.52	15.00	14.62	3.80	3.80
					3.32		10.97		2.88	
					1.51		17.89		4.72	
AL4 – 7	23.10.2022	218	130	75	1.51	4.23	4.62	12.89	2.42	3.88
					6.35		20.20		5.18	
					4.84		13.85		4.03	
AL4 – 8	28.10.2022	123	73	49	2.72	4.53	17.89	11.54	2.88	3.72
					4.53		10.39		3.57	
					6.35		6.35		4.72	
Monthly Average		145	90	47		2.96		11.73		3.22
Standard Deviation		34	21	14		0.92		2.61		0.79

Table 5 : Results of Air Pollutant Concentration at Gopalpuri Hospital					
Sampling Period	**Date**	**C_6H_6 [µg/m^3]**	***NMHC**	**CO [mg/m^3]**	**CO_2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL4 -1	03.10.2022	1.19	BQL	1.18	641
AL4 -2	06.10.2022	1.10	BQL	1.37	637
AL4 -3	11.10.2022	1.20	BQL	1.24	859
AL4 -4	14.10.2022	1.21	BQL	1.47	1061
AL4 – 5	17.10.2022	1.16	BQL	1.45	899
AL4 – 6	20.10.2022	1.20	BQL	1.46	545
AL4 – 7	23.10.2022	1.15	BQL	1.13	454
AL4 – 8	28.10.2022	1.17	BQL	1.43	364
Monthly Average		**1.17**	**-**	**1.34**	**683**
Standard Deviation		**0.04**	**-**	**0.14**	**238**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 at Gopalpuri Hospital was attributed by vehicle emission produced from light motor vehicles of the colony residents. The mean TSPM values at Gopalpuri Hospital were 145 µg/m^3, the mean PM_{10} value was 90 µg/m^3 and $PM_{2.5}$ was 47 µg/m^3 which was within the permissible limit. The average values of SO_2, NO_2 and NH_3 were 2.96 µg/m^3, 11.73 µg/m^3 and 3.22 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Gopalpuri Hospital. The mean Benzene concentration was 1.17 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon monoxide concentration was 1.34 mg/m^3 which is well below the permissible limit of 4.0 mg/m^3.

Location 5: Coal Storage Area (AL-5)

Table 6 : Results of Air Pollutant Concentration at Coal Storage Area										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL6 – 1	03.10.2022	495	319	158	2.12	3.22	13.85	16.93	5.18	6.33
					3.32		20.20		7.25	
					4.23		16.74		6.56	
AL6 – 2	06.10.2022	567	383	173	5.44	3.93	20.20	19.62	7.83	7.60
					3.63		23.66		6.79	
					2.72		15.00		8.17	
AL6 – 3	11.10.2022	587	412	180	10.09	6.73	26.55	26.93	5.18	5.45
					6.05		13.27		7.48	
					4.04		40.97		3.68	
AL6 – 4	14.10.2022	663	441	210	7.25	4.43	19.04	19.43	5.53	4.87
					3.32		15.00		2.99	
					2.72		24.24		6.10	
AL6 – 5	17.10.2022	671	451	217	7.86	7.45	21.35	16.35	6.68	5.03
					9.37		16.74		4.83	
					5.14		10.97		3.57	
AL6 – 6	20.10.2022	940	682	252	8.16	7.76	13.27	18.47	5.87	4.57
					5.74		17.89		5.18	
					9.37		24.24		2.65	
AL6 – 7	23.10.2022	983	713	267	7.55	5.54	15.00	19.62	7.02	5.87
					3.63		20.20		4.72	
					5.44		23.66		5.87	
AL6 – 8	28.10.2022	845	610	231	4.53	4.94	13.27	19.43	6.56	5.18
					6.95		25.97		4.83	
					3.32		19.04		4.14	
Monthly Average		719	501	211		5.50		19.60		5.61
Standard Deviation		182	147	39		1.67		3.22		0.98

Table 6 : Results of Air Pollutant Concentration at Coal Storage Area					
Sampling Period	**Date**	**C_6H_6 [µg/m^3]**	***NMHC**	**CO [mg/m^3]**	**CO_2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL5 – 1	03.10.2022	1.16	BQL	1.41	881
AL5 – 2	06.10.2022	1.09	BQL	1.61	888
AL5 – 3	11.10.2022	1.16	BQL	0.95	819
AL5 – 4	14.10.2022	1.17	BQL	1.64	1026
AL5 – 5	17.10.2022	1.14	BQL	1.42	878
AL5 – 6	20.10.2022	1.18	BQL	1.48	630
AL5 – 7	23.10.2022	1.15	BQL	1.13	454
AL5 – 8	28.10.2022	1.17	BQL	1.43	364
Monthly Average		**1.15**	**-**	**1.38**	**743**
Standard Deviation		**0.03**	**-**	**0.23**	**234**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 at Coal Storage Area was comparatively highest among all the locations of Air Quality monitoring in Kandla Port. High values of TSPM, $PM_{10,}$ $PM_{2.5}$, SO_2, NO_2 at this location was due to lifting of coal with grab and other coal handling processes near Berth no. 6 & 7. Moreover, the traffic was also heavy around this place for transport of coal thus emissions produced from heavy vehicles. The mean TSPM values at Coal storage were 719 µg/m^3, the mean PM_{10} value was 501 µg/m^3, and the $PM_{2.5}$ value was 211 µg/m^3 which was above the permissible limit prescribed by NAAQS. The average values of SO_2, NO_2 and NH_3 were 5.50 µg/m^3, 19.60 µg/m^3 and 5.61 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Coal Storage Area. The mean Benzene concentration was1.15 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.38 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 6: Tuna Port (AL-6)

Table 7 : Results of Air Pollutant Concentration at Tuna Port										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL5 -1	03.10.2022	71	42	23	0.60	2.32	4.62	5.19	3.91	2.65
					3.63		7.50		2.42	
					2.72		3.46		1.61	
AL5 – 2	06.10.2022	173	109	50	1.81	1.31	6.93	6.54	2.99	3.38
					1.21		7.50		3.91	
					0.91		5.19		3.22	
AL5 – 3	11.10.2022	186	122	56	3.46	2.40	7.50	8.46	2.65	2.49
					1.15		13.27		1.61	
					2.59		4.62		3.22	
AL5 – 4	14.10.2022	328	206	115	0.91	1.81	10.97	14.81	1.73	1.80
					2.42		13.85		2.65	
					2.12		19.62		1.04	
AL5 – 5	17.10.2022	252	186	58	2.42	3.32	12.12	8.85	5.29	3.72
					4.84		9.23		3.68	
					2.72		5.19		2.19	
AL5 – 6	20.10.2022	184	119	52	3.93	3.42	27.70	24.62	4.03	10.79
					2.72		29.43		15.57	
					3.63		16.74		12.76	
AL5 – 7	23.10.2022	209	131	78	2.42	2.82	12.12	8.46	4.72	3.84
					3.32		8.08		4.03	
					2.72		5.19		2.76	
AL5 – 8	28.10.2022	169	108	50	4.53	4.63	17.89	13.08	3.22	4.22
					6.95		13.27		3.57	
					2.42		8.08		5.87	
Monthly Average		196	128	60		2.76		11.25		4.11
Standard Deviation		74	50	27		1.04		6.27		2.81

Table 7 : Results of Air Pollutant Concentration at Tuna Port					
	Date	C_6H_6 [µg/m^3]	*NMHC	CO [mg/m^3]	CO_2 [ppm]
Sampling Period		8 hr		Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m3		4.0 mg/m3	-
AL6 -1	03.10.2022	1.1	BQL	1.28	1145
AL6 – 2	06.10.2022	1.16	BQL	1.23	736
AL6 – 3	11.10.2022	1.17	BQL	1.65	1081
AL6 – 4	14.10.2022	1.1	BQL	1.20	1059
AL6 – 5	17.10.2022	1.14	BQL	1.29	900
AL6 – 6	20.10.2022	1.18	BQL	1.42	647
AL6 – 7	23.10.2022	1.15	BQL	1.13	454
AL6 – 8	28.10.2022	1.17	BQL	1.43	364
Monthly Average		1.15	-	1.33	798
Standard Deviation		0.03	-	0.17	296

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The mean TSPM values at Tuna Port was 196 µg/m^3, the mean PM_{10} value was 128 µg/m^3 which was slightly exceed the permissible limit , the mean $PM_{2.5}$ value was 60 µg/m^3 which was within the permissible limit prescribed by NAAQS. The average values of SO_2, NO_2 and NH_3 were 5.50 µg/m^3, 19.60 µg/m^3 and 5.61µg/m^3 respectively and were all within the permissible limit prescribed by NAAQS.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Tuna Port. The mean Benzene concentration was 1.15 µg/m3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.33 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 7: Admin Building (Vadinar) (AL-7)

Table 8 : Results of Air Pollutant Concentration at Admin Building										
	Date	**TSPM [µg/m^3]**	**PM_{10} [µg/m^3]**	**$PM_{2.5}$ [µg/m^3]**	**SO_2 [µg/m^3]**		**NO_X [µg/m^3]**		**NH_3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL7 -1	03.10.2022	179	113	60	2.20	2.64	9.53	14.82	3.83	5.02
					3.08		15.24		5.87	
					2.64		19.69		5.36	
AL7 -2	06.10.2022	171	108	57	3.08	4.25	22.23	13.13	6.64	6.13
					5.28		11.43		7.91	
					4.40		5.72		3.83	
AL7 -3	10.10.2022	156	103	51	4.40	3.37	10.80	19.69	5.36	6.55
					2.64		28.58		7.91	
					3.08		19.69		6.38	
AL7 -4	13.10.2022	106	76	29	5.71	4.25	26.04	20.33	6.13	4.85
					4.40		19.69		3.06	
					2.64		15.24		5.36	
AL7 -5	17.10.2022	208	123	82	3.08	4.98	15.24	17.15	5.36	4.17
					5.28		19.69		4.34	
					6.59		16.51		2.81	
AL7 -6	20.10.2022	205	122	79	1.76	2.64	10.80	7.83	3.57	5.62
					1.32		6.99		7.91	
					4.84		5.72		5.36	
AL1 -7	25.10.2022	216	132	83	6.59	5.13	13.34	13.55	4.34	6.98
					4.84		10.80		8.68	
					3.96		16.51		7.91	
AL1-8	28.10.2022	240	144	91	4.40	3.52	5.72	9.74	6.38	4.08
					3.52		13.34		3.57	
					2.64		10.16		2.30	
Monthly Average		185	115	67		3.8		14.5		5.4
Standard Deviation		42	21	21		1		4		1

Table 8 : Results of Air Pollutant Concentration at Admin Building Vadinar					
Sampling Period	**Date**	**C_6H_6 [µg/m^3]**	***NMHC**	**CO [mg/m^3]**	**CO_2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL7 -1	03.10.2022	1.02	BQL	1.14	474
AL7 -2	06.10.2022	1.11	BQL	1.57	465
AL7 -3	10.10.2022	1.01	BQL	1.17	473
AL7 -4	13.10.2022	1.08	BQL	1.17	373
AL7 -5	17.10.2022	1.06	BQL	1.03	473
AL7 -6	20.10.2022	1.11	BQL	1.07	481
AL7 -7	25.10.2022	1.14	BQL	1.51	486
AL7 -8	28.10.2022	1.01	BQL	1.2	501
AL7 -9	29.10.2022	1.18	BQL	1.52	512
Monthly Average		**1.08**	**-**	**1.26**	**471**
Standard Deviation		**0.06**	**-**	**0.21**	**40**

*NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

At Admin Building, Vadinar the mean TSPM value was 185 µg/m^3, the mean PM_{10} value was 115 µg/m^{3}and the mean $PM_{2.5}$ value was 67 µg/m^3 which was slightly exceed the permissible limit. The average values of SO_2, NO_2 and NH_3 concentrations were 3.8 µg/m^3, 14.5 µg/m^3 and 5.4 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Vadinar Port. The mean Benzene concentration was 1.08 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.26 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 8: Signal Building (Vadinar) (AL-8)

Table 9 : Results of Air Pollutant Concentration at Signal Building Vadinar.										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL8 -1	03.10.2022	146	97	45	4.40	2.64	15.24	13.34	2.81	3.83
					1.32		13.34		3.32	
					2.20		11.43		5.36	
AL8 -2	06.10.2022	125	82	40	2.20	2.20	14.61	17.36	6.13	4.17
					1.32		22.87		3.32	
					3.08		14.61		3.06	
AL8 -3	10.10.2022	130	90	34	3.96	3.66	13.34	16.09	3.83	5.02
					4.84		24.14		3.32	
					2.20		10.80		7.91	
AL8 -4	13.10.2022	94	62	30	3.08	3.52	11.43	13.55	8.68	7.23
					4.84		20.33		5.36	
					2.64		8.89		7.66	
AL8 -5	17.10.2022	140	94	43	3.08	2.64	10.80	10.37	5.87	6.47
					2.64		6.99		7.91	
					2.20		13.34		5.62	
AL8 -6	20.10.2022	163	100	61	5.71	3.96	13.34	11.01	6.38	6.55
					2.20		10.16		7.91	
					3.96		9.53		5.36	
AL8 -7	25.10.2022	192	115	74	2.64	3.96	8.26	9.53	7.15	7.32
					5.28		13.34		4.34	
					3.96		6.99		10.47	
AL8-8	28.10.2022	205	125	77	4.84	4.69	12.07	14.82	3.32	3.83
					5.28		17.78		2.81	
					3.96		14.61		5.36	
Monthly Average		150	96	50		3.4		13.3		5.6
Standard Deviation		36	19	18		1		3		2

Table 9 : Results of Air Pollutant Concentration at Signal Building Vadinar					
	Date	C_6H_6 [µg/m^3]	*NMHC	CO [mg/m^3]	CO_2 [ppm]
Sampling Period		8 hr		Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m3		4.0 mg/m3	-
AL8 -1	03.10.2022	1.06	BQL	1.5	467
AL8 -2	06.10.2022	1.05	BQL	1.46	501
AL8 -3	10.10.2022	1.14	1.81	1.31	489
AL8 -4	13.10.2022	1.16	BQL	1.38	439
AL8 -5	17.10.2022	1.17	BQL	1.29	231
AL8 -6	20.10.2022	1.10	BQL	1.31	244
AL8 -7	25.10.2022	1.00	BQL	1.34	227
AL8 -8	28.10.2022	1.05	BQL	1.37	261
AL8 -9	29.10.2022	1.02	BQL	1.29	234
Monthly Average		1.08	-	1.36	344
Standard Deviation		0.06	-	0.08	125

* NMHC- Non- Methane Hydrocarbon
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

At Signal Building, Vadinar the mean TSPM value was 150 µg/m^3, the mean PM_{10} value was 96 µg/m^3 which was boundary line of the permissible limit, the mean $PM_{2.5}$ value was 50 µg/m^3 which was within the permissible limit. The average values of SO_2, NO_2 and NH_3 concentrations were 3.4 µg/m^3, 13.3 µg/m^3 and 5.6 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Vadinar Port. The mean Benzene concentration was 1.08 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.36 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Fig. No:-1 Average ambient air qulaity (PM) month of October-2022 at DPA and Vadinar Sampling Station

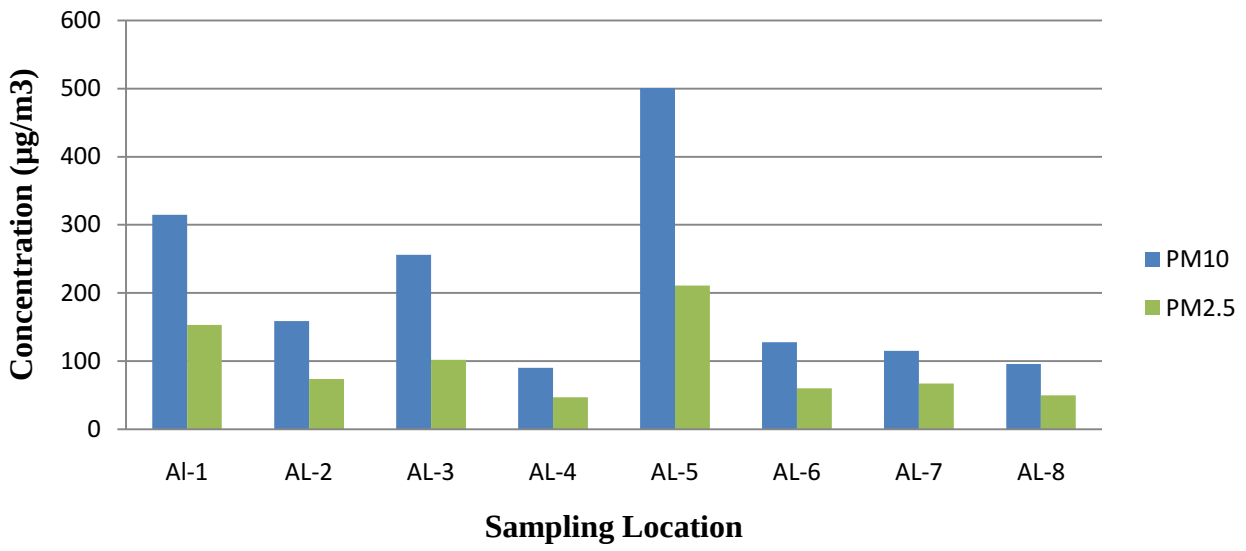


Fig. No:-2. Average ambient air qulaity (Gaseous) month of October-2022 at DPA and Vadinar sampling location

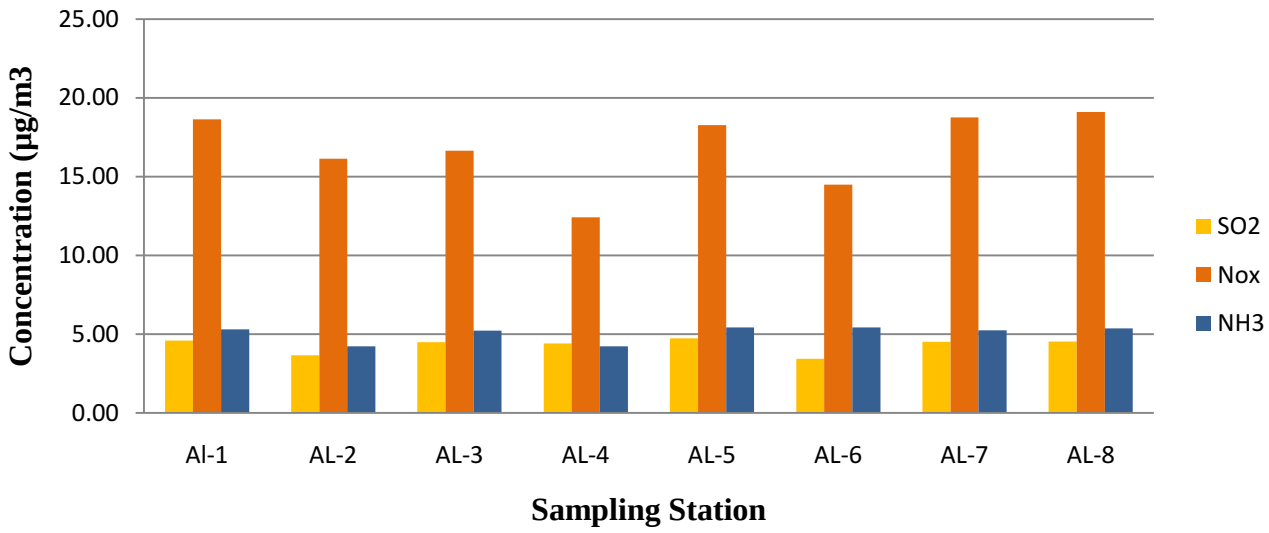


Fig. No:-3. Average ambient air qulaity (Gaseous) month of October-2022 at DPA and Vadinar sampling location

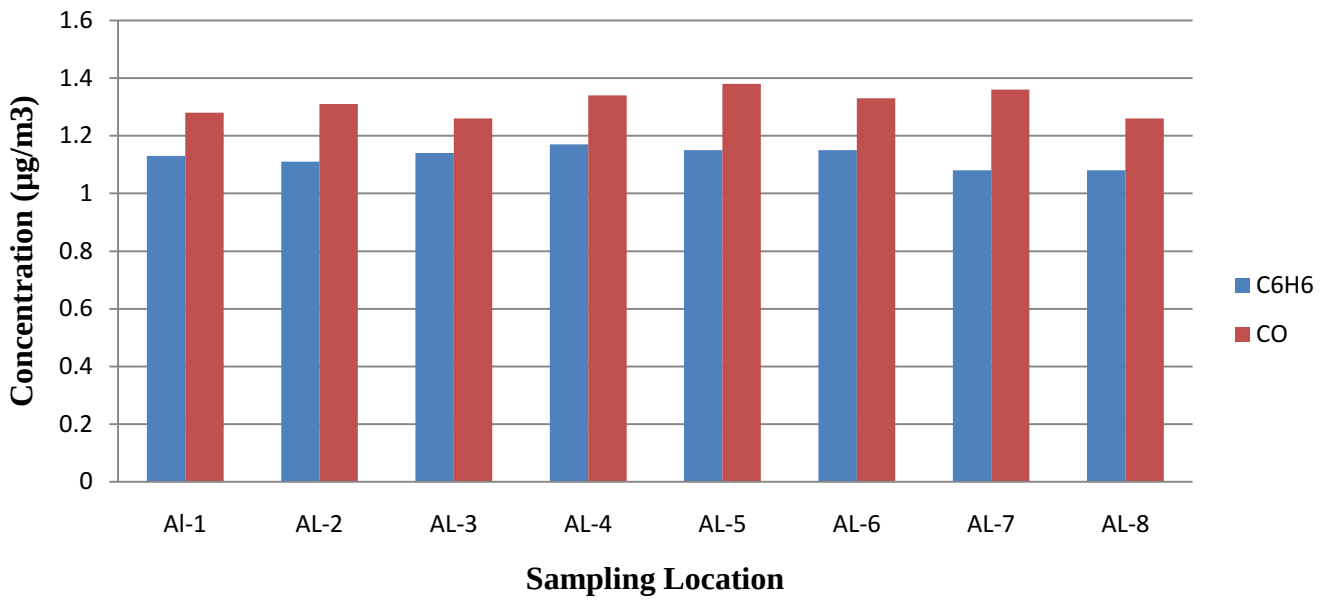
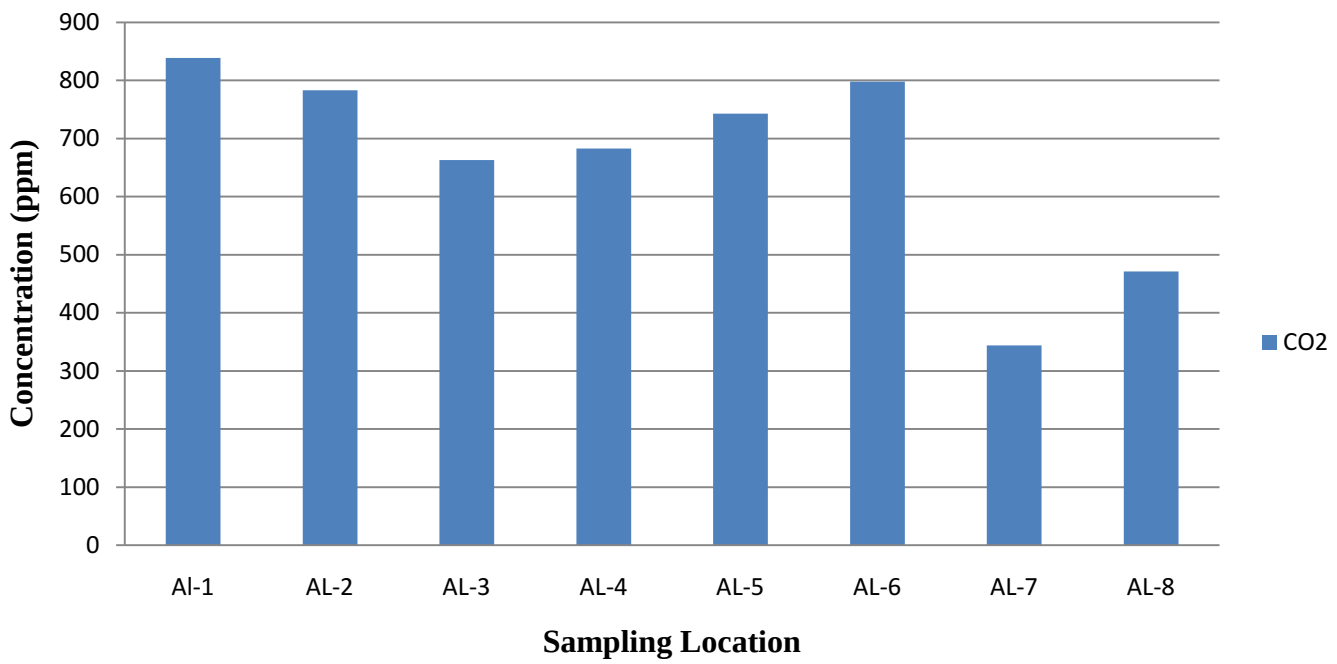


Fig. No:-4. Average ambient air qulaity (Gaseous) month of October-2022 at DPA and Vadinar sampling location



2.3 Observations and Conclusion

During the monitoring period, the overall Ambient Air Quality of the port area was found within permissible levels for various gaseous pollutants. However, Total Suspended Particulate matter as TSPM, Particulate matter as PM_{10} and $PM_{2.5}$ was found to exceed the limits at locations like Near Coal storage area, Marine Bhavan and Estate Office and Oil Jetty.

The concentration of PM_{10} slightly exceeded at Tuna Port while the mean concentration of $PM_{2.5}$ was 60 µg/m^3 which was within the limit. At Gopalpuri location concentration of monitored parameters of ambient air quality were found within the limit.

The mean concentration of PM_{10} and $PM_{2.5}$ were slightly exceeded at Admin building Vadinar & at Signal building Vadinar were within the permissible limit.

4.1 Meteorological Data

Automatic Weather station (ID KAZPHOEN424) have been installed in Seva Sadan-3 at the Deendayal Port which records the data on Temperature (°C), Relative Humidity (%),Wind speed (m/s),Wind Direction (°), Solar radiation (w/m^2) and Rainfall mm.

Meteorological factors play an important role in environmental pollution studies particularly in pollutant transport irrespective of their entry into the environment. The wind speed and direction play a major role in dispersion of environment pollutants. Effects of pollution on receptors animate and inanimate depends on atmospheric condition.

Temperature

At Deendayal Port, the day time temperature was found range 23.2-35.1^{0}C. The average day time temperature was 29.87°C. The night time temperature was range from 23.4-32.5^{0}C. The mean night time temperature recorded was 27.91 °C.

Solar Radiation

The mean Solar Radiation in October month was 185.99 w/m^2. The maximum solar radiation was recorded 856.7 w/m^2 in 1st October, 2022 and the minimum solar radiation was recorded 1.106 w/m^2 in 29th October, 2022.

Rainfall

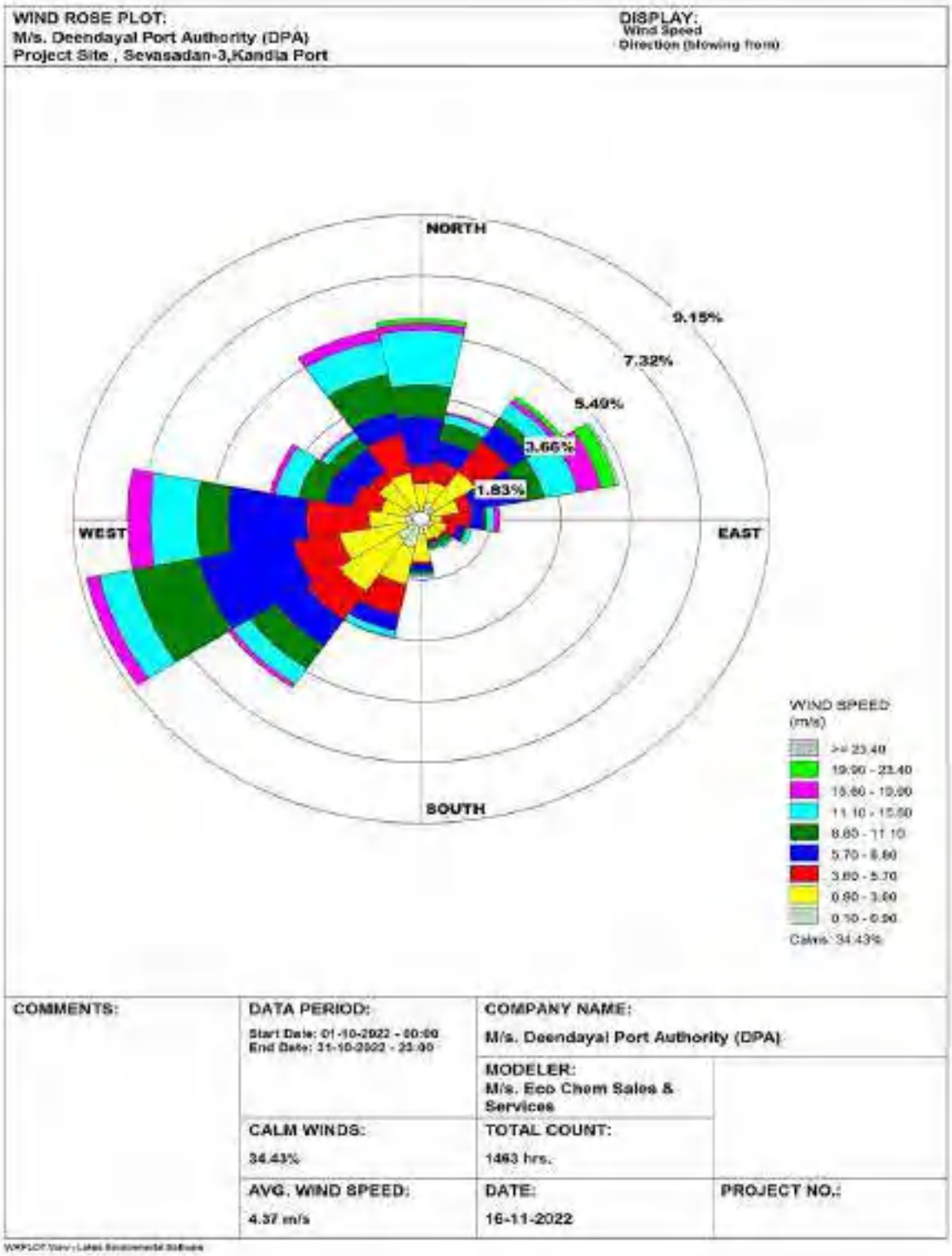
Rain fall of October month was recorded 0.00 mm.

Relative Humidity

The mean Relative humidity was 74.90 % for the month of October. Maximum Relative humidity was recorded 98.0 % and minimum Relative humidity was recorded 30.0 %.

Wind Velocity and Wind Direction

Velocity and direction of wind have a significant role in the dispersion of air borne materials and therefore determines the air quality of the area. The average wind velocity for the entire month of October was 1.22 m/s. Maximum wind velocity was recorded 6.50 m/s. The wind direction was mostly West-South.


WIND ROSE PLOT:
M/s. Deendayal Port Authority (DPA)
Project Site , Sevasadan-3,Kandla Port
DISPLAY:
Wind Speed
Direction (blowing from)
NORTH
SOUTH
WEST
EAST
9.15%
7.32%
5.49%
3.66%
1.83%
WIND SPEED (m/s)
>= 23.40
19.90 - 23.40
15.60 - 19.90
11.10 - 15.60
8.60 - 11.10
5.70 - 8.60
3.60 - 5.70
0.90 - 3.60
0.10 - 0.90
Calms: 34.43%
COMMENTS:
DATA PERIOD:
Start Date: 01-10-2022 - 00:00
End Date: 31-10-2022 - 23:00
COMPANY NAME:
M/s. Deendayal Port Authority (DPA)
MODELER:
M/s. Eco Chem Sales & Services
CALM WINDS:
34.43%
TOTAL COUNT:
1463 hrs.
AVG. WIND SPEED:
4.37 m/s
DATE:
16-11-2022
PROJECT NO.:

4.0 Drinking Water Quality Monitoring

Drinking Water Quality Monitoring was carried out at twenty stations at Kandla, Vadinar & Township Area of Deendayal Port.

Table No:-10. Drinking Water Sampling Location

Sr. No.	Name of Location	Location Code	Latitude	Longitude
1.	Nirman Building	DL-1	23° 0' 27"N	70° 13' 21"E
2.	P & C Building	DL-2	23° 0' 33"N	70° 13' 20"E
3.	North Gate	DL-3	23° 0' 26.97"N	70° 13' 21.87"E
4.	KPT-Canteen	DL-4	23° 2' 17.2674"N	70° 13'18.2814"E
5.	West Gate	DL-5	23° 59' 40.48"N	70° 12' 50.96"E
6.	Wharf Area	DL-6	22° 59' 52.2"N	70° 13' 22.95"E
7.	Sevasadan-3	DL-7	23° 0' 22.55"N	70° 13' 15.34"E
8.	Workshop	DL-8	23° 0' 33.74"N	70° 13' 20.05"E
9.	Custom Building	DL-9	23° 1' 8.70"N	70° 12' 52.0"E
10.	Kandla Colony	DL-10	23° 11' 14.9"N	70° 12' 48.4"E
11.	KPT Hospital	DL-11	23° 1' 5.02"N	70° 12' 44.38"E
12.	A.O. Building	DL-12	23° 3' 42.89"N	70° 8' 41.5"E
13.	Gopalpuri School	DL-13	23° 5' 1.03"N	70° 7' 55.42"E
14	Gopalpuri Guest House	DL-14	23° 4' 43.14"N	70° 7' 51.92"E
15.	E-Type Quarters	DL-15	23° 4' 59.90"N	70° 7' 56.72"E
16.	F-Type Quarters	DL-16	23° 4' 38.45"N	70° 8' 8.63"E
17.	Gopalpuri Hospital	DL-17	23° 4' 54.09"N	70° 8' 7.5"E
18.	Tuna Port	DL-18	23° 58' 23.06"N	70° 5' 35.6"E
19.	Vadinar Jetty	DL-19	22° 25' 51.73"N	69° 41' 36.62"E
20.	Vadinar Colony	DL-20	22° 30' 26.25"N	69° 39' 45.03"E

4.1 Drinking Water Monitoring Methodology

Samples for physico-chemical analysis were collected in 2 Carboys and samples for microbiological parameters were collected in sterilized bottles. These samples were then analyzed in laboratory for various drinking water parameters at Kandla Lab/Surat.

The Sampling was done as per IS: 3025 Part-1, analysis was done as per IS: 3025/APHA standard methods and, the analysis results compare with IS 10500:2012. The water samples were analyzed for various parameters, viz. Color , Odor, Turbidity , Conductivity , pH , Chlorides , TDS, Total Hardness, Iron , Sulphate, Salinity , DO, BOD, Na, K, Ca, Mg, F, NO_3, NO_2, Mn, Cr-6, Cu, Cd, As, Hg, Pb, Zn, Bacterial Count (CFU) .

4.2 Results

The Drinking Water Quality monitoring data for 20 stations are given in below from table No. 11 to Table No. 17

Table 11: Drinking Water Quality Monitoring Parameters for Nirman Building, P & C Building and Main Gate (North) at Kandla.

Sr. No.	Parameter	Unit	Nirman Building 1	P & C Building	Main Gate North	Acceptable Limits as per IS 10500 :2012 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.35	7.45	7.36	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	730	770	740	500	2000
3	Turbidity	NTU	1	1	0	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	1279	1341	1298	NS*	NS*
7	Biochemical Oxygen	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	375.84	395.88	390.87	250	1000
9	Ca as Ca	mg/l	36.87	36.07	34.47	75	200
10	Mg as Mg	mg/l	57.83	63.18	61.72	30	100
11	Total Hardness	mg/l	330	350	340	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	1.32	1.28	1.37	1	1.5
14	Sulphate as SO_4	mg/l	36.01	32.83	34.95	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	1.16	1.23	4.21	45	No Relaxation
17	Salinity	‰	0.68	0.72	0.71	NS*	NS*
18	Sodium as Na	mg/l	93.00	103.10	94.50	NS*	NS*
19	Potassium as K	mg/l	3.04	4.50	3.00	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe- 0.009 mg/l, Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu- 0.004 mg/l, Cd- 0.003 mg/l, As- 0.003mg/l, Hg- 0.001 mg/l, Pb- 0.006mg/l, Zinc- 0.021 mg/l).

Table 12: Drinking Water Quality Monitoring Parameters for Canteen, West Gate – I & Wharf Area at Kandla

Sr. No.	Parameter	Unit	Canteen	West Gate – I	Wharf Area	Acceptable Limits as per IS 10500 :	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.51	7.33	7.51	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	780	750	780	500	2000
3	Turbidity	NTU	1	1	1	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	1352	1316	1349	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	380.85	365.81	360.80	250	1000
9	Ca as Ca	mg/l	35.27	36.07	37.68	75	200
10	Mg as Mg	mg/l	68.53	63.18	57.35	30	100
11	Total Hardness	mg/l	370	350	330	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	1.25	1.27	1.22	1	1.5
14	Sulphate as SO4	mg/l	39.19	34.95	40.25	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	3.27	2.18	5.22	45	No Relaxation
17	Salinity	‰	0.69	0.66	0.65	NS*	NS*
18	Sodium as Na	mg/l	104.80	103.80	104.30	NS*	NS*
19	Potassium as K	mg/l	4.86	4.76	3.90	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 13: Drinking Water Quality Monitoring Parameters for Sewa sadan–3, Workshop I and Custom Building at Kandla

Sr. No.	Parameter	Unit	Sewa Sadan – 3	Workshop	Custom Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.53	7.42	7.32	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	760	770	710	500	2000
3	Turbidity	NTU	0	0	0	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	1324	1352	1242	NS*	NS*
7	Biochemical	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	355.79	370.82	320.71	250	1000
9	Ca as Ca	mg/l	38.48	36.07	36.87	75	200
10	Mg as Mg	mg/l	59.29	65.61	57.83	30	100
11	Total Hardness	mg/l	340	360	330	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	1.25	1.41	1.24	1	1.5
14	Sulphate as SO_4	mg/l	36.01	29.66	34.95096	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL		NS*	NS*
16	Nitrate as NO_3	mg/l	2.98	4.21	3.63	45	No Relaxation
17	Salinity	‰	0.64	0.67	0.58	NS*	NS*
18	Sodium as Na	mg/l	102.80	103.70	73.50	NS*	NS*
19	Potassium as K	mg/l	3.03	3.53	2.75	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 14: Drinking Water Quality Monitoring Parameters for Port Colony Kandla, Hospital Kandla and A.O. Building at Gandhidham.

Sr. No.	Parameter	Unit	Port Colony Kandla	Hospital Kandla	A.O. Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 :
1	pH	-	7.41	7.28	7.25	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	730	660	700	500	2000
3	Turbidity	NTU	1	1	1	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	1282	1159	1240	NS*	NS*
7	Biochemical	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	330.74	310.69	385.86	250	1000
9	Ca as Ca	mg/l	34.47	36.07	38.48	75	200
10	Mg as Mg	mg/l	56.86	53.46	54.43	30	100
11	Total Hardness	mg/l	320	310	320	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	1.18	1.12	1.41	1	1.5
14	Sulphate as SO_4	mg/l	36.01008	39.18744	41.30568	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	2.32	3.12	1.02	45	No Relaxation
17	Salinity	‰	0.60	0.56	0.70	NS*	NS*
18	Sodium as Na	mg/l	101.30	113.40	101.90	NS*	NS*
19	Potassium as K	mg/l	3.81	3.13	2.45	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 15: Drinking Water Quality Monitoring Parameters for School Gopalpuri, Guest House) and E - Type Quarter at Gopalpuri, Gandhidham

Sr. No.	Parameter	Unit	Gopalpuri School	Guest House	E - Type Quarter	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.23	7.21	7.31	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	670	720	740	500	2000
3	Turbidity	NTU	0	0	1	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	1164	1268	1308	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	320.71	330.74	340.76	250	1000
9	Ca as Ca	mg/l	39.28	40.08	41.68	75	200
10	Mg as Mg	mg/l	61.24	55.89	57.35	30	100
11	Total Hardness	mg/l	350	330	340	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	1.37	1.47	1.29	1	1.5
14	Sulphate as SO_4	mg/l	42.3648	36.01008	34.95096	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	1.31	2.18	1.09	45	No Relaxation
17	Salinity	‰	0.58	0.60	0.62	NS*	NS*
18	Sodium as Na	mg/l	108.20	109.50	104.40	NS*	NS*
19	Potassium as K	mg/l	2.52	3.86	2.96	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100 ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 16: Drinking Water Quality Monitoring Parameters for F-Type Quarter, Hospital Gopalpuri and Tuna Port.

Sr. No.	Parameter	Unit	F - Type Quarter	Hospital Gopalpuri	Tuna Port	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.29	7.33	7.55	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	730	700	980	500	2000
3	Turbidity	NTU	1	0	1	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	1270	1240	1706	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	325.72	335.75	405.90	250	1000
9	Ca as Ca	mg/l	40.88	39.28	63.33	75	200
10	Mg as Mg	mg/l	55.40	63.67	49.09	30	100
11	Total Hardness	mg/l	330	360	360	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	1.10	1.39	1.42	1	1.5
14	Sulphate as SO_4	mg/l	40.24656	42.3648	187.46424	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	1.31	1.52	5.22	45	No Relaxation
17	Salinity	‰	0.59	0.61	0.73	NS*	NS*
18	Sodium as Na	mg/l	108.40	104.50	105.90	NS*	NS*
19	Potassium as K	mg/l	3.58	3.35	3.85	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified, BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6-0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 17: Drinking Water Quality Monitoring Parameters for Vadinar Jetty and Port Colony at Vadinar.

Sr. No.	Parameter	Unit	Vadinar Jetty	Port Colony Vadinar	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.36	7.28	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	300	280	500	2000
3	Turbidity	NTU	1.00	1.00	1	5
4	Odor	-	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	5	15
6	Conductivity	µs/cm	559	280	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	145.32	135.30	250	1000
9	Ca as Ca	mg/l	36.07	36.87	75	200
10	Mg as Mg	mg/l	36.45	40.82	30	100
11	Total Hardness	mg/l	240	260	200	600
12	Iron as Fe	mg/l	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	1.15	1.09	1	1.5
14	Sulphate as SO_4	mg/l	4.13	3.71	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	1.38	1.60	45	No Relaxation
17	Salinity	‰	0.26	0.24	NS*	NS*
18	Sodium as Na	mg/l	108.5	110.8	NS*	NS*
19	Potassium as K	mg/l	2.35	2.89	NS*	NS*
20	Manganese	mg/l	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

4.3 Results & Discussion

The colour of all drinking water samples was found Colourless and odour of the samples also agreeable. All parameters were found within the specified limit as per the Drinking water Standard.

pH

The pH is measure of the intensity of acidity or alkalinity and the concentration of hydrogen ion in water. At DPA Site the pH values for drinking water samples ranged from 7.21-7.55 and mean value was 7.36 while at Vadinar pH ranged from 7.28-7.36 and mean value was 7.32. All the sampling points showed pH values within the prescribed limit by Indian Standards.

Turbidity

The selected drinking water sample location turbidity range from 0-1NTU at all location of DPA and Vadinar in month of October. The Turbidity values were within the permissible limit at all sampling location prescribed limit by Indian standards.

Total Dissolved Solids (TDS)

Water has the ability to dissolve a wide range of inorganic and some organic minerals or salts such as potassium, calcium, sodium, bicarbonates, chlorides, magnesium, sulfates etc.

TDS values at DPA varied between 660-980 mg/l. The average TDS value was found 745.0 mg/l. The minimum value for TDS was 660 mg/l at Hospital Gopalpuri and maximum was 980 mg/l at Tuna Port while at Vadinar TDS ranged from 280-300 mg/l and mean was 290.0 mg/l. The TDS values were within the permissible limit at all sampling location prescribed limit by Indian standards.

Conductivity

Electrical Conductivity is the ability of a solution to transfer (conduct) electric current. Conductivity is used to measure the concentration of dissolved solids which have been ionized in a polar solution such as water. The conductivity in the samples collected during the month of October DPA ranged from 1159.0 µs/cm at Hospital Gopalpuri to 1706.0 µs/cm at Tuna Port and mean value was 1305.0 µs/cm while at Vadinar ranged from 280-559 µs/cm and mean was 419.5 µs/cm.

BOD

BOD value in the studied area of DPA and Vadinar was found Below Quantification Limit (<2.0 mg/l). IS 10500:2012 does not show any standard values for BOD in drinking water.

Chlorides

Excessive chloride concentration increase rates of corrosion of metals in the distribution system. This can lead to increased concentration of metals in the supply. The Chloride value in the studied area of DPA ranged from 310.69-405.90 mg/l. The mean value was 355.79 mg/l. The minimum chloride was 310.69 mg/l at Hospital Gopalpuri and maximum was 405.90 mg/l at Tuna Port while at Vadinar location chloride ranged from 135.30-145.32 mg/l and mean was 140.31 mg/l. The Chloride was found within the Permissible limit of the Drinking Water Standard.

Calcium

Calcium is most abundant element on the earth crust and is very important for human cell physiology and bones. About 95% calcium in human body stored in bones and teeth. The high deficiency of calcium in humans may caused rickets, poor blood clotting, bones fracture etc. and the exceeding limit of calcium produced cardiovascular diseases.

The Calcium value in the studied area of DPA ranged from 34.47-63.33 mg/l. The mean value was 38.97 mg/l. The minimum calcium was 34.47 mg/l at Port Colony and maximum was 63.33 mg/l at Tuna Port while at Vadinar location Calcium ranged from 36.07-36.87 and mean was 36.47 mg/l. All the locations had calcium within the prescribed limits of 75-200 mg/L.

Magnesium

The magnesium value in the studied area of DPA ranged from 49.09-68.53 mg/l. The mean value was 59.0 mg/l. The minimum magnesium was 49.09 mg/l at Tuna Port and maximum was 68.53 mg/l at Canteen while at Vadinar location magnesium ranged from 36.45-40.82 and mean was 38.64 mg/l. All the locations had magnesium within the prescribed limits of 30-100 mg/L.

Total Hardness

Total Hardness value in the studied area of DPA ranged from 310.0 mg/l at DPA Hospital to 370.0 mg/l at Canteen and mean value was 340.0 mg/l while at Vadinar location total hardness ranged from 240.0-260.00 mg/l and mean was 250.0 mg/l. The values of total

hardness were found within the Permissible limit of the Drinking Water Standard (200-600 mg/L). These results clear, that hardness of water is according to the IS standards and it is not harmful for local inhabitants.

Iron

Iron values in the studied area of DPA & Vadinar were Below Quantification Limit (0.009 mg/l) and hence well below the permissible limit as per Indian Standards are 0.3 mg/L.

Fluoride

Fluoride value in the studied area of DPA varied between 1.10-1.42 mg/l and mean was 1.28 mg/l. The minimum value was 1.10 mg/ at F-Type Quarter and maximum was 1.42 mg/l at Tuna Port while at Vadinar location fluoride ranged from 1.09-1.15 mg/l and mean was 1.11 mg/l. The Fluoride values were well below the permissible limit as per Indian Standards is 1.0-1.5 mg/L. Moderate amounts lead to dental effects, but long-term ingestion of large amounts can lead to potentially severe skeletal problems.

Sulphate

Sulphate value in the studied area of DPA varied between 29.66–187.46 mg/l and mean was 45.48 mg/l. The minimum value was 29.66 mg/ at Workshop and maximum was 187.46 mg/l at Tuna Port while at Vadinar location sulphate ranged from 3.71-4.13 mg/l and mean was 3.92 mg/l. All the sampling points showed sulphate values within the prescribed limits by Indian Standards (200-400 mg/L). Sulphate content in drinking water exceeding the 400 mg/L imparts bitter taste.

Nitrites (NO_2) and Nitrates (NO_3)

The all values of Nitrates were well within the permissible limit of the Drinking water Standard.

Salinity

Salinity in drinking water in the present samples collected at DPA ranged from 0.56 ‰ at Hospital Gopalpuri to 0.73 ‰ at Tuna Port and average salinity was 0.64 ‰ while at Vadinar sampling location salinity ranged from 0.24-0.26 ‰. There are no prescribed Indian standards for salinity in Drinking water**.**

Sodium and Potassium Salts

Sodium values in the samples collected at DPA ranged from 73.50 - 113.40 mg/l and average was 102.28 mg/l while at Vadinar sodium ranged from 108.50- 110.8 mg/l. Potassium salts ranged at DPA ranged from 2.45 to 4.86 mg/l while average was 3.49 mg/l while at Vadinar sampling location ranged from 2.35-2.89 mg/l and mean was 2.62 mg/l. There are no prescribed limits of Sodium and Potassium in Indian standards for Drinking water**.**

Heavy Metals in Drinking Water

In the present study period drinking water samples were analyzed for Mn, Cr, Cu, Cd, As, Hg, Pb and Zn. All these heavy metals were well Below the Quantification limits prescribed by the Indian Standards.

Bacteriological Study

Analysis of the bacteriological parameter (E-coli and total coliform) at all location shows that Bacteria were not detectable. This shows that drinking water samples were safe for human consumption as per tested parameters.

4.4 Conclusions

These results were compared with permissible limits as prescribed in IS 10500:2012 – Drinking Water Specification. It was seen from the analysis data that during the study period at selected sampling location the water was safe for human consumption as per analyzed parameters at all drinking water monitoring stations.

5.0 Noise Level Monitoring

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. Noise Monitoring was done at 13 stations at Kandla, Vadinar and Township area.

5.1 Method of Monitoring

Sampling was done at all stations for 24 hour period. Data was recorded using automated sound level meter. The intensity of sound was measured in sound pressure level (SPL) and common unit of measurement is decibel (dB).

5.2 Results

Table 18: Noise Monitoring data for ten locations of Deendayal Port and three locations of Vadinar Port

Sr. No.	Location	Day Time Average Noise Level (SPL) in dB(A)	Night Time Average Noise Level (SPL) in dB(A)
	Sampling Time	**6:00 am to 10:00 PM**	**10:00PM to 6:00 AM**
1	Marine Bhavan	72.8	64.4
2	Nirman Building 1	69.7	63.3
3	Tuna Port	71.2	55.4
4	Main Gate North	71.0	61.5
5	West Gate I	71.7	58.5
6	Canteen Area	68.3	59.2
7	Main Road	70.3	64.0
8	ATM Building	71.8	62.9
9	Wharf Area /Jetty Area	72.6	64.7
10	Port & Custom Office	63.8	53.9
Vadinar Port			
11	Entrance Gate of Vadinar Port	57.2	53.6
12	Nr. Port Colony, Vadinar	58.4	56.9
13	Nr. Vadinar Jetty	58.0	57.5

5.3 Conclusions

Transportation systems are the main source of noise pollution in urban areas. Construction of buildings, highways, and roads cause a lot of noise, due to the usage of air compressors, bulldozers, loaders, dump trucks, and pavement breakers. Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships.

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. The Day Time Noise Level (SPL) in all 10 locations at Deendayal Port Authority ranged from 63.8 dB(A) to 72.8 dB(A) while at Vadinar port 3 location ranged from 57.2 dB(A) to 58.4 dB(A) which was within the permissible limits of 75 dB(A) for the industrial area for the daytime. The Night Time Average Noise Level (SPL) in all locations of Deendayal Port Authority ranged from 53.9 dB to 64.7 dB(A) while at Vadinar port ranged from 53.6 dB (A) to 57.5 dB(A) which was within the permissible limits of 70 dB(A) for the industrial area for the night time.

6.0 Soil Monitoring

Sampling and analysis of soil samples were undertaken at six locations within the study area (Deendayal Port and Vadinar Port) as a part of EMP. The soil sampling locations are initially decided based on the locations as provided in the tender document of the Deendayal Port.

Table No.:-19. Soil Sampling Location

Sr. No.	Name of Location	Location Code	Latitude	Longitude	Remarks
1.	Tuna Port	SL-1	22° 58' 10.18"N	70° 6' 3.7"E	Near main gate of Port
2.	IFFCO Plant	SL-2	23° 26' 8.37"N	70° 13' 4.4"E	10 m away from main gate
3.	Khori creek	SL-3	22° 58' 10.18"N	70° 6' 3.7"E	Sand from creek after tide
4.	Nakti Creek	SL-4	23° 2' 1.10"N	70° 9' 33.6"E	
5.	DPA admin site	SL-5	22° 26' 30.9"N	69° 40' 37.03"E	Vadinar
6.	DPA colony	SL-6	22° 23' 57.09"N	69° 42' 49.42"E	

6.1 Methodology

The soil samples were collected in the month of October 2022. The samples collected from the all locations are homogeneous representative of each location. At random locations were identified at each location and soil was dug from 30 cm below the surface. It was uniformly mixed before homogenizing the soil samples. The samples were filled in polythene bags, labeled in the field with number and site name and sent to laboratory for analysis.

6.2 Results

Table-20: Chemical Characteristics of Soil in the Study Area for Tuna port, IFFCO, Khori Creek, Nakti Creek, DPA admin site, DPA colony.

Sr. No.	Parameter	Unit	Station Name					
			SL1	SL2	SL3	SL4	SL5	SL6
			Tuna Port	IFFCO Plant	Khori Creek	Nakti Creek	DPA Admin Site	DPA Colony
			Near main gate of Port	10 m away from main	Sand from creek after tide		Vadinar	
1	Texture		Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	pH	-	8.60	8.20	7.90	7.80	6.50	7.10
3	Electrical Conductivity	µs/cm	10240.0	14400.0	9,180.00	17,290.0	910.0	522.0
4	Phosphorus	mg/kg	11.2	10.62	12.50	18.20	6.00	4.80
5	Moisture	%	16.76	17.5	2.02	17.70	7.20	10.10
6	Total Organic	%	1.56	0.1	0.30	0.39	0.11	0.79
7	Alkalinity	mg/kg	200.0	800.0	700.0	500.0	500.0	800.0
8	Total Nitrogen	%	BQL	BQL	BQL	BQL	BQL	BQL
9	Sulphate	mg/kg	215.00	282.00	189.90	210.80	52.0	50.0
10	Chloride	mg/kg	1878.0	2660.0	1,347.00	1,790.00	106.00	124.00
11	Calcium	mg/kg	2,124.00	2,424.00	2,004.00	2,264.00	1,062.00	1,609.00
12	Sodium	mg/kg	501	516.0	320.00	493.00	144.00	307.20
13	Potassium	mg/kg	468	444	293.70	370.00	26.66	29.28
14	Copper as Cu	mg/kg	25.9	20.1	15.40	16.90	54.10	31.60
15	Lead as Pb	mg/kg	7	8	5.20	25.50	BDL	BDL
16	Nickel as Ni	mg/kg	24.90	23.40	24.40	23.90	19.90	15.80
17	Zinc as Zn	mg/kg	43.5	67.50	39.70	50.00	25.70	31.80
18	Cadmium as Cd	mg/kg	BQL	BQL	BQL	BQL	BDL	BQL

BQL- Below Quantification Limit, (TN: 0.001%, Cd: 1.0mg/kg)

6.3 Discussion

- DPA Kandla soil sampling data shows that value of pH ranges from 7.80 at Nakti Creek to 8.60 at Tuna Port while the average value was 8.13. At Vadinar sampling location pH were 6.50 at DPA Admin site and 7.10 at DPA Colony.
- The conductivity of DPA Kandla soil sample ranged from 9180.0 µs/cm at Khori Creek (Sand from creek after tide) to 17290 µs/cm at Nakti Creek (Sand from creek after tide) and mean was 12777.50 µs/cm while Vadinar soil sampling location conductivity were 910 µs/cm at DPA Admin Site and 522 µs/cm at DPA Colony site.
- Total organic Carbon of DPA Kandla soil sample ranged from 0.1 % at IFFCO Plant to 1.56 % at Tuna Port (Near Main Gate) and mean was 0.59 % while Vadinar soil sample were 0.11% at DPA admin and 0.79 % at DPA Colony.
- The concentration of Phosphorus in the soil samples of DPA Kandla varies from 11.2 mg/kg at Tuna Port (Near Main Gate) and 18.20 mg/kg at Nakti Creek (Sand from creek after tide) and mean was 13.13 mg/kg while the Vadinar soil sample for Phosphorus were 4.80 mg/kg at DPA Colony and 6.00 mg at DPA Admin Site.
- Chloride in soil sample of DPA ranged from 1347.00 mg/kg at Khori Creek (Sand from creek after tide) to 2660 mg/kg at IFFCO Plant while Vadinar soil sample were 106 mg/kg at DPA admin and 124 mg/kg at DPA Colony.
- The Concentration of Potassium in the soil samples of DPA Kandla ranged from 293.70 mg/kg at Khori creek and 468 mg/kg at Tuna Port and mean was 393.93 mg/kg while the Vadinar soil sample for Potassium were 26.66 mg/kg at DPA Admin Site and 29.28 mg/kg at DPA Colony.
- The concentration of Sodium in the soil samples of DPA Kandla ranged from 320.0 mg/kg at Khori creek and 516.0 mg/kg at IFFCO Plant and mean was 457.50 mg/kg while the Vadinar soil sample for Sodium were 144.00 mg/kg at DPA Admin Site and 307.20 mg/kg at DPA Colony.

These differences in NPK in soil at different locations are due to the dissimilar nature of soil at each of the locations. Samples SL3 & SL4 (Khori Creek & Nakti Creek) were coastal soil; where as other locations are inland locations and have different chemical properties.

Heavy Metals in the Soil

Traces of Copper, Lead, Nickel and Zinc were observed in the soil samples collected from all the four locations of Deendayal Port Authority Kandla and two locations of Vadinar Port. Cadmium metal was below detection limit in the Soil.

6.4 Conclusion

The soils of Deendayal Port Authority Kandla and Vadinar Port appears to be neutral to basic with varying levels of Chloride, Sulphate, NPK and Calcium. As the nature of soil at different locations are different with respect to its proximity to the sea, the samples showed high degree of variations in their chemical properties.

7.0 Sewage Treatment Plant Monitoring

This involves safe collection of waste water (spent/used water) from wash areas, bathroom, industrial units, etc., waste from toilets of various buildings and its conveyance to the treatment plant and final disposal in conformity with the requirement and guidelines of State Pollution Control Board and other statutory bodies.

7.1 Methodology for STP Monitoring

To monitor the working efficiency of Sewage Treatment Plant (STP), STP Inlet and Outlet Samples were collected once a week. Locations selected are namely Gopalpuri Township, Deendayal Port and Vadinar. Samples were collected in 1 lit. Carboys and were analyzed in laboratory for various parameters.

Table No. 21. Sewage Treatment Plant

Sr. No.	Location of STP	Types of Treatment	STP Capacity	Treated water Utilization
1.	Gopalpuri Township	MBBR	450 KLD	Plantation and Gardening
2.	Deendayal Port, Kandla	MBBR	600 KLD	Discharge to marine through pipeline, Plantation, Gardening
3.	Vadinar Port Colony	MBBR	1.5 MLD	Plantation and Gardening

7.2 Results

Table 22: Sewage Water Monitoring at Kandla STP (1st Week)

Date of Sampling	01.10.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.58	7.35	6.5 - 8.5
2	Total Suspended Solids	mg/l	117.8	59.9	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	110	40.0	100
5	BOD @ 27 °C	mg/l	34.0	11.0	30
Aeration Tank					
6	MLSS	mg/l	12.0		
7	MLVSS	%	88.0		

Table 23: Sewage Water Monitoring at Kandla STP (2nd Week)

Date of Sampling	10.10.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.45	7.25	6.5 - 8.5
2	Total Suspended Solids	mg/l	105.4	50.9	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	92	32.0	100
5	BOD @ 27 °C	mg/l	28.0	8.0	30
Aeration Tank					
6	MLSS	mg/l	12.0		
7	MLVSS	%	88.0		

Table 24: Sewage Water Monitoring at Kandla STP (3rd Week)

Date of Sampling	17.10.2022

Sr. No.	**Parameters**	**Unit**	**Results**		**CPCB Prescribed Limit**
			DPA STP I/L	**DPA STP O/L**	
1	pH	-	7.48	7.27	6.5 - 8.5
2	Total Suspended Solids	mg/l	97.6	37.5	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	90	30	100
5	BOD @ 27 °C	mg/l	29.0	8.0	30
Aeration Tank					
6	MLSS	mg/l	20.0		
7	MLVSS	%	98.0		

Table 25: Sewage Water Monitoring at Kandla STP (4th Week)

Date of Sampling	28.10.2022

Sr. No.	**Parameters**	**Unit**	**Results**		**GPCB Prescribed Limit**
			DPA STP I/L	**DPA STP O/L**	
1	pH	-	7.53	7.35	6.5 - 8.5
2	Total Suspended Solids	mg/l	95.8	38.1	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	80	26	100
5	BOD @ 27 °C	mg/l	22.0	8.0	30
Aeration Tank					
6	MLSS	mg/l	33.0		
7	MLVSS	%	99.0		

Table 26: Sewage Water Monitoring at Gopalpuri STP (3rd Week)

Date of Sampling	17.10.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Gopalpuri STP I/L	Gopalpuri STP O/L	
1	pH	-	7.54	7.32	6.5 - 8.5
2	Total Suspended Solids	mg/l	100	41.8	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	82	40	100
5	BOD @ 27 °C	mg/l	22.0	11.0	30
Aeration Tank					
6	MLSS	mg/l	8.0		
7	MLVSS	%	98.0		

Table 27: Sewage Water Monitoring at Gopalpuri STP (4th Week)

Date of Sampling	28.10.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Gopalpuri STP I/L	Gopalpuri STP O/L	
1	pH	-	7.48	7.28	6.5 - 8.5
2	Total Suspended Solids	mg/l	110.2	42.1	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	78	40	100
5	BOD @ 27 °C	mg/l	24.0	12.0	30
Aeration Tank					
6	MLSS	mg/l	30.0		
7	MLVSS	%	99.0		

Table 28: Sewage Water Monitoring at Vadinar STP (1st Week)

Date of Sampling	01.10.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar STP O/L	
1	pH	-	7.35	7.21	6.5 - 8.5
2	Total Suspended Solids	mg/l	97.5	37.1	100
3	Residual Chlorine	mg/		<0.5	-
4	COD	mg/l	60.0	40	100
5	BOD @ 27 °C	mg/l	21.0	12.0	30

Table 29: Sewage Water Monitoring at Vadinar STP (2nd Week)

Date of Sampling	10.10.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar STP O/L	
1	pH	-	7.45	7.33	6.5 - 8.5
2	Total Suspended Solids	mg/l	88.1	36.6	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	80	20	100
5	BOD @ 27 °C	mg/l	23.0	6.0	30

Table 30: Sewage Water Monitoring at Vadinar STP (3rd Week)

Date of Sampling	17.10.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar O/L	
1	pH	-	7.54	7.32	6.5 - 8.5
2	Total Suspended Solids	mg/l	100	41.8	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	90	60	100
5	BOD @ 27 °C	mg/l	30.0	18.0	30

Table 31: Sewage Water Monitoring at Vadinar STP (4th Week)

Date of Sampling	28.10.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar STP O/L	
1	pH	-	7.54	7.36	6.5 - 8.5
2	Total Suspended Solids	mg/l	88.1	39.5	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	70	30	100
5	BOD @ 27 °C	mg/l	20.0	8.0	30

Table No. 32. General Standards for discharge of Environmental Pollutant Part-A

Sr. No.	Parameter	Inland Surface Water	Land Irrigation	Marine Coastal Areas
1.	pH	5.5-9.0	5.5-9.0	5.5-9.0
2.	Total Suspended Solids (mg/l)	100	200	100
3.	Residual Chlorine (mg/l)	1.0	-	1.0
4.	BOD (mg/l)	30	100	100
5.	COD (mg/l)	250	-	250

Sources:-CPCB

7.3 Results & Discussion

The STP Sample carried out to evaluate the efficiency and performance of the wastewater treatment plant at Gopalpuri, Kandla and Vadinar STP. The performance of these plants is an essential parameter to monitor because the treated sewage water is discharged for irrigation purposes and discharge into marine. Wastewater samples were collected from different unit operations of the plant i.e, the inlet, aeration tank and the final treated outlet. These samples were analyzed for various physico-chemical characteristics such as pH, TSS, Residual Chlorine, COD, BOD, MLSS and MLVS. The sampling of Gopalpuri STP was not done as per STP monitoring plan 1st Week dated 01.10.2022 and 2nd Week Dated 10.10.2022 as it was under construction.

- The final treated outlet observed pH values were within the allowed range at STP Gopalpuri, STP Kandla & STP Vadinar ranged from 7.28 -7.32, 7.23-7.35 & 7.21-7.36 respectively. The wastewater treatment makes it suitable for irrigation. These values are below the allowed limit of the GPCB.
- The final treated outlet observed Total suspended solid values at Gopalpuri, DPA Kandla & Vadinar ranged from 41.80-42.10 mg/l, 37.50-59.90 mg/l & 36.60-41.80 mg/l respectively. These values are below the allowed limit of the GPCB.
- The final treated outlet observed Residual Chlorine values were <0.5 at Gopalpuri, DPA Kandla & Vadinar. These values are below the allowed limit of the CPCB.

- The final treated outlet observed COD values were at Gopalpuri, DPA Kandla & Vadinar ranged from 40.0-40.0 mg/l, 26.0-40.0 mg/l & 20.0-60.0 mg/l respectively. These values are below the allowed limit of the CPCB.
- The main focus of wastewater treatment plants is supposed to reduce the BOD in the effluent discharged to natural waters. Wastewater treatment plants are designed to function as bacteria farms, where bacteria are fed oxygen and organic waste. The final treated outlet observed BOD values were at Gopalpuri, DPA Kandla & Vadinar ranged from 11.0-12.0 mg/l, 8.0-11.0 mg/l & 6.0-18.0 mg/l respectively. These values are below the allowed limit of the CPCB. .

7.4 Conclusions:

All parameters for STP outlet are within limit prescribed by CPCB. After the final treatment, it is found that the treated water is satisfactory.

8.0 Marine Water Monitoring

Marine Water Quality

The Forty Second Amendment to the Constitution in 1976 underscored the importance of 'green thinking'. Article 48A enjoins the state to protect and improve the environment and safeguard the forests and wildlife in the country. Further, Article 51A (g) states that the "fundamental duty of every citizen is to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures".

Policy Statement for Abatement of Pollution (1992) has suggested developing relevant legislation and regulation, fiscal incentives, voluntary agreements and educational programs and information campaigns. It emphasizes the need for integration by incorporating environmental considerations into decision making at all levels by adopting frameworks namely, pollution prevention at source, application of best practicable solution, ensure polluter pays for control of pollution, focus on heavily polluted areas and river stretches and involve public in decision-making. The National Conservation Strategy and Policy Statement on Environment and Development, (1992) aimed at "integrating environmental concerns with developmental imperatives to meet the challenges by redirecting the thrust of our developmental process so that the basic needs of our people could be fulfilled by making judicious and sustainable use of natural resources." The priorities mentioned in this policy document include the sustainable use of land and water resources, prevention and control of pollution and preservation of biodiversity.

The National Water Policy, (2002) contains provisions for developing, conserving, sustainable utilizing and managing this important water resources and need to be governed by national perspectives.

Sampling Stations

The monitoring of marine environment for the study of biological and ecological parameters was carried out on 05th & 06th October-2022 in harbor regions of DPA & Vadinar during Neap tide period of New moon phase of Lunar Cycle. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 12th & 16th October-2022 in harbor regions of DPA & Vadinar during Spring tide period first quarter of Lunar Cycle.

Plankton samples from sub surface layer was collected both during high tide period and low tide period from 3 water quality monitoring stations of DPA harbor area and two stations in Nakti creek and one station in Khori creek. The same sampling schedule was repeated during consecutive spring tide and neap tide in same month. Plankton samples from sub surface layer was collected both during high tide period and low tide period from 1 water quality monitoring stations near Vadinar jetty area during spring tide and neap tide in this month. Collected water samples were processed for estimation

of Chlorophyll- a, Pheophytin- a, qualitative & quantitative evaluation of phytoplankton, qualitative & quantitative evaluation zooplanktons (density and their population).

Sampling Locations

Offshore monitoring requirement	Number of locations
Offshore Installations	3 in Kandla creek 2 in Nakti creek 1 in Khori creek 1 near Vadinar Jetty 1 near 1st SBM
Total Number of locations	**8**

8.1 Marine Water Quality and Results

Marine water quality of marine waters of Deendayal Port Harbor waters, Khori & Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each month. The results of marine water quality from table no 33 to 40. During low tide DPA-6 Nakti-II location monitoring was not possible due to non-availability of marine water.

Table 33: Marine Water Quality Monitoring Parameters for Location Near DPA Colony

Sr. No.	Parameters	Unit	Kandla Creek Near DPA Colony (1)			
			23°0'58"N 70°13'22."E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.44	7.38	7.51	7.42
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	31.9	32.0	35.3	34.9
5	Turbidity	NTU	49	43	52	48
6	Total Dissolved Solids	mg/l	31916	30489	30236.0	31682.0
7	Total Suspended Solids	mg/l	568	537	532.9	629.5
8	Total Solids	mg/l	32484	31026	30768.9	32311.5
9	DO	mg/l	5.9	5.8	5.6	5.4
10	COD	mg/l	94.0	82.0	90.0	89.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	1.46	1.36	1.76	1.89
13	Phosphate	mg/l	0.30	0.30	0.21	0.20
14	Sulphate	mg/l	3262	3362	3019	2713
15	Nitrate	mg/l	4.28	1.52	2.60	2.83
16	Nitrite	mg/l	BQL	BQL	0.018	0.015
17	Calcium	mg/l	641.28	721.44	601.2	681.36
18	Magnesium	mg/l	1676.7	1676.7	1628.1	1603.8
19	Sodium	mg/l	7269.0	7901.0	7380.0	8302.0
20	Potassium	mg/l	310.9	336.1	330.0	346.0
21	Iron	mg/l	2.24	BQL	BQL	0.1
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	0.1	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 34: Marine Water Quality Monitoring Parameters for Location Near Passenger Jetty One at Kandla

Sr. No.	Parameters	Unit	Near passenger Jetty One (2)			
			23° 0'18 "N 70°13'31"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.53	7.45	7.38	7.45
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	32.8	31.9	33.9	33.5
5	Turbidity	NTU	46	41	47	43
6	Total Dissolved Solids	mg/l	35931	34021	36225.0	32423.0
7	Total Suspended Solids	mg/l	591	491	664.5	601.3
8	Total Solids	mg/l	36522	34512	36889.5	33024.3
9	DO	mg/l	5.6	5.3	5.5	5.7
10	COD	mg/l	96.0	106.0	92.0	96.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	1.45	1.67	1.37	1.86
13	Phosphate	mg/l	0.60	0.18	0.11	0.24
14	Sulphate	mg/l	2940	2628	2782	2690
15	Nitrate	mg/l	1.02	0.51	2.89	2.81
16	Nitrite	mg/l	BQL	BQL	0.021	0.019
17	Calcium	mg/l	601.20	641.28	761.52	721.44
18	Magnesium	mg/l	1773.9	1701	1603.8	1676.7
19	Sodium	mg/l	7771.0	7544.0	8076.0	7645.0
20	Potassium	mg/l	355.8	329.2	329.0	327.0
21	Iron	mg/l	BQL	BQL	BQL	BQL
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Nitrite: 0.05mg/lCu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 35: Marine Water Quality Monitoring Parameters for location Near Coal Berth

Sr. No.	Parameters	Unit	Near Coal Berth			
			22°59'12"N 70°13'40"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.38	7.27	7.52	7.37
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	33.0	33.8	35.3	33.9
5	Turbidity	NTU	47	46	43	40
6	Total Dissolved Solids	mg/l	37001	32999	38933.0	40080.0
7	Total Suspended Solids	mg/l	529	580	562.9	625.5
8	Total Solids	mg/l	37530	33579	39495.9	40705.5
9	DO	mg/l	5.4	5.6	5.4	5.3
10	COD	mg/l	86.0	94.0	76.0	70.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	1.36	1.54	1.96	1.80
13	Phosphate	mg/l	0.33	0.64	0.48	0.11
14	Sulphate	mg/l	2429	1628	2529	1651
15	Nitrate	mg/l	0.94	3.56	2.46	2.83
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	721.44	561.12	601.2	641.28
18	Magnesium	mg/l	1603.8	1652.4	1725.3	1652.4
19	Sodium	mg/l	8752.0	8590.0	8658.0	8592.0
20	Potassium	mg/l	326.5	251.8	319.0	314.0
21	Iron	mg/l	BQL	1.68	0.1	1.2
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 36: Marine Water Quality Monitoring Parameters for location Khori creek at Kandla

Sr. No.	Parameters	Unit	Khori creek			
			Near 15/16 Berth			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.51	7.55	7.47	7.25
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	33.6	33.2	33.5	33.0
5	Turbidity	NTU	41	38	41	39
6	Total Dissolved Solids	mg/l	30317	32240	35060.0	42810.0
7	Total Suspended Solids	mg/l	496	513	541.9	580.6
8	Total Solids	mg/l	30813	32753	35601.9	43390.6
9	DO	mg/l	5.5	5.7	5.5	5.7
10	COD	mg/l	68.0	60.0	85.0	82.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	1.36	1.62	1.80	1.61
13	Phosphate	mg/l	0.46	0.48	0.41	0.58
14	Sulphate	mg/l	1920	2204	1940	2046
15	Nitrate	mg/l	1.60	2.32	2.81	2.67
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	521.04	601.20	681.36	761.52
18	Magnesium	mg/l	1701	1701	1603.8	1603.8
19	Sodium	mg/l	8162.0	8150.0	8067.0	8323.0
20	Potassium	mg/l	313.9	304.2	304.0	310.0
21	Iron	mg/l	0.96	1.04	0.1	1.4
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 37: Marine Water Quality Monitoring Parameters for location Nakti Creek near Tuna Port

Sr. No.	Parameters	Unit	Nakti Creek Near Tuna Port			
			22°57'49."N 70° 7'0.67"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.48	7.36	7.31	7.28
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	33.6	32.9	35.3	33.9
5	Turbidity	NTU	47	41	43	38
6	Total Dissolved Solids	mg/l	39489	37081	34974.0	31295.0
7	Total Suspended Solids	mg/l	610	566	695.3	667.4
8	Total Solids	mg/l	40099	37647	35669.3	31962.4
9	DO	mg/l	5.5	5.3	5.8	5.5
10	COD	mg/l	110.0	109.0	90.0	88.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	1.38	1.76	1.78	1.61
13	Phosphate	mg/l	0.42	0.13	0.91	0.46
14	Sulphate	mg/l	2392	2691	2116	2494
15	Nitrate	mg/l	4.21	1.16	2.89	2.46
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	561.12	681.36	601.2	561.12
18	Magnesium	mg/l	1749.6	1701	1749.6	1798.2
19	Sodium	mg/l	7926.0	7840.0	8704.0	8444.0
20	Potassium	mg/l	299.9	324.6	325.0	321.0
21	Iron	mg/l	0.57	BQL	BQL	0.1
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 38: Marine Water Quality Monitoring Parameters for location Nakti Creek Near NH-8A at Kandla

Sr. No.	Parameters	Unit	Nakti Creek Near NH-8A			
			23° 02'01"N 70° 09'31"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.32	Sampling not possible during Low Tide	7.32	Sampling not possible during Low Tide
2	Color	-	Agreeable		Agreeable	
3	Odor	-	Agreeable		Agreeable	
4	Salinity	‰	34.0		34.4	
5	Turbidity	NTU	46		42	
6	Total Dissolved Solids	mg/l	37870		43337.0	
7	Total Suspended Solids	mg/l	625		682.7	
8	Total Solids	mg/l	38495		44019.7	
9	DO	mg/l	5.7		5.7	
10	COD	mg/l	109.0		92.0	
11	BOD	mg/l	BQL		BQL	
12	Silica	mg/l	1.81		1.47	
13	Phosphate	mg/l	0.35		0.58	
14	Sulphate	mg/l	2898		2344	
15	Nitrate	mg/l	3.19		2.81	
16	Nitrite	mg/l	BQL		BQL	
17	Calcium	mg/l	761.52		681.36	
18	Magnesium	mg/l	1603.8		1652.4	
19	Sodium	mg/l	7280.0		7795.0	
20	Potassium	mg/l	325.0		348.0	
21	Iron	mg/l	BQL		1.1	
22	Chromium	mg/l	BQL		BQL	
23	Copper	mg/l	BQL		BQL	
24	Arsenic	mg/l	BQL		BQL	
25	Cadmium	mg/l	BQL		BQL	
26	Mercury	mg/l	BQL		BQL	
27	Lead	mg/l	BQL		BQL	
28	Zinc	mg/l	BQL		BQL	

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 39: Marine Water Quality Monitoring Parameters for locations Nr. Vadinar Jetty

Sr. No.	Parameters	Unit	Nr.Vadinar Jetty			
			22°26'25.26"N 69°40'20.41"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.42	7.31	7.42	7.31
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	32.8	32.1	33.5	33.0
5	Turbidity	NTU	42	48	45	37
6	Total Dissolved Solids	mg/l	30232	32299	31650.0	26111.0
7	Total Suspended Solids	mg/l	511	604	525.6	518.2
8	Total Solids	mg/l	30743	32903	32175.6	26629.2
9	DO	mg/l	5.3	5.1	5.4	5.3
10	COD	mg/l	94.0	90.0	94.0	98.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	1.56	1.44	1.56	1.44
13	Phosphate	mg/l	0.04	0.04	0.43	0.38
14	Sulphate	mg/l	3412	2843	3412	2843
15	Nitrate	mg/l	1.45	2.32	3.92	2.55
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	721.44	601.20	641.28	601.2
18	Magnesium	mg/l	1603.8	1628.1	1652.4	1725.3
19	Sodium	mg/l	7797.0	7368.0	7112.0	6960.0
20	Potassium	mg/l	321.0	348.0	326.1	320.0
21	Iron	mg/l	0.11	0.05	0.2	0.4
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 40: Marine Water Quality Monitoring Parameters for locations Nr. Vadinar SPM

Sr. No.	Parameters	Unit	Nr. Vadinar SPM			
			22°30'56.15"N 69°42'12.07"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.27	7.33	7.36	7.23
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	32.2	31.9	31.7	30.8
5	Turbidity	NTU	32	38	47	41
6	Total Dissolved Solids	mg/l	28887	31949	28106.0	29489.0
7	Total Suspended Solids	mg/l	531	510	530.7	607.2
8	Total Solids	mg/l	29418	32459	28636.7	30096.2
9	DO	mg/l	4.9	4.7	5.4	5.2
10	COD	mg/l	92.0	104.0	100.0	98.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	1.60	1.52	1.60	1.52
13	Phosphate	mg/l	0.06	0.06	0.62	0.55
14	Sulphate	mg/l	3125	2834	3125	2834
15	Nitrate	mg/l	0.73	0.36	3.62	3.07
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	521.04	681.36	721.44	641.28
18	Magnesium	mg/l	1749.6	1603.8	1676.7	1749.6
19	Sodium	mg/l	7683.0	7305.0	8478.0	8284.0
20	Potassium	mg/l	307.0	336.0	355.0	310.0
21	Iron	mg/l	BQL	BQL	BQL	BQL
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l)

8.2 Results & Discussion for Marine water samples

Marine water quality of Deendayal Port Harbor waters, Khori and Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each month. The Heavy metal analyzed and found below quantification limit.

pH

During spring tide the pH values was ranged from 7.27-7.55 at DPA Kandla and 7.27-7.42 at Vadinar while during Neap Tide pH values was ranged from 7.25-7.52 at DPA Kandla and 7.31-7.42 at Vadinar.

Color and Odor

All marine samples for Odor and Color were found agreeable at all sampling locations.

Turbidity

During spring tide the Turbidity values was ranged from 38-49 NTU at DPA Kandla and 32-48 NTU at Vadinar while during Neap Tide Turbidity values was ranged from 38-52 NTU at DPA Kandla and 37-47 NTU at Vadinar. Turbidity is the amount of particulate matter that is suspended in water. Turbidity measures the scattering effect that suspended solids have on light: the higher the intensity of scattered light, the higher the turbidity (Yap et al, 2011). Materials that cause water to be turbid include clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, plankton and microscopic organisms (Lawler, 2004).

Total Dissolved Solids (TDS)

TDS values in the studied area during Spring Tide varied between 30317- 39489 mg/l at DPA Kandla and 28887- 32299 mg/l at Vadinar while during Neap Tide TDS values was varied 30236-43337 mg/l at DPA Kandla and 26111-43337 mg/l at Near Vadinar.

Calcium

Calcium value in the studied area during Spring Tide varied between 521.04-761.52 mg/l at DPA Kandla and 521.04-721.44 mg/l at Vadinar while during Neap Tide calcium values between 561.12-761.52 mg/l at DPA Kandla and 601.20-721.44 mg/l at Vadinar.

Magnesium

Magnesium value in the studied area during Spring Tide varied between 1603.80-1773.90 mg/l at DPA Kandla and 1603.80-1749.60 mg/l at Vadinar while during Neap Tide magnesium values between 1603.80-1798.20 mg/l at DPA Kandla and 1652.4 -1749.60 at Vadinar. Calcium and magnesium both play an important role in antagonizing the toxic effects of various ions and neutralizing the excess acid produced (Narayan R. et. al., 2007)

Nitrate

Nitrate value in the studied area during Spring Tide varied between 0.51-4.28 mg/l at DPA Kandla and 0.36-2.32 mg/l at Vadinar while during Neap Tide Nitrate values between 2.46-2.89 mg/l at DPA Kandla and 2.55-3.92 at Vadinar.

The variations were observed due to variation in phytoplankton excretion, oxidation of ammonia, reduction of nitrate and by recycling of nitrogen and bacterial decomposition of planktonic detritus (Asha and Diwakar, 2007).

Iron

Iron values in the studied area during Spring Tide ranged from 0.57-2.24 mg/l at DPA Kandla and 0.05-0.11mg/l at Vadinar while during Neap Tide ranged from 0.05-0.11 mg/l while during Neap Tide the iron values was varied 0.06-1.40 mg/l at DPA Kandla and 0.19 to 0.36 mg/l at Vadinar.

Sulphates

Sulphate values in the studied area during Spring Tide ranged from 1628.0-3362.0 mg/l at DPA Kandla and 2834.0- 3412.0 mg/l at Vadinar while during Neap Tide the Sulphate values was varied 1651.0-3019.0 mg/l at DPA Kandla and 2834.0 -3412.0 mg/l at Vadinar.

Salinity

Salinity values in the studied area during Spring Tide varied ranged 31.90 to 34.00 ‰ at DPA Kandla and 31.90 to 32.80 ‰ at Vadinar while during Neap Tide the Salinity values was varied 33.00 to 35.33 ‰ at DPA Kandla and 31.69 to 34.40 ‰ at Vadinar.

Sodium and Potassium Salts

During Spring Tide the Sodium values ranged from 7269.0-8752.0 mg/l at DPA Kandla & 7305.0-7797.0 mg/l at Vadinar and Potassium salts ranged from 251.80-355.80 mg/l at DPA Kandla & 307.0-348.0 mg/l at Vadinar while during Neap Tide the Sodium values was

ranges from 7380.0-8704.0 mg/l at DPA Kandla & 6960.0-8478.0 mg/l at Vadinar and Potassium salts ranged from 304.0-348.0 mg/l at DPA Kandla & 310.0-355.0 mg/l at Vadinar.

DO

The DO refers to the amount of oxygen dissolved in the water and it is particularly important in limnology {(aquatic ecology) (Weiss 1970)}. The fate and behavior of DO is of critical importance to marine organisms in determining the severity of adverse impacts (Best et al. 2007). The major factor controlling dissolved oxygen concentration is biological activity: photosynthesis producing oxygen while respiration and nitrification consume oxygen (Best et al. 2007). From the studied samples, DO in marine water during Spring Tide was found in ranges from 5.3-5.9 mg/l at DPA Kandla and 4.7-5.3 mg/l at Vadinar while during Neap Tide 5.3-5.8 mg/l at DPA Kandla and 5.2-5.4 mg/l at Vadinar.

BOD

BOD in marine water at all sampling location in the studied samples were found <2.0 mg/l.

Heavy Metals in Marine Water

In the present study period marine water samples were analyzed for Cr, Cu, Cd, As, Hg, Pb and Zn. All these heavy metals were well Below the Quantification limits prescribed by the Indian Standards.

9.3 Conclusion

In the present study period marine water samples were analyzed and found inline as per Primary Water Quality criteria for class-IV WATERS (For Harbour Waters).

9.0 Marine Sediments

The deep-sea ocean floor is made up of sediment. This sediment is composed of tiny particles such as fine sand, silt, clay, or animal skeletons that have settled on the ocean bottom. Over long periods of time, some of these particles become compressed and form stratified layers. Scientists that study these layers look at particle size, particle composition, and origin to help them create historical records of the deep ocean floor. This process is called weathering. Weathering can be either mechanical or chemical. Mechanical weathering can occur as ice, wind, or water wears away the rock's surface. Chemical weathering can occur as rocks are dissolved by a chemical such as acid rain. The particles created as a result of weathering are called terrigenous sediments. These particles are transported to the ocean by wind and by rivers and streams. Once the particles enter the ocean, they are dispersed by waves, currents, and tides. The heaviest and largest particles that reach the oceans, such as sand, settle very quickly to the bottom as a result of gravity. Sand is deposited near the coast whereas the smaller silt and clay particles are transported farther distances offshore before they settle to the bottom. Sediments are an important component of aquatic ecosystems because they provide nutrients and habitat for aquatic organisms (Benhamed et al. 2016). However, human activities result in accumulation of toxic substances such as heavy metals in marine sediments. Heavy metals are well-known environmental pollutants due to their toxicity, persistence in the environment, and bioaccumulation. Metals affect the ecosystem because they are not removed from water by self-purification, but accumulate in sediments and enter the food chain (Astakhov et al. 2015).

Sediment samples were collected with Van Veen Grab from the six locations in Kandla Port Waters and two locations in Vadinar Port. Benthic surface grab samplers look like giant metal jaws. They dig into the bottom and take a bite of the sediment. These samplers are good for collecting softer, sandy or silty sediments that do not contain rocks. A box corer is a cross between a surface sampler and a sediment corer. It is a special device that is used to collect an undisturbed sample of the very top surface layers and the sediment underneath. Samples were collected and preserved in silver foil in ice box to prevent the contamination/decaying of the samples.

10.1 Results

The Sediment Quality results are given in below from table no. 41 & 42.

Table 41: Results of Analysis of Sediment of Kandla & Vadinar Port (Neap Tide)

Sr. No.	Parameters	Unit	DPA – 1	DPA - 2	DPA - 3	DPA - 4	DPA - 5	Jetty	SPM
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	0.19	16.9	3.3	21.7	6.11	23.70	36.68
3	Organic Carbon	mg/kg	0.11	9.75	1.95	12.4	3.51	13.65	21.06
4	Inorganic Phosphate	mg/kg	89.00	84.00	99.00	78.00	105.00	99.00	102.00
5	Moisture	%	17.70	16.34	16.20	18.25	13.34	15.67	14.80
6	Aluminum	mg/kg	ND	ND	ND	ND	ND	ND	ND
7	Silica	mg/kg	6.68	8.34	8.90	4.87	11.82	9.43	13.52
8	Phosphate	mg/kg	768.00	680.00	712.00	889.00	598.00	513.00	634.00
9	Sulphate	mg/kg	724.00	618.00	529.00	489.00	501.00	734.00	534.00
10	Nitrite	mg/kg	0.13	0.09	0.08	0.14	0.13	0.10	0.11
11	Nitrate	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
12	Calcium	mg/kg	761.00	7402.00	861.00	1823.00	1042.00	1322.00	1663.00
13	Magnesium	mg/kg	437.00	1239.00	486.00	1336.00	656.00	1530.00	1615.00
14	Sodium	mg/kg	344.4	2718.6	972.5	3079.8	1762.3	5205.00	615.00
15	Potassium	mg/kg	41.30	414.20	55.70	518.70	165.20	3073.0	2904.0
16	Chromium	mg/kg	BQL	10.60	13.10	12.90	10.90	15.35	22.36
17	Nickel	mg/kg	BQL	12.20	9.90	10.80	7.50	11.35	15.24
18	Copper	mg/kg	BQL	BQL	BQL	7.20	BQL	21.24	16.53
19	Zinc	mg/kg	BQL	12.60	6.70	14.40	5.30	18.25	23.65
20	Cadmium	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
21	Lead	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
22	Mercury	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
23	Arsenic	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL

*ND - Not Detected, BQL: Below Quantification Limit (NO3:10.0mg/kg, Cd: 1.0mg/kg, Hg: 1.0mg/kg, As: 1.0mg/kg).

Table 42 : Results of Analysis of Sediment of Kandla & Vadinar Port (Spring Tide)

Sr. No.	Parameters	Unit	DPA – 1	DPA - 2	DPA - 3	DPA - 4	DPA - 5	Jetty	SPM
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	0.43	0.25	0.64	0.43	0.90	0.86	0.79
3	Organic Carbon	mg/kg	0.25	0.14	0.37	0.25	0.25	0.49	0.45
4	Inorganic Phosphate	mg/kg	104.00	99.25	85.00	83.00	122.00	86.00	92.00
5	Moisture	%	23.25	13.36	15.42	19.52	21.34	22.59	18.18
6	Aluminum	mg/kg	ND	ND	ND	ND	ND	ND	ND
7	Silica	mg/kg	6.78	8.15	9.12	7.11	8.89	8.80	8.98
8	Phosphate	mg/kg	11.23	14.49	18.16	10.07	10.45	474.00	797.00
9	Sulphate	mg/kg	857.00	798.00	815.00	940.00	680.00	842.00	380.00
10	Nitrite	mg/kg	0.15	0.13	0.09	0.14	0.16	0.10	0.12
11	Nitrate	mg/kg	1.11	3.8	19.01	26.6	36.1	3.65	0.87
12	Calcium	mg/kg	1302.00	3647.00	1422.00	1262.00	1442.00	2024.00	1943.00
13	Magnesium	mg/kg	1251.00	328.00	1081.00	583.00	862.00	1956.00	2272.00
14	Sodium	mg/kg	5439.00	8044.30	14361.00	1717.00	3286.00	463.44	445.10
15	Potassium	mg/kg	419.5	555.7	461.8	373.8	487.4	453.48	111.27
16	Chromium	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
17	Nickel	mg/kg	11.56	10.25	9.98	18.45	21.63	14.25	16.87
18	Copper	mg/kg	BQL	BQL	BQL	BQL	BQL	11.25	17.33
19	Zinc	mg/kg	11.24	12.65	BQL	5.47	BQL	25.42	21.56
20	Cadmium	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
21	Lead	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
22	Mercury	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
23	Arsenic	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL

*ND - Not Detected, BQL: Below Quantification Limit (NO3:10.0 mg/kg,Cd: 1.0 mg/kg, Hg: 1.0mg/kg, As: 1.0mg/kg)

9.2 Discussion of Marine Sediment samples

Marine Sediments of Deendayal Port Harbor waters, Khori and Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each month. The Heavy metal analyzed and found below quantification limit.

9.3 Conclusion

The sediment types are majority Sandy loamy. Also all heavy metals found below Quantification limit wise Al, Pb, Cd, Hg , As and Nitrate for some locations.

10.0 INTRODUCTION:

10.1 Sampling Stations:

The monitoring of marine environment for the study of biological and ecological Parameters was carried out on 03rd October 2022 in harbour region of DPA at Kandla Creek, and on 04th October 2022 in creeks near by the port during Neap tide. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 10th October, 2022 in harbour region of DPA at Kandla Creek and on11th October, 2022 in creeks near by the port during spring tidal condition.

Plankton samples from sub surface layer was collected both during high tide period and low tide period from 3 water quality monitoring stations of KPT harbour area and two stations in Nakti creek and one station in Khori creek. Sampling at second sampling station of Nakti creek was possible only during high tide period.

Plankton samples from sub surface layer were collected during high tide period and low tide period from monitoring station near Vadinar jetty at Path Finder Creek during Neap tide on 03/10/2022 and Spring tide period on 10/10/2022. Collected water samples were processed for estimation of Chlorophyll- a, Pheophytin- a, qualitative and quantitative evaluation of phytoplankton, qualitative and quantitative evaluation of zooplankton density and their population.

TABLE 43. SAMPLING LOCATIONS

monitoring requirement	**Number of locations**
Kandla creek	3 in Kandla creek
Nakti creek	2 in Nakti creek
Khori Creek	1 in Khori creek
Vadinar jetty	1 near Vadinar Jetty
SPM	1 near I stSPM
Total Number of locations	**8**

Sampling methodology adopted:

A marine sampling is an estimation of the body of information in the population. The theory of the sampling design is depending upon the underlying frequency distribution of the population of interest. The requirement for useful water sampling is to collect a representative sample of suitable volume from the specified depth and retain it free from contamination during retrieval.

50 litres of the water sample were collected from Sub surface by using bucket. From the collected water sample 1 litres of water sample was taken in an opaque plastic bottle for chlorophyll estimation, thereafter plankton samples were collected by using filtration assembly with Nylobolt cloth of 20µm mesh size. . During low tide DPA-6 Nakti-II location monitoring was not possible due to non-availability of marine water.

Samples Processing for chlorophyll estimation:

Samples for chlorophyll estimation were preserved in ice box on board in darkness to avoid degradation in opaque container covered with aluminium foil. Immediately after reaching the shore after sampling, 1 litre of collected water sample was filtered through GF/F filters (pore size 0.45 µm) by using vacuum filtration assembly. After vacuum filtration the glass micro fiber filter paper was grunted in tissue grinder, macerating of glass fiber filter paper along with the filtrate was done in 90% aqueous Acetone in the glass tissue grinder with glass grinding tube. Glass fiber filter paper will assist breaking the cell during grinding and chlorophyll content was extracted with 10 ml of 90% Acetone, under cold dark conditions along with saturated magnesium carbonate solution in glass screw cap tubes. After an extraction period of 24 hours, the samples were transferred to calibrated centrifuge tubes and adjusted the volume to original volume with 90% aqueous acetone solution to make up the evaporation loss. The extract was clarified by using centrifuge in closed tubes. The clarified extracts were then decanted in clean cuvette and optical density was observed at wavelength 664, 665 nm. By using corrected optical density, Chlorophyll-a value was calculated as given in (APHA, 2017).

PLANKTON:

The entire area open water in the sea is the pelagic realm. Pelagic organisms live in the open sea. In contrast to the pelagic realm, the benthic realm comprises organisms and zone of the bottom of the sea. Vertically the pelagic realm can be dividing into two zones based on light penetration; upper photic or euphotic zone and lower dark water mass, aphotic zone below the photic zone.

The term plankton is a general term for organisms which have such limited powers of locomotion that they are at the mercy of the prevailing water movement. Plankton is subdivided to phytoplankton and zooplankton. Phytoplanktons are free floating organisms that are capable of photosynthesis and zooplankton is the various free-floating animals.

Pelagic zone, represents the entire ocean water column from the surface to the deepest depths, is home to a diverse community of organisms. Differences in their locomotive ability categorize the organisms in the pelagic realm into two, ***plankton*** and ***nekton*** (Lalli and Parsons, 1997). ***Plankton*** consists of all organisms drifting in the water and is unable to swim against water currents, whereas ***Nekton*** includes organisms having strong locomotive power. Ecological studies on the plankton community, which form the base of the aquatic food chain, help in the better understanding of the dynamics and

functioning of the marine ecosystem. The term 'Plankton' first coined by Victor Hensen (1887), Plankton, (Greek word: *planktos*meaning "passively drifting or wandering") is defined as drifting or free-floating organisms that inhabit the pelagic zone of water. Based on their mode of nutrition planktonic organisms are categorised into phytoplankton (organisms having an autotrophic mode of nutrition) and zooplankton (organisms having a heterotrophic mode of nutrition).

Phytoplankton in the marine environment:

Phytoplanktons are free floating unicellular, filamentous and colonial eutrophic organisms that grow in aquatic environments whose movement is more or less dependent upon water currents. These micro flora acts as primary producers as well as the basis of food chain, source of protein, bio-purifier and bio-indicators of the aquatic ecosystems of which diverse array of the life depends .They are considered as an important component of aquatic flora, play a key role in maintaining equilibrium between abiotic and biotic components of aquatic ecosystem.

The phytoplankton includes a wide range of photosynthetic and phototrophic organisms. Marine phytoplankton is mostly microscopic and unicellular floating flora, which are the primary producers that support the pelagic food-chain. The two most prominent groups of phytoplankton are Diatoms (Bacillariophyceae) and Dinoflagellates (Dinophyceae).The phytoplankton those normally captured in the net from the Gulf of Kutch is normally dominated by these two major groups; Diatoms and Dinoflagellates. Phytoplankton also include numerous and diverse collection of extremely small, motile algae which are termed micro flagellates (naked flagellates) as well as and Cyanophytes (Blue-green algae).

Algae are an ecologically important group in most aquatic ecosystems and have been an important component of biological monitoring programs. Algae are ideally suited for water quality assessment because they have rapid reproduction rates and very short life cycles, making them valuable indicators of short-term impacts.

Aquatic populations are impacted by anthropogenic stress, resulting in a variety of alterations in the biological integrity of aquatic systems. Algae can serve as an indicator of the degree of deterioration of water quality, and many algal indicators have been used to assess environmental status.

Zooplankton in the marine environment:

Zooplankton includes a taxonomically and morphologically diverse community of heterotrophic organisms that drift in the waters of the world's oceans. Qualitative and quantitative studies on zooplankton community are a prerequisite to delineate the ecological processes active in the marine ecosystem. Zooplankton community plays a pivotal role in the pelagic food web as the primary consumers of phytoplankton and act as the food source for organisms in the higher trophic levels, particularly the economically essential groups such as fish larvae and fishes. They also function in the cycling of elements in the marine ecosystem. The dynamics of the zooplankton community, their reproduction, and growth and survival rate are all significant factors determining the recruitment and

abundance of fish stocks as they form an essential food for larval, juvenile and adult fishes (Beaugrand et al., 2004). Zooplankton grazing in the marine environment controls the primary Production and helps in determining the pelagic ecosystem (Banse, 1995). Through grazing in surface waters and following the production of sinking faecal matters and also by the active transportation of dissolved and particulate matter to deeper waters via vertical migration, they help in the transport of organic carbon to deep ocean layers and thus act as key drivers of 'biological pump' in the marine ecosystem. Zooplankton grazing and metabolism also, transform particulate organic matter into dissolved forms, promoting primary producer community, microbial demineralization, and particle export to the ocean's interior.

The categorisation of zooplankton into various ecological groups is based on several factors such as duration of planktonic life, size, food preferences and habitat. As they vary significantly in size from microscopic to metazoic forms, the classification of zooplankton based on size has paramount importance in the field of quantitative plankton research.

Based on the duration of planktonic life, zooplankton are categorised into Holoplankton (organisms which complete their entire lifecycle as plankton) and Meroplankton (organisms which are planktonic during the early part of their lives such as the larval stages of benthic and nektonic organisms). Tychoplankton are organisms which live a brief planktonic life, such as the benthic crustaceans (Cumaceans, mysids, isopods) which ascend to the water column at night for feeding and certain ectoparasitic copepods, they leave the host and spend their life as plankton during their breeding cycle.

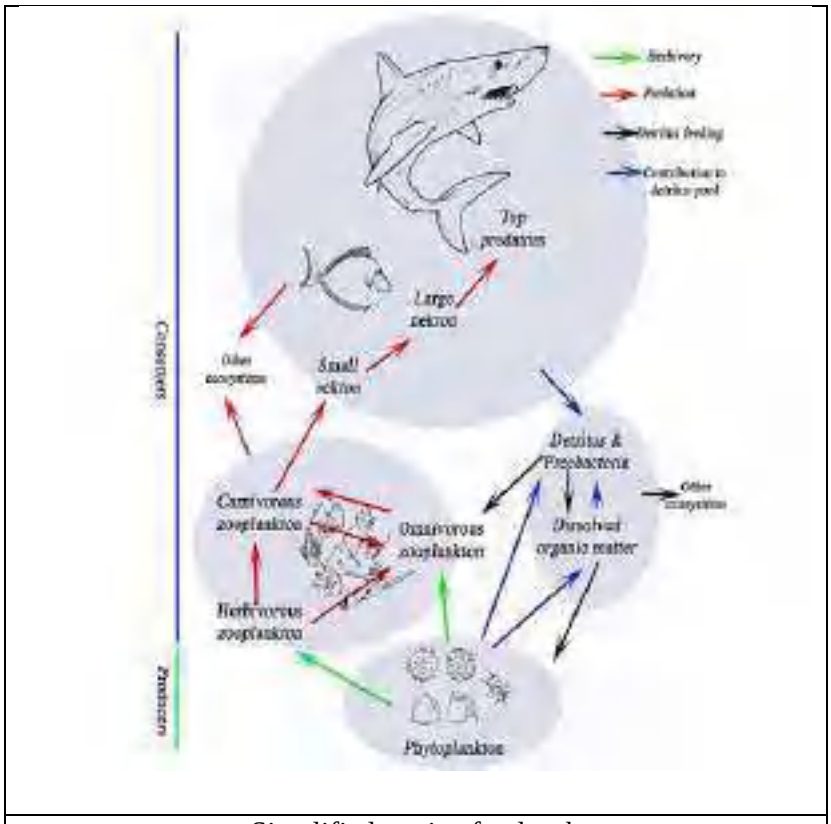
Zooplankton can be subdivided into holoplankton, i.e., permanent members of the plankton (e.g., Calanoid copepods), and meroplankton, i.e., temporary members in the plankton e.g., larvae of fish, shrimp, and crab). The meroplankton group consists of larval and young stages of animals that will adopt a different lifestyle once they mature. In contrast to phytoplankton which consist of a relatively smaller variety of organisms, Zooplankton are extremely divers, consist of a host of larval and adult forms representing many animal phylum.

Among the zooplankton one group always dominate than others; members of sub class copepods (Phylum Athropoda) and Tintinids (Phylum Protozoa) among the net planktons. These small animals are of vital importance in marine ecosystem as one of the primary herbivores animals in the sea, and it is they provide vital link between primary producer (autotrophs) and numerous small and large marine consumers.

As their community structure and function are highly susceptible to changes in the environmental conditions regular monitoring of their distribution as well as their interactions with various physicochemical parameters is inevitable for the sustainable management of the ecosystem (Kusum et al., 2014). Of all the marine zooplankton groups, copepods mainly Calanoid copepods are the

dominant groups in marine subtropical and tropical waters and exhibit considerable diversity in morphology and habitats they occupy (Madhupratap, 1991 ;)

It has been well established that potential of pelagic fishes viz. finfishes, crustaceans, molluscs and marine mammals either directly or indirectly depend on zooplankton. The herbivorous zooplanktons are efficient grazers of the phytoplankton and are referred to as living machines transforming plant material into animal tissue. Hence they play an essential role as the intermediaries for nutrients/energy transfer between primary and tertiary trophic levels. Due to their large density, shorter lifespan, drifting nature, high group/species diversity and different tolerance to the stress, they used as the indicator organisms for the physical, chemical and biological processes in the aquatic ecosystem (Ghajbhiye, 2002).



Simplified marine food web

Spatial distribution of Plankton:

A characteristic of plankton population is that they tend to occur in patches, which are varying spatially on a scale of few meters to far as few kilo metres in distance. They also vary in time scale, season as well as vertically in the water column. It is this patchiness and its constant changes in time and spot, that has made it so difficult for plankton biologist to learn about the ecology of plankton. The biological factors that causes this patchiness is due to the ability of zooplankton to migrate vertically and graze out the phytoplankton at a rapid rate that can create patchiness. Similarly the active swimming ability by certain zooplankton organisms can cause to aggregate in dense group.

At its most extreme, because the water in which plankton is suspended is constantly moving, each sample taken by the plankton biologists remain a different volume of water, so each sample is unique and replicate does not exist.

Plankton in the month of October also exhibit vertical patchiness. Physical factors contribute to this type of patchiness include light intensity, nutrients and density gradients in the water column.

Phytoplankton in particular tends to be unequally distributed vertically, which leads to the existence of different concentration of a chlorophyll value between photic zone and below the photic zone.

Methodology adopted for Plankton sampling:

Mixed plankton sample were obtained from the sub surface layer at each sampling locations by towing the net horizontally with the weight. After a tow of about 15-30 minutes, plankton net was pulled up and washed down to the tail and the plankton adhered to plankton net is collected in the collection bucket at the bottom by springing outer and inner surface of the net with sea water, while the net was hanging with the mouth upward. For quantitative evaluation 50 L water samples were collected from subsurface layer and filtered through 20 µm mesh size net by using bucket and filtration assembly.

Preservation and storage:

Both filtered plankton and those collected from the plankton net were preserved with 5% buffered formalin and stored in 1L plastic container for further processing in the laboratory.

Sample concentration:

The collected plankton samples were concentrated by using centrifuge and made up to 50 ml with 5% formalin -Glycerine mixture.

Taxonomic evaluation:

Before processing, the sample was mixed carefully and a subsample was taken with a calibrated Stempel-pipette. 1 ml of the concentrated plankton samples were transferred on a glass slide with automatic pipette. The plankton sample on the glass slides were stained by using Lugol's iodine and added glycerin to avoid drying while observation. The plankton samples were identified by using Labex triangular Research microscope with photographic attachment. Microphotographs of the plankton samples were taken for record as well as for confirming the identification. The bigger sized zooplankton was observed through dissecting stereomicroscope with magnification of 20-30 x. Plankton organisms in the whole slide were identified to the lowest taxon possible. A thorough literature search was conducted for the identification of the different groups of phytoplankton and zooplankton that were encountered

Cell counts by drop count method:

The common glass slide mounted with a 1ml of concentrated phytoplankton/zooplankton sample in glycerol and covered with cover slip 22 mm x 60 mm was placed under the compound microscope provided with a mechanical stage. The plankton was then counted from the microscopic field of the

left top corner of the slide. Then slide is moved horizontally along the right side and plankton in each microscopic field was thus counted. When first microscopic field row was finished the next consecutive row was adjusted using the mechanical device of the stage. In this way all the plankton present in entire microscopic field are counted. From this total number in 1ml of the concentrated plankton, total amount of phytoplankton in the original volume of sample filtered was calculated as units/L and Zooplankton as N/m^3.

BENTHIC ORGANISMS:

Benthos is those organisms that are associated with the sea bed or benthic habitats. Epi- benthic organisms live attached to a hard substratum or rooted to a shallow depth below the surface. In fauna organisms live below the sediment–water interface. Interstitial organisms live and move in pore water among sedimentary grains.

Because the benthic organisms are often collected and separated on sieves, a classification based on the overall size is used. Macro benthos include organisms whose shortest dimension is greater than or equal to 0.5 mm. Meio benthos are smaller than 0.5mm but larger than 42µ in size.

The terms such as macro fauna and Meio fauna generally have little relevance with taxonomic classification. The terms Meio fauna and macro fauna depend on the size. Meio fauna were considered as good bioassay of community health and rather sensitive indicators of environmental changes

SAMPLING METHODOLOGY ADOPTED FOR SUB TIDAL REGION:

Van veen sampler ($0.09m^2$) was used for sampling bottom sediments. Two sets of sediments were sampled from each location, one for macro fauna and other for Meio fauna. The macro fauna in the sediments were sieved on board to separate out the organisms. The fixation of Meio fauna is normally done by bulk fixation of the sediment sample. The bulk fixation is done by using 10% formalin (Buffered with borate). The organisms were preserved with seawater as diluting agent.

Sample sieving:

Sediments samples were sieved to extract the organisms. Sieving was performed carefully as possible to avoid any damage to the animals. The large portion of the sediment was split in to smaller portions and mixed with sea water in a bucket. The cohesive lumps were broken down by continuous stirring. The disaggregated sediments were then passed through the sieves.

Sample staining:

Sorting of the Meio fauna from the sieve is difficult task especially in the preserved material, because organisms are not easily detectable. To facilitate the animal detection the entire sample retained on the sieve after sieving operation were stained by immersing the sieve in a flat bottom tub with 1% Rose Bengal stain; a protein stain. A staining period of 10-30 minutes is sufficient for sample detection.

DIVERSITY INDICES:

On the whole, diversity indices provide more information about community composition than simply species richness (number of species present); they also, take the relative abundances of different species into account. Based on this fact, diversity indices therefore depend not only on species richness but on the evenness, or equitability, with which individuals are distributed among the different species (Magurram, A. E. (1988)

A diversity index is a measure of species diversity within a community that consists of co-occurring populations of several (two or more) different species. It includes two components: richness and evenness. Richness is the measure of the number of different species within a sample showing that more the types of species in a community, the higher is the diversity or greater is the richness. Evenness is the measure of relative abundance of the different species with in a community.

The basic idea of diversity index is to obtain a quantitative estimate of biological variability that can be used to compare biological entities composed of discrete components in space and time (Carol H. R. *etal*. 1998). Biodiversity is commonly expressed through indices based on species richness and species abundances (Whittaker 1972, Lande 1996, Purvis and Hector 2000). Biodiversity indices are a non-parametric tool used to describe the relationship between species number and abundance. The most widely used bio diversity indices are Shannon Weiner index and Simpson's index.

A diversity Index is a single statistic that incorporates information on richness and evenness. Any study intended to interpret causes and effect of adverse impact on Biodiversity of communities require suitable measures to evaluate specie richness and Diversity. The former is number of species in community, while latter is a function of relative frequency of different species. Species richness is the iconic measure of biological diversity (Magurran, 2004). Several indices have been created to measure the diversity of species; however, the most widely used in the last decades are the Shannon (1948) and Simpson (1949) (Buzas and Hayek 1996; Gorelick 2006), with the components of diversity: richness (*S)* and evenness (*J)*

Simpson's diversity index

Simpson's index (**D**) is a measure of diversity, which takes into account both species richness, and evenness of abundance among the species present. The Simpson index is one of the meaningful and robust biodiversity measures available. (Magurran , 2004).

The formula for calculating D is presented as:

$$D = \frac{\sum n_i(n_i - 1)}{N(N-1)}$$

Where n_i = the total number of organisms of each individual species

N = the total number of organisms of all species

The value of D ranges from 0 to 1. With this index, 0 represents infinite diversity and, 1, no diversity. When D increases diversity decreases. Simpson's index is therefore usually expressed as 1-D or 1/D. (Magurran, 2004)

Low species diversity suggests:

- relatively few successful species in the habitat
- the environment is quite stressful with relatively few ecological niches and only a few organisms are really well adapted to that environment
- food webs which are relatively simple
- change in the environment would probably have quite serious effects

High species diversity suggests:

- a greater number of successful species and a more stable ecosystem
- more ecological niches are available and the environment is less likely to be hostile complex food webs
- environmental change is less likely to be damaging to the ecosystem as a whole

Species richness indices

The species richness***(S)*** is simply the number of species present in an ecosystem. Species richness Indices of species richness are widely used to quantify or monitor the effects of anthropogenic disturbance. A decline in species richness in may be concomitant with severe or chronic human-induced perturbation (Fair Fair weather 1990) Species richness measures have traditionally been the mainstay in assessing the effects of environmental degradation on the biodiversity of natural assemblages of organisms (Clarke &Warwick, 2001)

Species richness is the iconic measure of biological diversity (Magurran, 2004). The species richness***(S)*** is simply the number of species present in an ecosystem. This index makes no use of relative abundances. The term species richness was coined by Mc Intosh (1967) and oldest and most intuitive measure of biological diversity (Magurran, 2004).

Margalef's diversity index is a species richness index. Margalef's Species richness index (d), or indices that describe the evenness of the distribution of the numbers of individuals among species, were derived.

The value of a diversity index increases both when the number of types increases and when evenness increases. For a given number of types, the value of diversity index is maximised when all types are equally abundant [Rosenzweig, M. L. (1995)]

Shannon-Wiener's index:

An index of diversity commonly used in plankton community analyses is the Shannon-Wiener's index **(H),** which emphasizes not only the number of species (richness or variety), but also the apportionment of the numbers of individuals among the species (Odum 1971 and Reish 1984).

Shannon-Wiener's index **(H)** reproduces community parameters to a single numberby using an equation.

Shannon and Weiner index represents entropy. It is a diversity index taking into account the number of individuals as well as the number of taxan. It varies from 0 for communities with only single taxa to high values for community with many taxan each with few individuals. This index can also determine the pollution status of a water body. Normal values range from 0 to 4. This index is a combination of species present and the evenness of the species. Examining the diversity in the range of polluted and unpolluted ecosystems, Wilham and Dorris (1968) concluded that the values of the index greater than

3 indicate clean water, values in the range of 1 to 3 are characterized by moderate pollution and values less than 1 are characterized as heavily polluted

$$H' = -\sum_{i=1}^{s} \frac{n_i}{N} \ln\left(\frac{n_i}{N}\right)$$

10.2:- RESULTS:

CHLOROPHYLL-a:

In the sub surface water chlorophyll-a was varying from 0.462 -0.764 mg/m^3 with an average value 0.621 mg/m^3 in harbour region of DPA in Kandla Creek during sampling done in spring tide period of October 2022. In the nearby creeks chlorophyll-a was varying from 0.409-0.765 mg/m^3 with an average value 0.543mg/m^{3}Pheophytin –a level was below detectable limit- the all the sampling stations during springtide. Even though the plankton diversity and abundance were more during the spring tide sampling, the chlorophyll -a content was less due to the fact that the phytoplankton communities were mainly represented by bloom diatom *Chaetoceros* sp. and abundance of another diatom; *Ditylum sp*.

In the sub surface water chlorophyll-a was varying from 0.412 - 0.779 mg/m^{3}with an average value 0.567 mg/m^{3}in harbour region of DPA in Kandla Creek during sampling done in Neap tide period of October2022. In the nearby creeks chlorophyll-a was varying from 0.526- 0.646 mg/m^3 with an average value 0.564mg/m^3.Pheophytin –a level was below detectable limit- the all the sampling stations. During neap tide sampling phytoplankton communities were mainly represented by bloom forming diatom *Ditylum sp*.

In the sub surface water chlorophyll-a was varying from 0.308 - 0.528 mg/m^3 in harbour region of DPA OOT in path finder Creek during sampling done in spring tide period of October 2022. In the sub surface water chlorophyll-a was varying from 0.559 - 0.647 mg/m^3 in harbour region of DPA OOT in path finder Creek during sampling done in Neap Tide period of October2022

TABLE 44. VARIATIONS IN CHLOROPHYLL –a PHEOPHYTIN- a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPA HARBOUR AREA IN KANDLA CREEK ,NEAR BY CREEKS AND DPA OOT JETTY IN PATH FINDER CREEK AND SPM NEAR VADINARDURING SPRING TIDE IN OCTOBER 2022

Sr. No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPA HARBOUR AREA KANDLA CREEK					
1	DPA-1	High tide	0.764	BDL	51.19
		Low tide	0.562	BDL	37.65
2	DPA- 2	High tide	0.630	BDL	42.21
		Low tide	0.646	BDL	43.28
3	DPA-3	High tide	0.662	BDL	44.35
		Low tide	0.462	BDL	30.95
CREEKS					
4	DPA-4 Khori-I	High tide	0.559	BDL	37.45
		Low tide	0.409	BDL	27.40
5	DPA-5 Nakti-I	High tide	0.765	BDL	51.26
		Low tide	0.442	BDL	29.61
6	DPA-6 Nakti-II	High tide	ND	ND	ND
PATHFINDER CREEK VADINAR					
7	VADINAR-I jetty	High tide	0.528	BDL	35.38
8		Low tide	0.425	BDL	28.48
9	SPM	High tide	0.308	BDL	20.64
10		Low tide	0.475	BDL	31.83

BDL: Below Detectable Limit., ND: Not detected

TABLE 45. VARIATIONS IN CHLOROPHYLL –a PHEOPHYTIN- a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPA HARBOUR AREA, NEAR BY CREEKS AND DPA OOT JETTY IN PATH FINDER CREEK AND SPM NEAR VADINARDURING NEAP TIDE IN OCTOBER 2022

Sr. No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPA HARBOUR AREA KANDLA CREEK					
1	KPT1	High tide	0.779	BDL	52.19
		Low tide	0.646	BDL	43.28
2	KPT 2	High tide	0.592	BDL	39.66
		Low tide	0.426	BDL	28.54
3	KPT 3	High tide	0.544	BDL	36.45
		Low tide	0.412	BDL	27.60
CREEKS					
4	KPT-4 Khori-I	High tide	0.543	BDL	36.38
		Low tide	0.646	BDL	43.28
5	KPT-5 Nakti-I	High tide	0.526	BDL	35.24
		Low tide	0.542	BDL	36.31
6	KPT-6 Nakti-II	High tide	ND	ND	ND
PATHFINDER CREEK VADINAR					
7	VADINAR-I jetty	High tide	0.647	BDL	43.35
8		Low tide	0.647	BDL	43.35
9	SPM	High tide	0.559	BDL	37.45
10		Low tide	0.598	BDL	40.07

BDL: Below Detectable Limit. ND: Not detected

PHYTOPLANKTON POPULATION:

For the evaluation of the Phytoplankton population in DPA harbour area and within the immediate surroundings of the port, sampling was conducted from 5 sampling locations (3 in harbour area and two in Nakti creek) during high tide period and low tide period of spring tide and neap tide.

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by, Diatoms, Blue green algae and Dinoflagellates during spring tide period. Diatoms were represented by 28 genera, Blue green algae were presented by 3 genera and Dinoflagellates were represented by 4 genera during the sampling conducted in spring tide in October, 2022. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 84-353 units/ L during high tide period and 242-322 units/ L during low tide of Spring Tide. During spring tide sampling phytoplankton communities were dominated by diatom *Chaetoceros* sp., almost forming a bloom in the Kandla creek and other nearby creek area and abundant population diatoms; *Biddulphia* sp, *Ditylum sp and Skeletonema* sp.

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by Diatoms, Blue green algae and Dinoflagellates during Neap tide period. Diatoms were represented by 25 genera, Blue green algae were represented 3 generaand Dinoflagellates with4 genera during the sampling conducted in Neap tide in October, 2022. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 71-268 units/ L during high tide period and 249-342 units/ L during low tide of Neap Tide. During Neap tide sampling phytoplankton communities were dominated by, diatom *Ditylum sp and Asterionellopsis sp*.

For the evaluation of the Phytoplankton population in DPA OOT jetty area in Path Finder creek sampling was conducted from two sampling locations; jetty area and SPM area during high tide period and low tide of spring tide and Neap tide period.

The phytoplankton community of the sub surface water in the path finder creeks was represented by Diatoms, Blue green algae and Dinoflagellates during spring tide period. Diatoms were represented by 30 genera, Blue green algae by 3 genera and Dinoflagellates by 5genera during the sampling conducted in spring tide in October, 2022. Phytoplankton of the sampling stations at sub surface path finder creek near OOT Jetty area was 258 units/ L during high tide period and 196units/ L during low tide of Spring Tide. Phytoplankton of the sampling stations at sub surface layer in the *SPM* area was varying from 148 units/ L during high tide period and 208 units/ L during low tide of Spring Tide.

The phytoplankton community of the sub surface water in the path finder creeks was represented by Diatoms, Blue green and Dinoflagellates during Neap tide period. Diatoms were represented by 34 genera and Blue green algae by 2 genera and Dinoflagellates by 7 generaduring the sampling conducted in Neap tide in October, 2022. Phytoplankton of the sampling stations at sub surface path finder creek near OOT Jetty was varying from 420 units/L during high tide period and 410 units/L

during low tide of Neap Tide. Phytoplankton of the sampling stations at sub surface path finder creek near SPM area was varying from 331 units/ L during high tide period and 397 units/L during low tide of Neap Tide.

Species Richness Indices and Diversity Indices:

Margalef's diversity index (Species Richness)

Margalef's diversity index (Species Richness) of phytoplankton communities in the Kandla creek and nearby creeks sampling stations was varying from 3.837- 5.114with an average of 4.599during the sampling conducted in High tide period of spring tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek region and nearby creeks was varying from4.008- 5.195 with an average of 4.573during the consecutive low tide period.

Margalef's diversity index (Species Richness) of phytoplankton communities in the stations in Kandla creek and nearby creeks was varying from 2.514- 3.302 with an average of 2.843 during the sampling conducted in High tide period of Neap tide. While Margalef's diversityindex (Species Richness) of phytoplankton communities in the Kandla creek region and nearby creeks was varying from1.912-3.754 with an average of 2.698 during consecutive low tide.

Margalef's diversity index (Species Richness) of phytoplankton communities in the stations was4.862 at OOT jetty area and 4.202 at SPM area during the sampling conducted in High tide period of spring tide. While Margalef's diversity index (Species Richness) of phytoplankton communities in the path finder creek near OOT jetty was 4.926 and 4.684 at SPM during the consecutive low tide period.

Margalef's diversity index (Species Richness) of phytoplankton communities in the stations was 4.801 at OOT jetty area and 4.998at SPM area during the sampling conducted in High tide period of Neap tide. While Margalef's diversity index (Species Richness) of phytoplankton communities in the path finder creek near OOT jetty was 4.322 and SPM area was 4.345 during the consecutive low tide period.

Shannon-Wiener's index:

Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 1.092 - 1.124 between selected sampling stations with an average value of 1.109during high tide period of spring tide at Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 1.024-1.116 between selected sampling stations with an average value of 1.088duringconsecutive low tide at Kandla creek and nearby creeks.

Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.762 –0.876 between selected sampling stations with an average value of 0.822 during high tide period of neap tide at Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton

communities in the sampling stations was in the range of 0.636 - 0.883 between selected sampling stations with an average value of 0.731during consecutive low tide at Kandla creek and nearby creeks.

Shannon-Wiener's Index (H) of phytoplankton communities in the stations was1.041 at OOT jetty area and 0.979 at SPM area during the sampling conducted in High tide period of spring tide. While Shannon-Wiener's Index (H) of phytoplankton communities in the path finder creek near OOT jetty was 1.092 and 0.988 at SPM during the consecutive low tide period of spring tide.

Shannon-Wiener's Index (H) of phytoplankton communities in the stations was1.011 at OOT jetty area and 1.059 at SPM area during the sampling conducted in High tide period of Neap tide. While Shannon-Wiener's Index (H) of phytoplankton communities in the path finder creek near OOT jetty was 0.975 and at SPM area was0.899during the consecutive low tide period.

Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon-Wiener's index increases as both the richness and the evenness of the community increase. This result indicates that diversity of phytoplankton of Kandla Harbour region and nearby creeks is less but with abundant population of few, with relatively few ecological niches and only very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson's diversity index:

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks, which was varying from 0.837- 0.915 between selected sampling stations with an average of 0.875 during high tide period of spring tide. Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks except few, which was varying from 0.833- 0.886 between selected sampling stations with an average of 0.866 during consecutive low tide.

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations except few in Kandla Harbour region and nearby creeks, during high tide period and low tide period during Neap tide also, which was varying from 0.739- 0.810 with an average value of 0.771 between selected sampling stations during high tide period and 0.616- 0.796 varying from with an average value of 0.692 between selected sampling stations during consecutive low tide period Low species diversity suggests a relatively few successful species in this habitat.

Simpson diversity index (1-D) of phytoplankton communities in the stations was 0.869 at OOT jetty area and0.839 at SPM area during the sampling conducted in High tide period of spring tide at Path finder creek. While Simpson diversity index (1-D) of phytoplankton communities in the path finder creek near OOT jetty was 0.874 and 0.846 at SPM during the consecutive low tide period in the path finder creek.

Simpson diversity index (1-D) of phytoplankton communities in the stations was 0.816 at OOT jetty area and 0.818 at SPM area during the sampling conducted in High tide period of Neap tide at Path

finder Creek. While Simpson diversity index (1-D) of phytoplankton communities in the path finder creek near OOT jetty was 0.784 and at SPM area was 0.725 during the consecutive low tide period. Low species diversity suggests a relatively few successful species in this habitat. The environment is well for ecological niches. This result indicates that diversity of phytoplankton of Kandla Harbour region and nearby creeks stations is slightly high with very minimum diverse population but very few opportunist organisms are really well adapted to this environment and thrive better than other species.

TABLE 46. PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND ,NEAR BY CREEKS DURING SPRING TIDE IN OCTOBER 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% Of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	353	31/35	88.57	5.114	1.092	0.8369
	2	309	29/35	82.86	4.884	1.118	0.8648
	3	315	27/35	77.14	4.52	1.114	0.8764
	4	293	26/35	74.29	4.401	1.103	0.8842
	5	326	29/35	82.86	4.839	1.124	0.8761
	6	84	18/35	51.43	3.837	1.102	0.9145
LOW TIDE	1	302	26/35	74.29	4.378	1.024	0.8334
	2	322	31/35	88.57	5.195	1.115	0.8663
	3	269	26/35	74.29	4.469	1.083	0.8631
	4	273	28/35	80.00	4.813	1.116	0.8823
	5	242	23/35	65.71	4.008	1.103	0.8863

TABLE.47. PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND ,NEAR BY CREEKS DURING NEAP TIDE IN OCTOBER 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	268	17/32	53.13	2.862	0.7622	0.7391
	2	233	19/32	59.38	3.302	0.876	0.8104
	3	262	15/32	46.88	2.514	0.8365	0.7844
	4	262	17/32	53.13	2.873	0.8283	0.7623
	5	236	17/32	53.13	2.928	0.8336	0.7846
	6	71	12/32	37.50	2.581	0.7935	0.7449
LOW TIDE	1	269	22/32	68.75	3.754	0.8834	0.7957
	2	249	16/32	50.00	2.719	0.7497	0.7133
	3	251	15/32	46.88	2.534	0.6416	0.6161
	4	342	16/32	50.00	2.571	0.7462	0.703
	5	315	12/32	37.50	1.912	0.6361	0.6315

TABLE 48. ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND, NEAR BY CREEKS DURING SPRING TIDE IN OCTOBER2022

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	DIATOMS	83-329	28/35	80.00
			BLUE GREEN ALGAE	1-11	3/35	8.57
			DINOFLAGELLATES	0-18	4/35	11.43
			TOTAL PHYTO PLANKTON	**84-353**	**35**	
LOW TIDE	Sub surface	5	DIATOMS	232-300	28/35	80.00
			BLUE GREEN ALGAE	3-6	3/35	8.57
			DINOFLAGELLATES	3-17	4/35	11.43
			TOTAL PHYTO PLANKTON	**242-322**	**35**	

TABLE 49. ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND, NEAR BY CREEKS DURING NEAP TIDE IN OCTOBER 2022

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	DIATOMS	71-264	25/32	78.12
			BLUE GREEN ALGAE	0-9	3/32	9.38
			DINOFLAGELLATES	0-4	4/32	12.50
			TOTAL PHYTO PLANKTON	**71-268**	**32**	
LOW TIDE	Sub surface	5	DIATOMS	242-331	25/32	78.12
			BLUE GREEN ALGAE	0-9	3/32	9.38
			DINOFLAGELLATES	0-2	4/32	12.50
			TOTAL PHYTO PLANKTON	**249-342**	**32**	

TABLE 50. PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA OOT AT PATH FINDER CREEK, VADINAR & NEAR BY SPM, DURING SPRING TIDE IN OCTOBER 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	258	28/38	73.68	4.862	1.041	0.869
	SPM	148	22/38	57.89	4.202	0.979	0.839
LOW TIDE	Jetty	196	27/38	71.05	4.926	1.092	0.874
	SPM	208	26/38	68.42	4.684	0.988	0.846

TABLE 51. PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING NEAP TIDE IN OCTOBER 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	420	30/43	69.77	4.801	1.011	0.816
	SPM	331	30/43	69.77	4.998	1.059	0.818
LOW TIDE	Jetty	410	27/43	62.79	4.322	0.975	0.784
	SPM	397	27/43	62.79	4.345	0.899	0.725

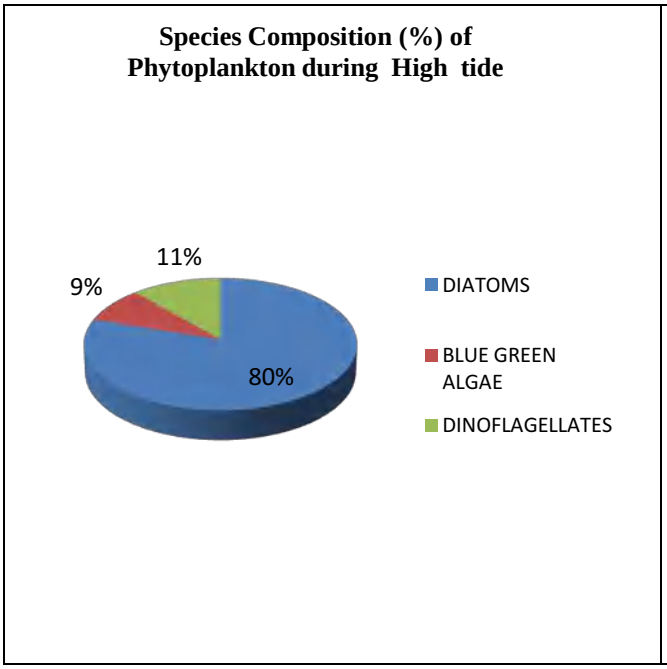
TABLE 52. ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPA OOT AT PATH FINDER CREEK, VADINAR & NEAR BY SPM, DURING SPRING TIDE IN OCTOBER 2022

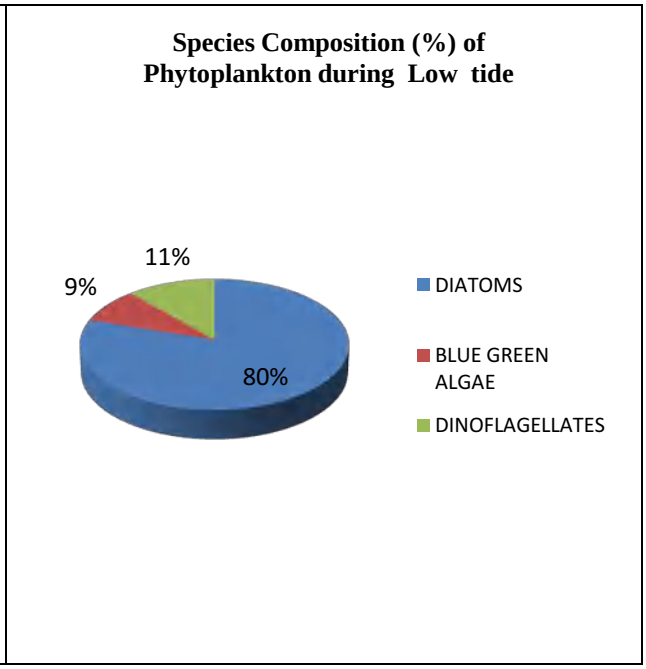
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	DIATOMS	135-249	30/38	78.95
			BLUE GREEN ALGAE	4-8	3/38	7.89
			DINOFLAGELLATES	5	5/38	13.16
			TOTAL PHYTO PLANKTON	**148-258**	**38**	
LOW TIDE	Sub surface	2	DIATOMS	180-199	30/38	78.95
			BLUE GREEN ALGAE	3-10	3/38	7.89
			DINOFLAGELLATES	6	5/38	13.16
			TOTAL PHYTO PLANKTON	**196-208**	**38**	

TABLE 53. ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPA OOT AT PATH FINDER CREEK, VADINAR & NEAR BY SPM, DURING NEAP TIDE IN OCTOBER 2022

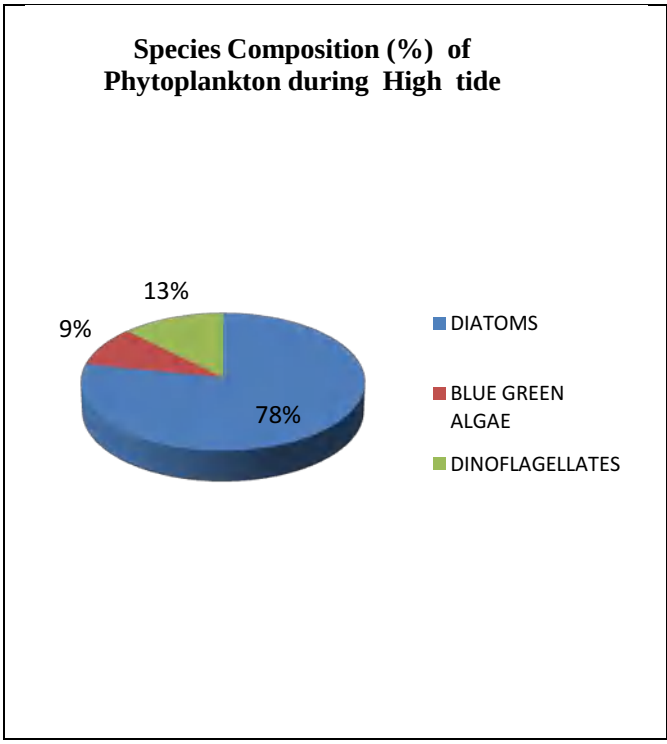
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	DIATOMS	320-411	34/43	79.07
			BLUE GREEN ALGAE	4	2/43	4.65
			DINOFLAGELLATES	5-7	7/43	16.28
			TOTAL PHYTO PLANKTON	**331-420**	**43**	
LOW TIDE	Sub surface	2	DIATOMS	379-397	34/43	79.07
			BLUE GREEN ALGAE	2-4	2/43	4.65
			DINOFLAGELLATES	11-14	7/43	16.28
			TOTAL PHYTO PLANKTON	**397-410**	**43**	

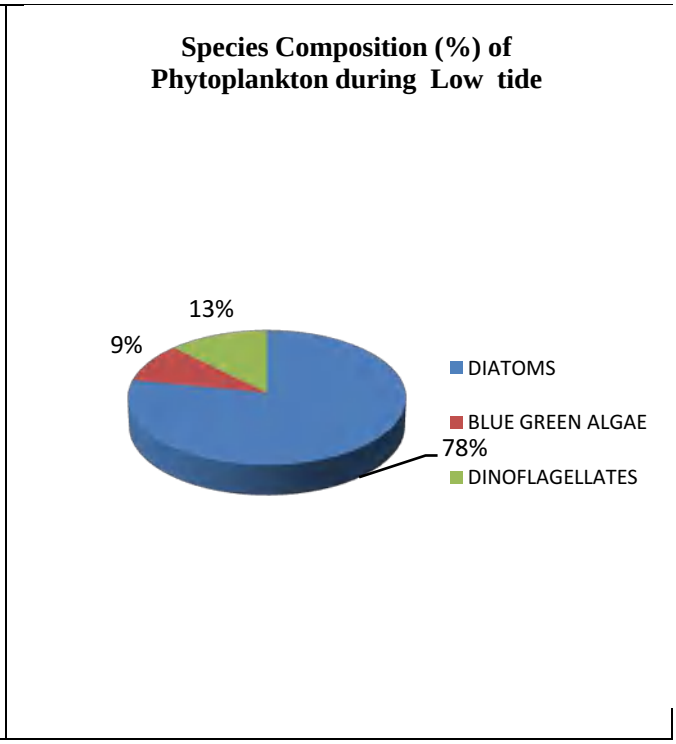
Species Composition (%) of Phytoplankton during High tide and Low tide period during spring tide in Kandala creek and nearby creeks



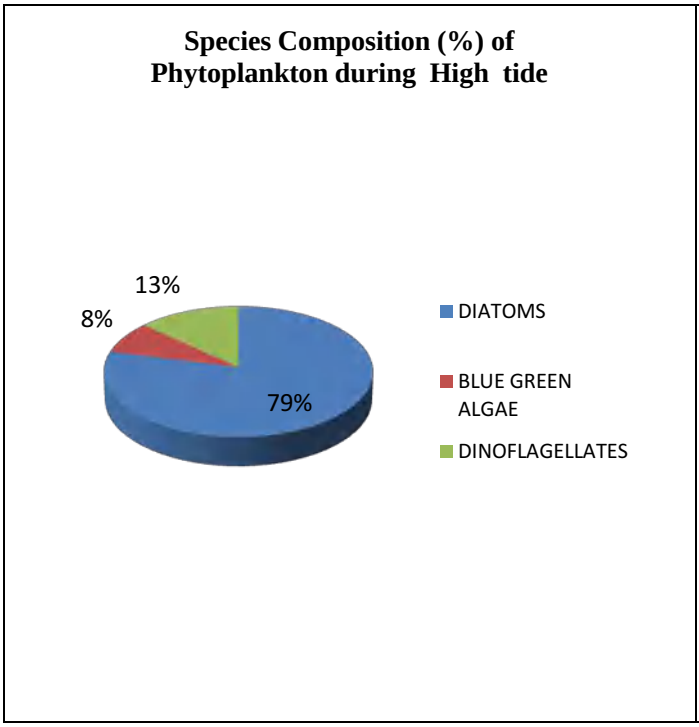


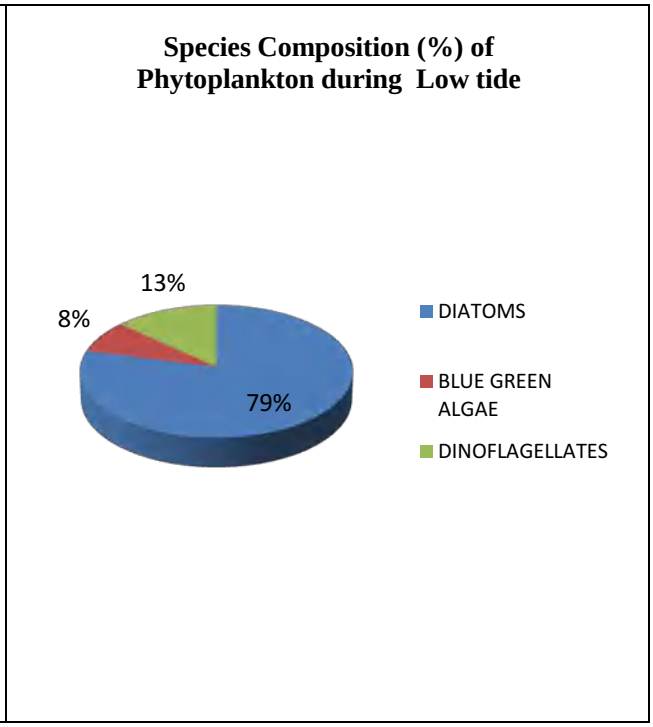
Species Composition (%) of Phytoplankton during High tide and Low tide period during Neap tide in Kandla creek and nearby creeks



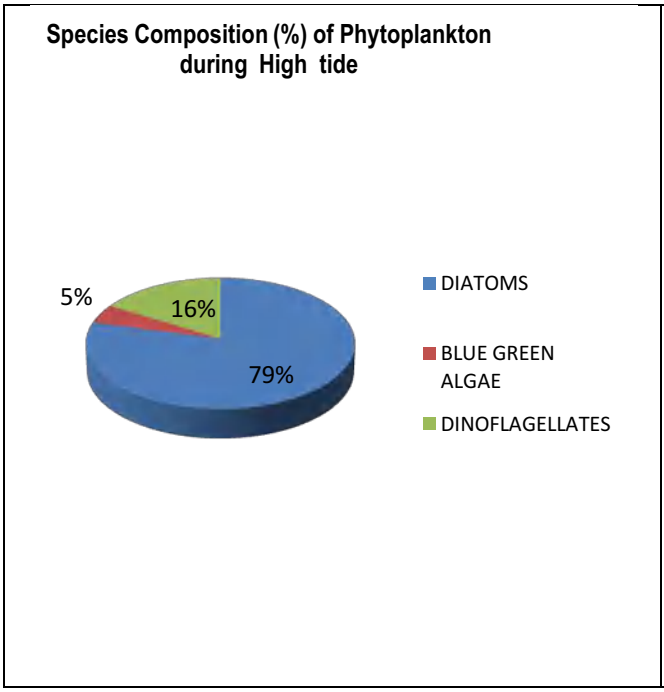


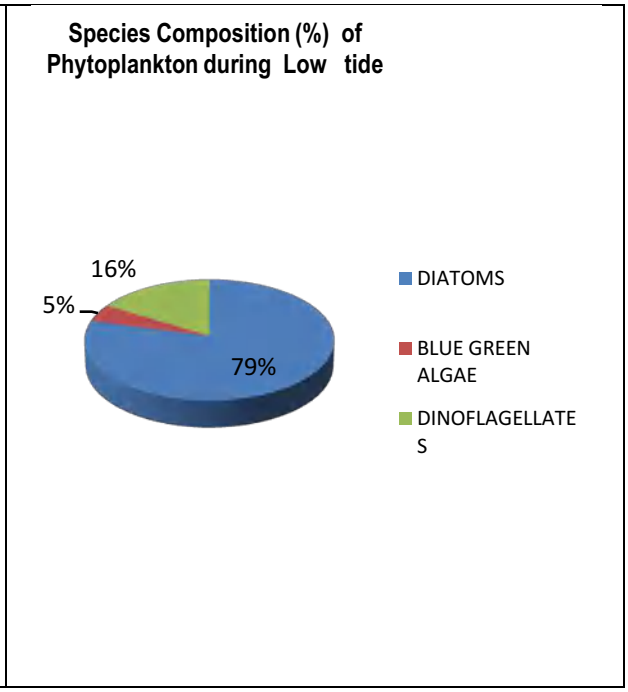
Species Composition (%) of Phytoplankton during High tide and Low tide period during spring tide in Path Finder Creek, Vadinar





Species Composition (%) of Phytoplankton during High tide and Low tide period during Neap tide in Path Finder Creek, Vadinar





ZOOPLANKTON POPULATION:

For the evaluation of the Zooplankton population in DPA harbour area and within the immediate surroundings of the port sampling was conducted from 6 sampling locations (3 in harbour area and two in Nakti creek and one in Khori creek) during high tide period and low tide period of spring tide and Neap tide in October, 2022. The Zooplankton community of the sub surface water in the harbour and nearby creeks during spring tide was represented by mainly eight groups; Tintinids, Copepods, Arrow worms, Mysids, Urochordata, Ciliates, Medusa, Nematodes and 8 larval forms. The Zooplankton community of the sub surface water in the harbour and nearby creeks during neap tide was represented by mainly eight groups; Tintinids, Copepods, Arrow worms, Mysids, Urochordata, Ciliates, Medusa, Nematode and 6 larval forms.

Zooplankton of the sampling stations at sub surface layer in the DPA harbour area and nearby creek was varying from 30-107 $x10^3$ N/ m^3 during high tide and 73-91$x10^3$ N/m^3 during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPA harbour area and nearby creek was varying from 25-124$x10^3$ N/m^3 during high tide and 76-107$x10^3$ N/ m^3 during low tide of Neap Tide period.

For the evaluation of the Zooplankton population in DPA OOT jetty area in Path Finder creek and SPM in Vadinar selected 2 sampling locations (1 in jetty area and one near SPM).
During spring tide sampling plankton sample were collected at Jetty area and near SPM during consecutive high tide period and low tide period. During Neap tide sampling Plankton samples were collected from jetty area and SPM during consecutive high tide period and low tide period.
The Zooplankton community of the sub surface water in the path finder creek during spring tide was represented by mainly three groups Titinids, Copepods, Mysids and 4 larval forms.

The Zooplankton community of the sub surface water in the path Finder creeks at Jetty region and SPM during neap tide was represented by mainly five groups, Titinids, Copepods, Arrow worms, Mysids, Urochordata and 7 larval forms.

Zooplankton of the sampling stations at sub surface layer in the DPA OOT Jetty area of path finder creek was 38 $x10^3$ N/ m^3 during high tide and 38$x10^3$ N/ m^3 during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPASPM area of path finder creek was 28$x10^3$ N/ m^3 during high tide and36$x10^3$ N/ m^3 during low tide of spring Tide period.

Zooplankton of the sampling stations at sub surface layer in the DPA OOT jetty area in path finder creek was recorded 113$x10^3$ N/ m^3during high tide and 103$x10^3$ N/ m^3 during consecutive low tide period of Neap tide. Zooplankton of the sampling stations at sub surface layer in the DPASPM area in

path finder creek was recorded $89x10^3$ N/m^3 during high tide and$110x10^3$ N/m^3 during consecutive low tide period of Neap Tide.

Species Richness Indices and Diversity Indices:

Margalef's diversity index (Species Richness)

Margalef's diversity index (Species Richness) of Zooplankton communities in the stations Kandla creek region and nearby creeks were varying from 2.352- 5.35 with an average of 3.250 during the sampling conducted in High tide period. Margalef's diversity index (Species Richness) S of Zooplankton communities varying from 2.031- 3.35 with an average of 2.715 during the sampling conducted in low tide period during Spring tide.

Margalef's diversity index (Species Richness) of Zooplankton communities in the Kandla creek region and nearby creeks sampling stations were varying from 2.175-4.856 with an average of 3.832 during the sampling conducted in high tide and varying from 3.002-4.265 with an average of 3.596 during the sampling conducted in low tide during Neap tide period.

Margalef's diversity index (Species Richness) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted inconsecutive High tide period and low tide of spring tide was recorded as 3.849 and 3.299 respectively. Margalef's diversity index (Species Richness) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 3.601 and 1.953 respectively.

Margalef's diversity index (Species Richness) of Zooplankton communities near Jetty at Path finder creek were varying from 3.385 and 2.805 respectivelyduring the sampling conducted in consecutive High tide period and Low tide period of Neap tide. While Margalef's diversity index (Species Richness) S of Zooplankton communities near SPM at Path finder creek were varying from 3.565 - 3.404 respectivelyduring the consecutive high tide and low tide period.

Shannon-Wiener's index:

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of0.768 -1.151between selected sampling stations with an average value of0.915 during high tide period of spring tide. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.873-0.984 between selected sampling stations with an average value of 0.931 during consecutive low tide period.

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.784-1.148 between selected sampling stations with an average value of 1.02 during high tide period of Neap tide. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range 0.962-1.09 of between selected sampling stations with an average value of 1.024 during consecutive low tide period.

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 1.041-0.891respectively.Shannon-Wiener's Index (H) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 1.013 - 0.787respectively.

Shannon-Wiener's Index (H) of Zooplankton communities near jetty at Path finder creek was varying from 0.979 - 0.888respectively during the sampling conducted consecutive High tide period and Low tide period of Neap tide. While Shannon-Wiener's Index (H) of Zooplankton communities near SPM at Path finder creek was varying from0.890-0.987during the consecutive High tide and low tide period.

Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon-Wiener's index increases as both the richness and the evenness of the community increase. This result indicates that diversity of Zooplankton of Kandla Harbour region and nearby creeks stations is slightly high with very minimum diverse population but very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson's diversity index:

Simpson diversity index (1-D) of Zooplankton communities was below 0.9 most of sampling stations in the Kandla Harbour region and nearby creeks during high tide and low tide of spring tide period except few stations, which was varying from 0.791-0.898 between selected sampling stations with an average of 0.839 during high tide period and was varying from 0.844- 0.879 with an average value of 0.862 between selected sampling stations during low tide.

Simpson diversity index (1-D) of Zooplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks during high tide and low tide period of Neap tide except few, which was varying from 0.833- 0.910 between selected sampling stations with an average of 0.879 during high tide period and was varying from 0.866-0.898 with an average value of 0.881 between selected sampling stations during consecutive low tide .This species diversity suggests a relatively few successful species in this habitat during October, 2022 sampling.

Simpson diversity index (1-D) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.902 and 0.821respectively.Simpson diversity index (1-D) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as0.910 and 0.819respectively.

Simpson diversity index (1-D) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of Neap tide was recorded as 0.867- 0.825 respectively. Simpson diversity index (1-D) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.806 and 0.874 respectively.

TABLE 54. ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING SPRING TIDEIN OCTOBER 2022

Tide	Sampling Station	Abundance In Nx10^3/ m^3	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	85	17/36	47.22	3.601	0.9751	0.8655
	2	53	11/36	30.56	2.519	0.8207	0.8113
	3	107	26/36	72.22	5.35	1.151	0.8984
	4	83	14/36	38.89	2.942	0.8995	0.8434
	5	80	13/36	36.11	2.738	0.8775	0.8237
	6	30	9/36	25.00	2.352	0.768	0.7908
LOW TIDE	1	88	16/36	44.44	3.35	0.9836	0.8788
	2	84	10/36	27.78	2.031	0.8727	0.8439
	3	78	12/36	33.33	2.525	0.8933	0.8472
	4	91	15/36	41.67	3.104	0.9755	0.8745
	5	73	12/36	33.33	2.564	0.9305	0.8638

TABLE 55. ZOOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA HARBOUR AREAAT KANDLA CREEK AND NEARBY CREEKS DURING NEAP TIDE INOCTOBER 2022

Tide	Sampling Station	Abundance In No x10^3/ m^3	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	114	24/32	75.00	4.856	1.148	0.9096
	2	121	22/32	68.75	4.379	1.05	0.8671
	3	113	17/32	53.13	3.385	1.029	0.8911
	4	124	23/32	71.88	4.564	1.103	0.8959
	5	82	17/32	53.13	3.631	1.008	0.8759
	6	25	8/32	25.00	2.175	0.7836	0.8333
LOW TIDE	1	93	18/32	56.25	3.751	1.031	0.881
	2	92	17/32	53.13	3.538	0.998	0.866
	3	86	20/32	62.50	4.265	1.09	0.8977
	4	107	17/32	53.13	3.424	1.041	0.896
	5	76	14/32	43.75	3.002	0.9619	0.866

TABLE 56. ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA HARBOUR AREAATKANDLA CREEK AND NEAR BY CREEKS DURING SPRING TIDE IN OCTOBER 2022

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^3/ m^3$ Group Range	Genera or species /total Zooplankton	Species Composition (%) (Group level)
HIGH TIDE	Sub surface	6	Tintinids	2-22	10/36	27.78
			Copepods	8-35	11/36	30.56
			Arrow worms	0-2	1/36	2.78
			Mysids	0-1	1/36	2.78
			Urochordata	0-3	2/36	5.56
			Ciliates	0-2	1/36	2.78
			Medusa	0	1/36	2.78
			Larval forms	20-48	8/36	22.20
			Nematode	0-1	1/36	2.78
			TOTAL ZOOPLANKTON N/ M^3	**30-107**	**36**	
LOW TIDE	Sub surface	5	Tintinids	13-17	10/36	27.78
			Copepods	21-24	11/36	30.56
			Arrow worms	0-1	1/36	2.78
			Mysids	0	1/36	2.78
			Urochordata	0	2/36	5.56
			Ciliates	0-1	1/36	2.78
			Medusa	0-1	1/36	2.78
			Larval forms	37-51	8/36	22.20
			Nematode	0	1/36	2.78
			TOTAL ZOOPLANKTON N/M^3	**73-91**	**36**	

TABLE 57. ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA HARBOUR AREA IN KANDLA CREEK AND, NEAR BY CREEKS DURING NEAP TIDE IN OCTOBER 2022

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^{3/}/ m^3$ Group Range	Genera or species /total Zooplankton	Species Composition (%) (Group level)
HIGH TIDE	Sub surface	6	Tintinids	1-13	6/32	18.74
			Copepods	13-55	12/32	37.50
			Arrow worms	0-1	1/32	3.13
			Mysids	0-4	2/32	6.25
			Urochordata	0-2	2/32	6.25
			Ciliates	0-2	1/32	3.13
			Medusa	0-2	1/32	3.13
			Larval forms	11-53	6/32	18.74
			Nematode	0-1	1/32	3.13
			TOTAL ZOOPLANKTON N/M^3	**25-124**	**32**	
LOW TIDE	Sub surface	5	Tintinids	4-10	6/32	18.74
			Copepods	34-53	12/32	37.50
			Arrow worms	0-2	1/32	3.13
			Mysids	0-2	2/32	6.25
			Urochordata	0-3	2/32	6.25
			Ciliates	0-4	1/32	3.13
			Medusa	0-1	1/32	3.13
			Larval forms	25-43	6/32	18.74
			Nematode	0	1/32	3.13
			TOTAL ZOOPLANKTON N/M^3	**76-107**	**32**	

Table 58. ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING SPRING TIDE IN OCTOBER 2022

Tide	Sampling Station	Abundance In $x10^3N / m^3$	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	38	15/19	78.95	3.849	1.041	0.902
	SPM	28	13/19	68.42	3.601	1.013	0.910
LOW TIDE	Jetty	38	13/19	68.42	3.299	0.891	0.821
	SPM	36	8/19	42.11	1.953	0.787	0.819

TABLE 59. ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURINGNEAP TIDE IN OCTOBER 2022

Tide	Sampling Station	Abundance In $Nx10^3/ m^3$	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	113	17/25	68.00	3.385	0.979	0.867
	SPM	89	17/25	68.00	3.565	0.890	0.806
LOW TIDE	Jetty	103	14/25	56.00	2.805	0.888	0.825
	SPM	110	17/25	68.00	3.404	0.987	0.874

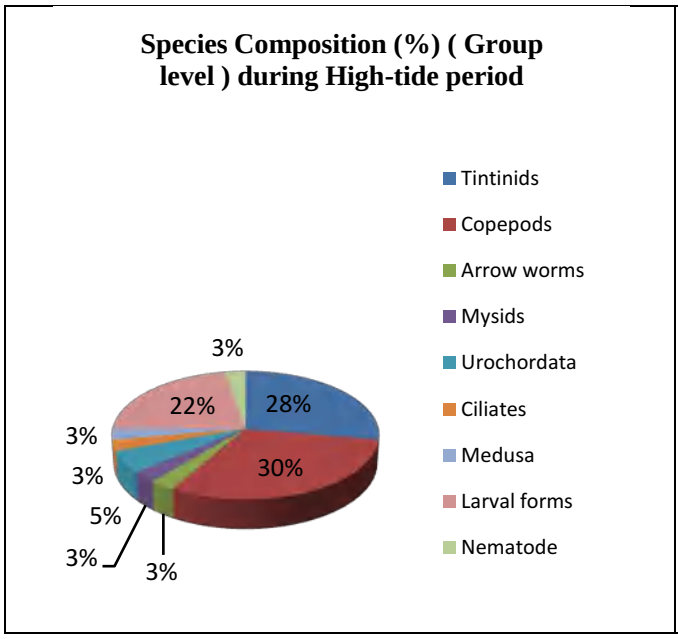
TABLE 60. ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA OOT AREAAND PATH FINDER CREEK AND NEAR BY SPM DURING SPRING TIDE IN OCTOBER 2022

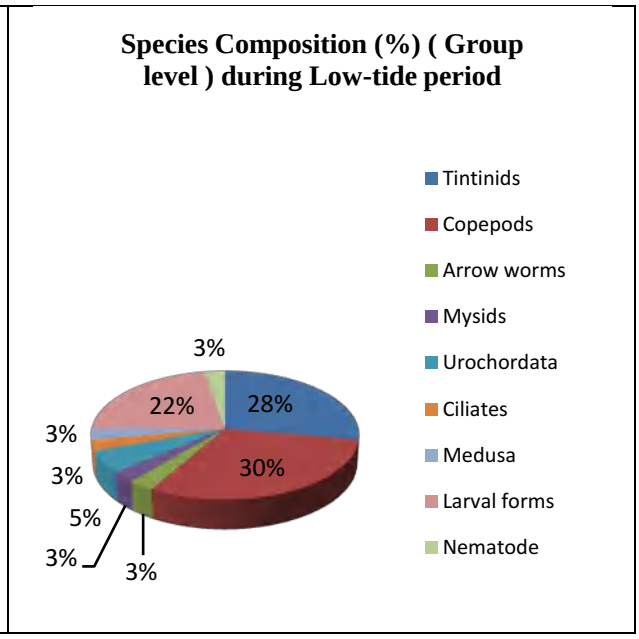
Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^{3/}/ m^3$ Group Range	Genera or species /total Zooplankton	Species Composition (%) (Group level)
HIGH TIDE	Sub surface	2	Tintinids	8-10	5/19	26.31
			Copepods	12-16	8/19	42.11
			Mysids	0-1	2/19	10.53
			Larval forms	8-11	4/19	21.05
			TOTAL ZOOPLANKTON NO/L	**28-38**	**19**	
			Tintinids	6-7	5/19	26.31
			Copepods	14-15	8/19	42.11
			Mysids	0-1	2/19	10.53
			Larval forms	14-17	4/19	21.05
			TOTAL ZOOPLANKTON NO/L	**36-38**	**19**	

TABLE 61. ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING NEAP TIDE IN OCTOBER 2022

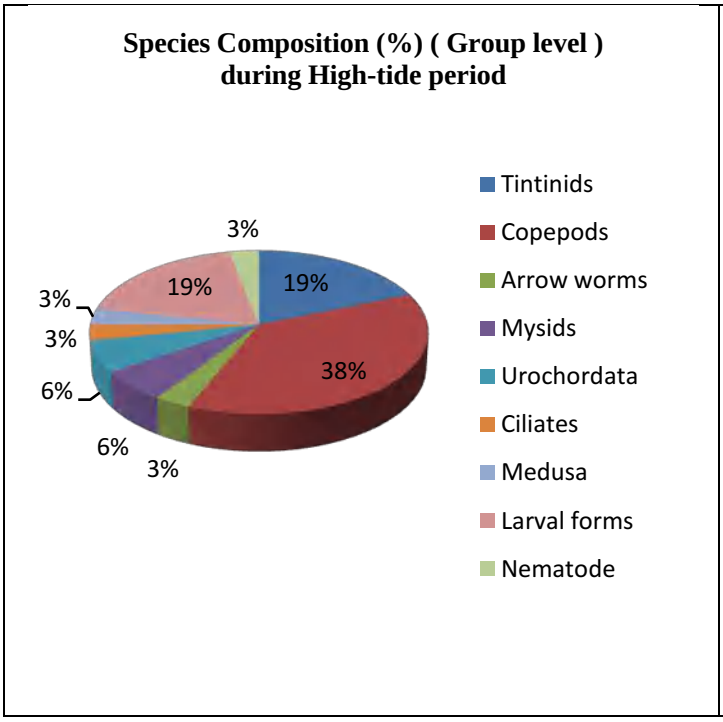
Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^3/ m^3$ Group Range	Genera or species /total Zooplankton	Species Composition (%) (Group level)
HIGH TIDE	Sub surface	2	Tintinids	17-31	7/25	28.00
			Copepods	26-27	7/25	28.00
			Arrow worms	1-2	1/25	4.00
			Mysids	1-4	1/25	4.00
			Urochordata	1-3	2/25	8.00
			Larval forms	41-48	7/25	28.00
			TOTAL ZOOPLANKTON	**89-113**	**25**	
LOW TIDE	Sub surface	2	Tintinids	25-28	7/25	28.00
			Copepods	22-34	7/25	28.00
			Arrow worms	0-1	1/25	4.00
			Mysids	1-2	1/25	4.00
			Urochordata	1-5	2/25	8.00
			Larval forms	46-48	7/25	28.00
			TOTAL ZOOPLANKTON	**103-110**	**25**	

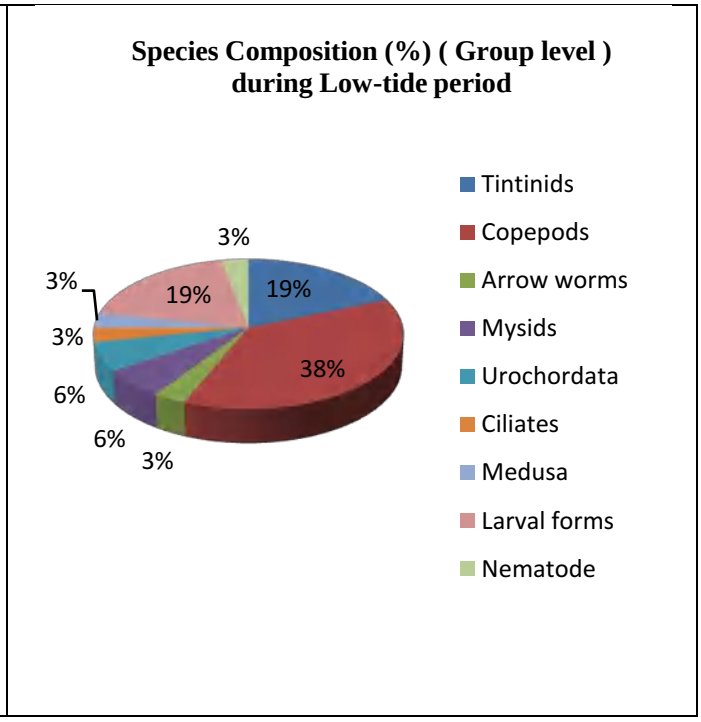
Species Composition (%) of Zooplankton during High tide and Low tide period of Spring tide In Kandla Creek and nearby Creeks



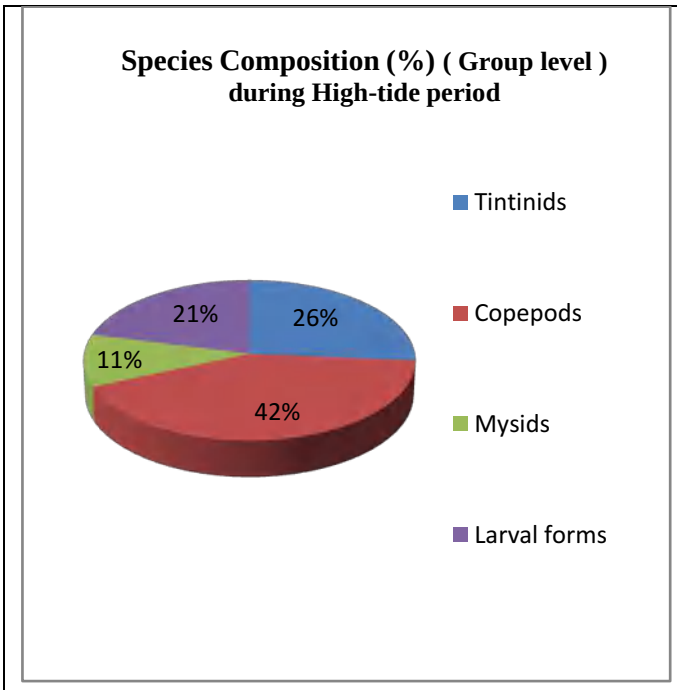


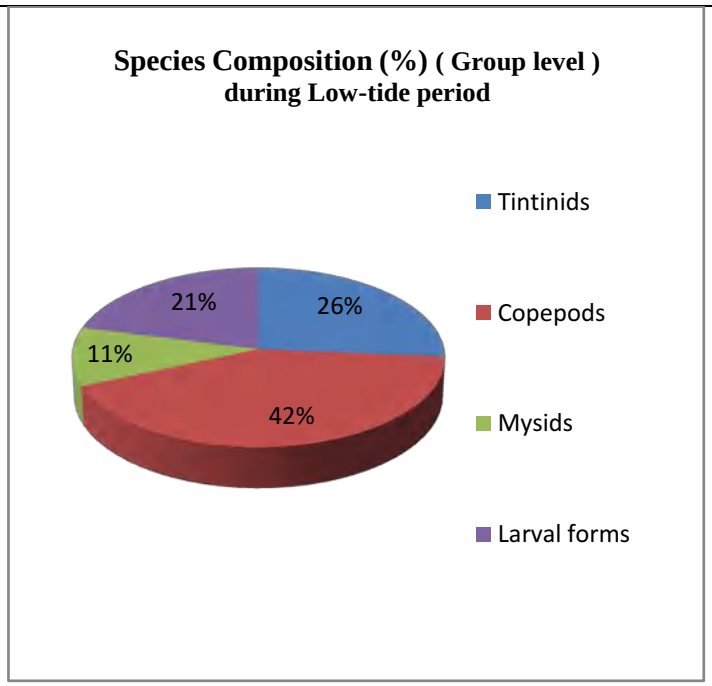
Species Composition (%) of Zooplankton during High tide and Low tide period of Neap tide In Kandla Creek and nearby Creeks



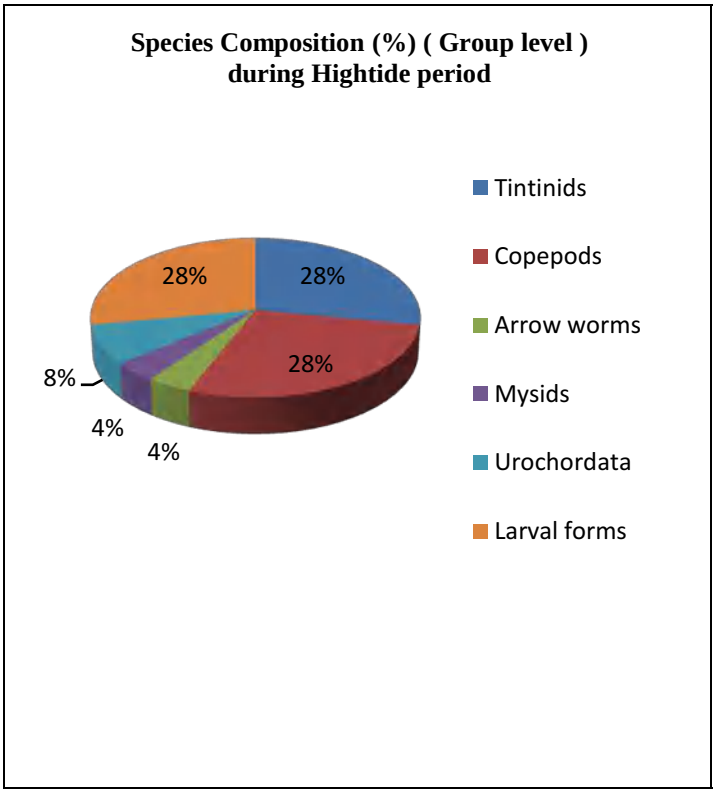


Species Composition (%) of Zooplankton during High tide and Low tide period of Spring tide In Path Finder Creek and near Jetty





Species Composition (%) of Zooplankton during High tide and Low tide period of Neap tide In Path Finder Creek near jetty and nearby SPM



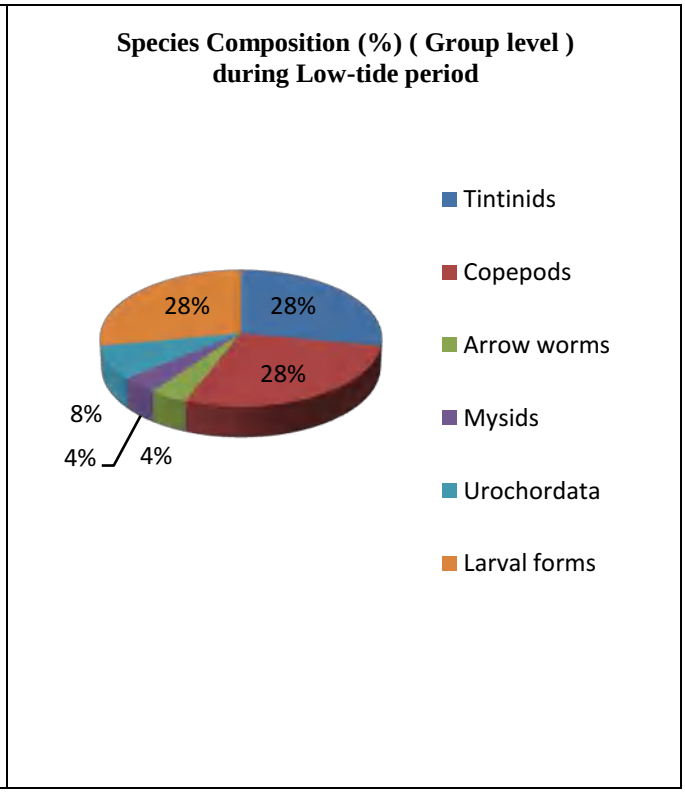


TABLE 62. SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS OF DPA HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING NEAP TIDE OF OCTOBER 2022

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
Cyanophyceae	Nostocales	Oscillatoriaceae	*Lyngbya sp.*	B1	Very sparse
			Oscillatoria sp.	B2	Very sparse
	Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B3	Sparse
Coscinodiscophyceae	Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D1	Abundant
	Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp.	D2	Sparse
	Corethrales	Corethraceae	*Corethron* sp	D3	Very sparse
	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D4	Scattered
	Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D5	Very sparse
		Hemiaulaceae	*Eucampia* sp	D6	Very sparse
	Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D7	Sparse
	Leptocylindrales	Leptocylindraceae	*Leptocylindrus sp*	D8	Very sparse
	Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D9	Dominant
	Thalassiosirales	Thalassiosiraceae	*Planktoniella*sp	D10	Very sparse
		Lauderiaceae	*Lauderia* sp	D11	Very sparse
		Skeletonemataceae	*Skeletonema* sp	D12	Sparse
	Triceratiales	Triceratiaceae	*Odontella* sp.	D13	Very sparse
			Triceratium sp.	D14	Very sparse
Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria* sp.	D15	Very sparse
			Nitzschia sp	D16	Very sparse
			Pseudo-Nitzschia sp.	D17	Sparse
	Naviculales	Naviculaceae	*Navicula* sp.	D18	Very sparse
		Pleurosigmataceae	*Pleurosigma* sp.	D19	Very sparse
	Surirellales	Surirellaceae	*Surirella sp.*	D20	Very sparse
Fragilariophyceae	Fragilariales	Fragilariaceae	*Asterionellopsis sp*	D21	Abundant
			*Fragilaria*sp	D22	Very sparse
			*Synedra*sp	D23	Very sparse
	Thalassionematales	Thalassionemataceae	*Thalassionema sp.*	D24	Scattered
			Thalassiothrix sp.	D25	Scattered
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Very sparse
	Gonyaulacales	Pyrophacaceae	*Pyrophacus sp.*	DF2	Very sparse
		Ceratiaceae	*Ceratium furca*	DF3	Very sparse
			Ceratium tripos	DF4	Very sparse

TABLE 63. SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPA HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING SPRING TIDE OF OCTOBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
Cyanophyceae	Nostocales	Oscillatoriaceae	*Lyngbya sp.*	B1	Very sparse
			Oscillatoria sp.	B2	Very sparse
	Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B3	Sparse
Coscinodiscophyceae	Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D1	Abundant
	Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp.	D2	Dominant
	Corethrales	Corethraceae	*Corethron* sp	D3	Sparse
	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D4	Scattered
	Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D5	Very sparse
		Hemiaulaceae	*Cerataulina sp.*	D6	Sparse
			Eucampia sp	D7	Very sparse
		Streptothecaceae	*Helicotheca sp*	D8	Very sparse
	Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D9	Scattered
	Leptocylindrales	Leptocylindraceae	*Leptocylindrus sp*	D10	Very sparse
	Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D11	Abundant
	Thalassiosirales	Thalassiosiraceae	*Planktoniella*sp	D12	Sparse
		Lauderiaceae	*Lauderia* sp	D13	Sparse
		Skeletonemataceae	*Skeletonema* sp	D14	Abundant
	Triceratiales	Triceratiaceae	*Odontella* sp.	D15	Sparse
			Triceratium sp.	D16	Very sparse
Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria* sp.	D17	Sparse
			Nitzschia sp	D18	Very sparse
			Pseudo-Nitzschia sp.	D19	Scattered
	Naviculales	Naviculaceae	*Navicula* sp.	D20	Very sparse
		Pleurosigmataceae	*Pleurosigma* sp.	D21	Sparse
	Surirellales	Entomoneidaceae	*Entomoneis sp.*	D22	Very sparse
		Surirellaceae	*Surirella sp.*	D23	Very sparse
Fragilariophyceae	Fragilariales	Fragilariaceae	*Asterionellopsis sp*	D24	Abundant
			*Fragilaria*sp	D25	Sparse
			*Synedra*sp	D26	Very sparse
	Thalassionematales	Thalassionemataceae	*Thalassionema sp.*	D27	Scattered
			Thalassiothrix sp.	D28	Sparse
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Sparse
	Gonyaulacales	Pyrophacaceae	*Pyrophacus sp.*	DF2	Very sparse
		Ceratiaceae	*Ceratium furca*	DF3	Sparse
			Ceratium tripos	DF4	Very sparse

TABLE 64. SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPA OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINARDURING NEAP TIDE OF OCTOBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
Cyanophyceae	Nostocales	Oscillatoriaceae	*Oscillatoria sp.*	B1	Very sparse
	Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B2	Very sparse
Coscinodiscophyceae	Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D1	Scattered
	Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp	D2	Dominant
	Corethrales	Corethraceae	*Corethron* sp	D3	Sparse
	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D4	Scattered
	Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D5	Sparse
		Hemiaulaceae	*Cerataulina sp.*	D6	Sparse
			Eucampia sp	D7	Scattered
			Hemiaulus sp	D8	Very sparse
		Streptothecaceae	*Helicotheca sp*	D9	Very sparse
	Leptocylindrales	Leptocylindraceae	*Leptocylindrus sp*	D10	Very sparse
	Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D11	Abundant
	Rhizosoleniales	Rhizosoleniaceae	*Dactyliosolen sp.*	D12	Very sparse
			Rhizosolenia sp.	D13	Scattered
	Thalassiosirales	Skeletonemataceae	*Skeletonema sp.*	D14	Very sparse
		Lauderiaceae	*Lauderia sp*	D15	Sparse
		Thalassiosiraceae	*Planktoniella*sp	D16	Very sparse
			*Thalassiosira*sp	D17	Very sparse
	Triceratiales	Triceratiaceae	*Odontellasp*	D18	Sparse
			Triceratium sp	D19	Very sparse
Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria* sp.	D20	Abundant
			Hanitzschia sp.	D21	Very sparse
			Nitzschia sp	D22	Scattered
			*Pseudo-Nitzschia*sp	D23	Scattered
	Naviculales	Naviculaceae	*Meuniera sp.*	D24	Very sparse
			Navicula sp	D25	Very sparse
		Pinnulariaceae	*Pinnularia sp*	D26	Very sparse
		Pleurosigmataceae	*Pleurosigma* sp	D27	Sparse
	Surirellales	Entomoneidaceae	*Entomoneis sp.*	D28	Very sparse
		Surirellaceae	*Campylodiscus* sp	D29	Very sparse
			Surirella sp	D30	Very sparse
Fragilariophyceae	Fragilariales	Fragilariaceae	*Asterionellopsis sp.*	D31	Very sparse
			Synedra sp.	D32	Very sparse
	Thalassionematales	Thalassionemataceae	*Thalassionema sp.*	D33	Scattered
			Thalassiothrix sp.	D34	Scattered
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Sparse
	Gonyaulacales	Goniodomataceae	*Pyrodinium* sp.	DF3	Very sparse
		Pyrophacaceae	*Pyrophacus sp.*	DF4	Very sparse
		Ceratiaceae	*Ceratium furca*	DF5	Very sparse
			Ceratium fusus	DF6	Very sparse
			Ceratium tripos	DF7	Very sparse

TABLE 65. SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPAOOT AREA AT PATH FINDER CREEKAND NEARBY SPM AT VADINAR DURING AND SPRING TIDE OF OCTOBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
Cyanophyceae	Nostocales	Oscillatoriaceae	*Lyngbya sp.*	B1	Very sparse
			Oscillatoria sp.	B2	Very sparse
	Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B3	Very sparse
Coscinodiscophyceae	Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D1	Scattered
	Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp.	D2	Dominant
	Corethrales	Corethraceae	*Corethron* sp	D3	Very sparse
	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D4	Scattered
	Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D5	Sparse
		Hemiaulaceae	*Cerataulina sp.*	D6	Sparse
			Eucampia sp	D7	Sparse
		Streptothecaceae	*Helicotheca sp*	D8	Very sparse
	Rhizosoleniales	Rhizosoleniaceae	*Dactyliosolen sp.*	D9	Very sparse
			Rhizosolenia sp.	D10	Abundant
	Leptocylindrales	Leptocylindraceae	*Leptocylindrus sp*	D11	Very sparse
	Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D12	Abundant
	Thalassiosirales	Thalassiosiraceae	*Planktoniella*sp	D13	Very sparse
			Thalassiosira sp	D14	Very sparse
		Lauderiaceae	*Lauderia* sp	D15	Very sparse
		Skeletonemataceae	*Skeletonema* sp	D16	Sparse
	Triceratiales	Triceratiaceae	*Odontella* sp.	D17	Sparse
			Triceratium sp.	D18	Very sparse
Bacillariophyceae	Achnanthales	Achnanthaceae	*Achnanthes* sp	D19	Very sparse
	Bacillariales	Bacillariaceae	*Bacillaria* sp.	D20	Abundant
			Nitzschia sp	D21	Scattered
			Pseudo-Nitzschia sp.	D22	Very sparse
	Naviculales	Pinnulariaceae	*Pinnularia sp*	D23	Very sparse
		Pleurosigmataceae	*Pleurosigma* sp.	D24	Very sparse
	Surirellales	Entomoneidaceae	*Entomoneis sp.*	D29	Very sparse
		Surirellaceae	*Campylodiscus* sp	D26	Very sparse
Fragilariophyceae	Fragilariales	Fragilariaceae	*Asterionellopsis sp*	D27	Sparse
			*Fragilaria*sp	D28	Very sparse
			*Synedra*sp	D29	Very sparse
	Thalassionematales	Thalassionemataceae	*Thalassiothrix sp.*	D30	Very sparse
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Sparse
	Gonyaulacales	Pyrophacaceae	*Pyrophacus sp.*	DF2	Very sparse
		Ceratiaceae	*Ceratium furca*	DF3	Very sparse
			Ceratium fusus	DF4	Very sparse
			Ceratium tripos	DF5	Very sparse

TABLE 66. SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPA HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKSDURING NEAP TIDE OF OCTOBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnus sp.*	T1	Sparse
		Codonellidae	*Tintinnopsis dadayi*	T2	Very sparse
			Tintinnopsis failakkaensis	T3	Very sparse
			Tintinnopsis gracilis	T4	Very sparse
			Tintinnopsis radix	T5	Very sparse
		Xystonellidae	*Favella sp.*	T6	Sparse
Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Sparse
			Parvocalanus sp.	C2	Very sparse
		Acartiidae	*Acartia sp.*	C3	Very sparse
		Clausocalanidae	*Clausocalanus sp.*	C4	Very sparse
		Centropagidae	*Centropages sp.*	C5	Very sparse
		Eucalanidae	*Pareucalanus sp.*	C6	Very sparse
			Subeucalanus sp.	C7	Very sparse
		Temoridae	*Temora sp.*	C8	Very sparse
	Cyclopoida	Oithonidae	*Oithona sp.*	C9	Abundant
	Harpacticoida	Ectinosomatidae	*Microsetella* sp.	C10	Scattered
		Euterpinidae	*Euterpina sp.*	C11	Scattered
	Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C12	Very sparse
Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse
Malacostraca	Mysida, Decapoda	Penaeidae	*Metapenaeus sp.*	M1	Very sparse
		Solenoceridae	*Solenocera sp.*	M2	Very sparse
Appendicularia		Fritillariidae	*Fritillaria sp.*	U1	Very sparse
		Oikopleuridae	*Oikopleura sp.*	U2	Very sparse
Oligohymenophorea	Sessilida	Zoothamniidae	*Zoothamnium sp.*	CI1	Very sparse
Hydrozoa			Unidentified medusa	ME1	Very sparse
Copepoda			Nauplius larvae of copepods	L1	Dominant
Malacostraca Decapoda			Brachyuran zoea larvae	L2	Sparse
Maxillopoda Thecostraca			Cirripede larvae	L3	Sparse
			Cyphonautes larvae	L4	Very sparse
			Ophiopluteus larvae	L5	Very sparse
Polychaeta			Trochophore larvae	L6	Abundant
			Unidentified nematodes	N1	Very sparse

TABLE 67. SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING OF DPA HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKSDURING SPRING TIDES OF OCTOBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnus sp.*	T1	Sparse
		Codonellidae	*Tintinnopsis dadayi*	T2	Very sparse
			Tintinnopsis failakkaensis	T3	Very sparse
			Tintinnopsis gracilis	T4	Very sparse
			Tintinnopsis mortensenii	T5	Very sparse
			Tintinnopsis radix	T6	Very sparse
			Tintinnopsis tocantinensis	T7	Very sparse
		Tintinnidae	*Amphorides sp.*	T8	Very sparse
			Eutintinnus sp.	T9	Very sparse
		Xystonellidae	*Favella sp.*	T10	Sparse
Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Scattered
			Parvocalanus sp.	C2	Very sparse
		Acartiidae	*Acartia sp.*	C3	Sparse
		Clausocalanidae	*Clausocalanus sp.*	C4	Very sparse
		Centropagidae	*Centropages sp.*	C5	Very sparse
		Eucalanidae	*Subeucalanus sp.*	C6	Very sparse
		Temoridae	*Temora sp.*	C7	Very sparse
	Cyclopoida	Oithonidae	*Oithona sp.*	C8	Abundant
	Harpacticoida	Ectinosomatidae	*Microsetella* sp.	C9	Very sparse
		Euterpinidae	*Euterpina sp.*	C10	Sparse
	Poicilostomatatoida	Corycaeidae	*Corycaeus sp.*	C11	Very sparse
Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse
Malacostraca	Mysida, Decapoda	Penaeidae	*Metapenaeus sp.*	M1	Very sparse
Appendicularia		Fritillariidae	*Fritillaria sp.*	U1	Very sparse
		Oikopleuridae	*Oikopleura sp.*	U2	Very sparse
Oligohymenophorea	Sessilida	Zoothamniidae	*Zoothamnium sp.*	CI1	Very sparse
Hydrozoa			Unidentified medusa	ME1	Very sparse
Copepoda			Nauplius larvae of copepods	L1	Dominant
Malacostraca Decapoda			Brachyuran zoea larvae	L2	Abundant
Maxillopoda Thecostraca			Cirripede larvae	L3	Very sparse
			Cyphonautes larvae	L4	Very sparse
Superclass: Pisces			Fish larvae	L5	Very sparse
			Ophiopluteus larvae	L6	Very sparse
Polychaeta			Trochophore larvae	L7	Scattered

Pelecypoda			Veliger larvae of bivalves	L8	Very sparse
			Unidentified nematodes	N1	Very sparse

TABLE 68. SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPA OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINARDURING NEAP TIDE OF OCTOBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnus sp.*	T1	Sparse
		Codonellidae	*Tintinnopsis failakkaensis*	T2	Very sparse
			Tintinnopsis gracilis	T3	Very sparse
			Tintinnopsis mortensenii	T4	Very sparse
			Tintinnopsis radix	T5	Sparse
			Tintinnopsis tocantinensis	T6	Very sparse
		Xystonellidae	*Favella* sp.	T7	Abundant
Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Scattered
			Parvocalanus sp.	C2	Very sparse
		Eucalanidae	*Subeucalanus sp.*	C3	Very sparse
	Cyclopoida	Oithonidae	*Oithona sp.*	C4	Scattered
	Harpacticoida	Euterpinidae	*Euterpina sp.*	C5	Very sparse
		Ectinosomatidae	*Microsetella* sp.	C6	Very sparse
	Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C7	Very sparse
Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse
Malacostraca	Mysida, Decapoda	Penaeidae	*Metapenaeus sp.*	M1	Very sparse
Appendicularia		Fritillariidae	*Fritillaria sp.*	U1	Very sparse
		Oikopleuridae	*Oikopleura sp.*	U2	Very sparse
Copepoda			Nauplius larvae of copepods	L1	Dominant
Malacostraca Decapoda			Brachyuran zoea larvae	L2	Very sparse
Maxillopoda Thecostraca			Cirripede larvae	L3	Scattered
			Ophiopluteus larvae	L4	Very sparse
Gastropoda Streptoneura			Opisthobranchia larvae	L5	Very sparse
Polychaeta			Trochophore larvae	L6	Very sparse
Pelecypoda			Veliger larvae of bivalves	L7	Very sparse

TABLE 69. SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPAOOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING SPRING TIDE OF OCTOBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnus sp.*	T1	Sparse
		Codonellidae	*Tintinnopsis dadayi*	T2	Very sparse
			Tintinnopsis gracilis	T3	Very sparse
			Tintinnopsis radix	T4	Very sparse
		Xystonellidae	*Favella sp.*	T5	Sparse
Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Sparse
			Parvocalanus sp.	C2	Very sparse
		Centropagidae	*Centropages sp.*	C3	Very sparse
		Clausocalanidae	*Clausocalanus sp.*	C4	Very sparse
	Cyclopoida	Oithonidae	*Oithona sp.*	C5	Sparse
	Harpacticoida	Euterpinidae	*Euterpina sp.*	C6	Very sparse
		Ectinosomatidae	*Microsetella* sp.	C7	Very sparse
	Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C8	Very sparse
Malacostraca	Mysida, Decapoda	Penaeidae	*Metapenaeus sp.*	M1	Very sparse
		Solenoceridae	*Solenocera sp.*	M2	Very sparse
Copepoda			Nauplius larvae of copepods	L1	Scattered
Gastropoda Streptoneura			Opisthobranchia larvae	L2	Very sparse
Polychaeta			Trochophore larvae	L3	Very sparse
Pelecypoda			Veliger larvae of bivalves	L4	Very sparse

BENTHIC ORGANISMS:

Few Benthic organisms were observed in the collected sediments by using the Van-veen grabs during the sampling conducted during spring tide period and Neap tide period from DPA harbour region and nearby creek. The meio-benthic organisms during spring tide were represented by Polychaetes *Dasybranchus sp.*, *Brittle star larvae* and during Neap tide *by Ophelia sp.*and few AmphipodsPopulation of benthic fauna was varying from 10-60- N/m^2 during spring tide and 20-30 N/m^2 during Neap tide. The benthic communities at path finder Creek were represented by Polychaetes*Notomastus* sp. *Dasybranchus* sp. *Nephthys sp* and few Amphipods . Their population was varying as 100 N/m^2 at OOT jetty premises and 140 N/m^2 near the SPM area during spring tide and 20 N/m^2 at OOT jetty premises and 40 N/m^2 near the SPM area during Neap tide period.

TABLE 70. BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPA HARBOUR AREA CREEKS DURING SPRING TIDE IN OCTOBER 2022

ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS						
REPRESENTATION BY GROUP	**DPA HARBOUR**			**CREEKS**		
Benthic fauna						
POLYCHAETES	DPA-1	DPA-2	DPA-3	DPA-4	DPA-5	DPA-6
Family : CAPITELLIDAE *Dasybranchus sp.*	10	20	20	20	10	NS
Brittle star larvae	0	40	0	0	0	NS
TOTAL Benthic Fauna NUMBER/ M^2	10	60	20	20	10	NS

NS: No sample

TABLE 71. BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPA HARBOUR AREA CREEKS DURING NEAP TIDE IN OCTOBER 2022

ABUNDANCE IN NO/M^2 DIFFERENT SAMPLING STATIONS						
REPRESENTATION BY GROUP	**DPA HARBOUR**			**CREEKS**		
Benthic fauna						
POLYCHAETES	DPA-1	DPA-2	DPA-3	DPA-4	DPA-5	DPA-6
Family : Ophellidae *Ophelia sp.*	10	20	10	10	20	NS
Amphipoda	20	0	10	20	0	
TOTAL Benthic Fauna NUMBER/ M^2	30	20	20	30	20	NS

TABLE 72. BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPA OOT JETTY AREA, VADINAR DURING SPRING TIDE IN OCTOBER 2022

ABUNDANCE IN NO/M^2 DIFFERENT SAMPLING STATIONS		
REPRESENTATION BY GROUP	**OOT Jetty Area**	**SPM area**
POLYCHAETES		
Family : Capit*ellidae* *Notomastus* sp.	20	70
Family : Capit*ellidae* *Dasybranchus*sp.	40	10
Family: *Nephtyidae* *Nephthys sp*.	40	30
Amphipoda	0	30
TOTAL Benthic Fauna NUMBER/ M^2	100	140

TABLE 73. BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPA OOT JETTY AREA, VADINAR DURING NEAP TIDE IN OCTOBER 2022

ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS		
REPRESENTATION BY GROUP	**OOT Jetty Area**	**SPM area**
POLYCHAETES		
Family: *Nephtyidae* *Nephthys sp*.	20	10
FAMILY: *Orbinidae* *Scoloplos sp.*	0	30
TOTAL Benthic Fauna NUMBER/ M^2	20	40

11.0 Conclusive Summary and Remedial measures Suggested

- The AAQ monitoring of six locations at Deendayal Port Kandla indicates that the mean PM_{10} and $PM_{2.5}$ values for four locations viz. Marine Bhavan, Oil Jetty, Estate Office and Coal storage area were found higher than the permissible limit (standards100 µg/m^3, 60 µg/m^3). The higher concentration of Particulate matter at Marine Bhavan may be due to vehicles emissions during loading-unloading of food grains and timbers; at Estate office due to construction work, vehicles emission produced from trucks, heavy duty vehicles that pass through the road outside Kandla port and Oil jetty area; while at Coal Storage area lifting of coal from grab yard and other coal handling processes. Moreover, the transportation of coal produces pollution from heavy vehicles. At Tuna Port location, concentration of PM_{10} varied from 42-206 µg/m^3 and mean value was observed 128 µg/m^3 which was slightly exceed the prescribed standard limit (100 µg/m^3), concentration of $PM_{2.5}$ was ranged from 23-115 µg/m^3 and mean was found 60 µg/m^3 which was within the prescribed limit (60 µg/m^3). At Gopalpuri PM_{10} and $PM_{2.5}$ were found within permissible limit prescribed by NAAQS.
- At Vadinar, the average concentration of PM_{10} was 115 µg/m^3 and $PM_{2.5}$ was 67 µg/m^3 at Admin Colony which was slightly exceed the permissible limit and while at Signal building the concentration PM_{10} and $PM_{2.5}$ was within the permissible limit.
- Further, precautionary measures and management strategies to minimize the effect of particulate as well as gaseous pollutants have also been suggested for achieving its ambient levels in and around Kandla Port and Vadinar Port, Gujarat, India.

- Drinking water at all the twenty locations was found potable and it was found within in line of BIS standards (IS: 10500-2012).
- Transportation systems are the main source of noise pollution in project areas. Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. All sampling location were within the permissible limit day time 75 dB (A) and night time 70 dB (A) for the industrial area.

- The treated sewage water of Kandla STP, Deendayal Port Colony (Gopalpuri) STP and Vadinar were in line with the standards set by the Central Pollution Control Board.
- It was suggested to monitor the STP performance on regular basis to avoid flow of contamination / Polluted water into the sea.

- Good species diversity suggests a relatively successful species in this habitat. A greater number of successful species and a more stable ecosystem. More ecological niches are available and the environment is less likely to be hostile complex food webs environmental change is less likely to be damaging to the ecosystem as a whole.
- The results obtained from the study for biological and ecological parameters in marine water for Arabian Sea at surrounding area of Deendayal Port Authority (DPA) Kandla and Vadinar were not affected by Port activities.

The mean day time temperature at Deendayal Port was 29.87 °C. The Day time temperature ranged from 23.2-35.1°C. The mean night time temperature recorded was 27.91 °C. The night-time temperature ranged from 23.4-32.5°C. The mean Solar Radiation in October month was 185.99 w/m^2. The maximum solar radiation was recorded 856.7 w/m^2 on 01.10.2022 and the minimum solar radiation was recorded 1.106 w/m^2 29.10.2022. The mean Relative humidity was 74.90 % for the month of October. Maximum Relative humidity was recorded 98.0 % and minimum Relative humidity was recorded 30.0 %. The average wind velocity for the entire month of October was 1.22 m/s. Maximum wind velocity was recorded 6.50 m/s. The wind direction was mostly West-South.

- The results obtained from the study for the month of October 2022 for biological and ecological parameters in marine water for Arabian Sea at surrounding area of Deendayal Port Authority (DPA) Kandla and Vadinar were not affected by Port activities.

Reasons for higher Values of PM_{10}

- The unloading of coal directly in the truck, using grabs cause coal to spread in air as well as coal dust to fall on ground. This settled coal dust again mixes with the air while trucks travel through it.
- Also, the coal loaded trucks were not always covered with tarpaulin sheets and these results in spillage of coal from trucks/dumpers during its transit from vessel to yard or storage site. This also increased PM values around marine Bhavan & Coal storage area.

Remedial Measures

The values of PM_{10} & $PM_{2.5}$ during the month of October, 2022 were beyond the permissible limit at 4 locations (Coal Storage, Marine Bhavan, Oil Jetty and Estate office) except Gopalpuri while at the Tuna Port the concentration of particulate matter was slightly exceed . Given below are the remedial measures suggest to minimize the Air pollution.

- During October, 2022 overall ambient air quality of the DPA was within CPCB permissible limits except TSPM, PM_{10}, $PM_{2.5}$ at Coal storage area, Marine Bhavan, Oil Jetty and Estate Office. To improve air quality the port was using number of precautionary measures, such as maintained a wide expanse of Green zone, initiated Inter-Terminal Transfer (ITT) of tractor-trailers, Centralized Parking Plaza, providing shore power supply to tugs and port crafts, the use of LED lights at DPA area helps in lower energy consumption and decreases the carbon foot prints in the environment, time to time cleaning of paved and un paved roads, use of tarpaulin sheets to cover dumpers at project sites etc. are helping to achieve the cleaner and green future at port.

Solution towards the Green port:

Today, it is increasingly recognized that air pollution hurts human health. Consequently, efficient mitigation strategies need to be implementation for substantial environmental and health co-benefits.

The guidelines can be considered a basis for governments for the implementation of a strategic plan focused on the reduction of multi pollutant emission, as well as of the overall air pollution related risk.

- The plantation should be all along the periphery of the port and inside and outside the port along with the road. Trees having high dust trapping efficiency (*Azadirachta indica, Cassia fistula, Delonix regia, Ficus religiosa, Pterocarpus marsupium*) are to be grown alongside the roads.
- The water sprinkling should be use at each and every stage of transporting coal up the loading of truck to avoid generation of coal dust.
- The vehicles should be covered during transportation and the vehicle carrying the coal should not be overloaded by raising the height of carriage.

- The water sprinklers should be use during transportation of loaded heavy vehicles on raw road.
- It should be ensure that regular sweeping of coal internal, main road and space a free circulation.
- Practice should be initiated for using mask as preventative measure, to avoid Inhalation of dust particle- Mask advised in sensitive areas.
- Department for use maintenance should have a routine checkup noise level by replacing bearings, tights of all loose parts that can vibrate.
- Speed control is also an effective way to mitigate noise pollution, the lowest sound emission arise from vehicles moving smoothly.
- Use of renewable energy like solar energy should be optimal and ensure to work continuously.
- Keep neat and clean public transport and all basic items at public interaction places as much as possible.
- Technology like Electric cart, Inter-Terminal Transfer (ITT) are worthy selection to reduce Port operation efficiency and fuel cost.
- Conventional RTGCs should be altered as E-RTGCs counting inside the port completely.
- Initiate Natural Gas (CNG) as fuel by all buses and trucks.

Green Ports Initiative

- Deendayal Port is committed to sustainable development and adequate measures are being taken to maintain the Environmental well-being of the Port and its surrounding environs. Weighing in the environmental perspective for sustained growth, the Ministry of Shipping had started “Project Green Ports” which will help in making the Major Ports across India cleaner and greener. “Project Green Ports” will have two verticals - one is “Green Ports Initiatives” related to environmental issues and second is “Swachh Bharat Abhiyaan”.

- The Green Port Initiatives include twelve initiatives such as preparation and monitoring plan, acquiring equipments required for monitoring environmental pollution, acquiring dust suppression system, setting up of waste water treatment plants/ garbage disposal plant, setting up Green Cover area, projects for energy generation from renewable energy sources, completion of shortfalls of Oil Spill Response (OSR) facilities (Tier-I),

prohibition of disposal of almost all kind of garbage at sea, improving the quality of harbour wastes etc.

- Deendayal port has also appointed GEMI as an Advisor for "Making Deendayal Port a Green Port - Intended Sustainable Development under the Green Port Initiatives.
- Deendayal Port has also signed MOU with Gujarat Forest Department in August 2019 for Green Belt Development in an area of 31.942 Ha of land owned by Deendayal Port Trust. The plantation is being carried out by the Social Forestry division of Kachchh.

ENVIRONMENTAL MONITORING REPORT FOR DEENDAYAL PORT AUTHORITY

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ENVIRONMENTAL MONITORING PLAN FOR DEENDAYAL PORT ENVIRONMENTALMONITORING REPORT- NOVEMBER, 2022

1. EXECUTIVE SUMMARY

Monitoring of various environmental aspects of the Deendayal port by M/s Detox Corporation Pvt. Ltd. has been carried out through collection of samples, analysis of the same, comparing results with respect to the national standards and any other relevant standards by GBCB/CPCB/MoEF & CC to understand status of various parameters in the Environment of the Deendayal Port. The results shall address the identified impacts and suggest measures to minimize the environmental impact due to various operations at Deendayal Port.

A) Ambient Air

The monitoring of Ambient Air quality at 6-locations at Deendayal Port Authority Kandla and 2- location at Vadinar Port on 24 hourly basis for TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2, NH_3, CO_2, CO, C_6H_6 and NMHC in twice a week 24 hourly at uniform intervals (as per NAAQS) at Gopalpuri, Tuna Port, Marine Bhavan Building, Coal storage area, Estate building, Oil jetty and at Vadinar port, Vadinar Jetty and Vadinar colony area using respirable dust sampler, Fine particulate sampler and gaseous sampler.

The Maximum TSPM values in month of November 2022 were found 846 µg/m^3 at Coal Storage area on 25.11.2022 and minimum 107 µg/m^3 at Gopalpuri Hospital on 01.11.2022. The Maximum PM_{10} values were 654 µg/m^3 at Coal Storage area on 25.11.2022 and minimum was 67 µg/m^3 at Gopalpuri Hospital 01.11.2022. Maximum $PM_{2.5}$ values were 187 µg/m^3 at Coal Storage area on 25.11.2022 and minimum was 34 µg/m^3 at Gopalpuri on 01.11. 2022. The PM_{10} and $PM_{2.5}$ values were found for all monitoring locations (Marine Bhavan Building, Oil Jetty, Estate Office, Gopalpuri, Coal Storage Area and Tuna Port) to exceed the Standard limit (NAAQS).

At Gopalpuri location the mean concentration of PM_{10} was 127 µg/m^3 & $PM_{2.5}$ was 66 µg/m^3 which are slightly exceed the Standard limit (NAAQS).

The AAQ monitoring for Vadinar at Admin building the mean TSPM, PM_{10} and $PM_{2.5}$ were 237µg/m^3, 138 µg/m^3 and 97 µg/m^3 respectively which was exceed the Standard limit (NAAQS) the while at Signal Building the mean TSPM, PM_{10} and $PM_{2.5}$ were 113 µg/m^3 , 74 µg/m^3 and 38 µg/m^3 respectively slightly exceed the Standard limit (NAAQS).

The overall values of November for Gaseous SO_2, NO_2, NH_3, CO_2, CO, C_6H_6 concentration were within the permissible limit at all location and NMHC were found BQL (Below Quantification Limit).

B) Weather

The mean day time temperature at Deendayal Port was 27.92 °C. The day-time maximum temperature was 32.9°C and minimum was 21.1 °C. The mean night time temperature recorded was 25.47 °C. The night-time maximum temperature was 29.7°C and minimum was 20.0 °C. The mean Solar Radiation in November month was 167.27 w/m^2. The maximum solar radiation was recorded 759 w/m^2 in 4th November, 2022 and the minimum solar radiation was recorded 1.80 w/m^2 in 30th November, 2022. The mean Relative humidity was 69.00 % for the month of November. Maximum Relative humidity was recorded 99.0 % and minimum Relative humidity was recorded 34.0 %. The average wind velocity for the entire month of November was 1.21 m/s. Maximum wind velocity was recorded 10.19 m/s. The wind direction was mostly West-South.

C) Marine Ecology (Flora and Fauna) / Marine Water / Sediments:

The results obtained from the study for the month of November 2022 for biological and ecological parameters in marine water for Arabian Sea at surrounding area of Deendayal Port Authority (DPA) Kandla and Vadinar were not affected by Port activities.

D) Drinking Water Quality

The drinking water being supplied to Deendayal Port Authority was safe for drinking purpose. At all drinking water monitoring stations around port area were in line with the standard limit as per the drinking water specifications given in IS 10500:2012 as per tested parameters only.

The average results for 20 locations were as: pH were found Min 7.24 and maximum 7.52, TDS were found min 300.0 mg/l and Max found 1060.0 mg/l, Chloride were found Min 140.31 mg/l and Max 576.28 mg/l, Total Hardness were found Min 270.0 mg/l and Max 380.0 mg/l and Calcium were found Min 34.47 mg/l and Max 43.29 mg/l, color were colorless and odor were odorless. In all water samples BOD, Heavy metal like manganese, Hexavalent chromium, Copper, Cadmium, Arsenic, Mercury, Lead, zinc all are found BQL (Below Quantification Limit). The bacterial count (E-coli & Coliform) is absent in all drinking water samples.

E) Monitoring Performance of Sewage Treatment Plant

It was seen that the performance of STP at Deendayal Township Gopalpuri, DPA STP Plant Kandla and Vadinar STP plant was satisfactory by overall. The treatment plant was well maintained during [November 2022] with considerable removal efficiency achieving the standards prescribed for final disposal. At Gopalpuri STP, the pollutant removal efficiency for TSS, BOD and COD was ranged from 49.66-81.04%, 58.97-68.42% and 45.45-73.33% respectively. At Kandla STP, removal efficiency for TSS, BOD and COD was ranged from 53.47-73.49%, 46.15-76.74% and 50.00-82.35% respectively & at Vadinar STP removal efficiency for TSS, BOD and COD was ranged from 42.09-56.69%, 50.00-78.12% and 60.00-84.61% respectively. At all STP location treated waste water the pH were ranged from 7.21-7.42,Total Suspended Solids were found 16.9-67.9 mg/l , Residual Chlorine were below Detection Limit (< 0.5) , COD were found 20-60 mg/l and 3day BOD @ 27 °C were found 7.0-16.0 mg/l.

F) Noise

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. The Day Time Noise Level (SPL) in all 10 locations at Deendayal Port Authority ranged from 53.2 dB(A) to 70.4 dB(A) while at Vadinar port 3 location ranged from 52.5 dB(A) to 60.6 dB(A) which was within the permissible limits of 75 dB(A) for the industrial area for the daytime. The Night Time Average Noise Level (SPL) in all locations of Deendayal Port Authority ranged from 45.4 dB to 61.7 dB(A) while at Vadinar port ranged from 52.5 dB (A) to 60.6 dB(A) which was within the permissible limits of 70 dB(A) for the industrial area for the night time.

1.0 Introduction

About Deendayal Port

The Deendayal Port is situated in the Kandla Creek and is 90 Kms. From the mouth of Gulf of Kachchh. Latitude: 23° 01" N Longitude: 70° 13"E. Deendayal Port's journey began in 1931 with construction of RCC Jetty by Maharao Khengarji. After partition, Deendayal Port's success story has continued and it rise to the No. 1 Port in India in the year 2007-08 and since then retained the position for the 15 consecutive year. On 31.03.2016, Deendayal Port created history by handling 100 MMT cargoes in a year, the first Major Port to achieve the milestone. Kandla, also known as the Deendayal Port Authority is a seaport in Kutch District of Gujarat state in western India, near the city of Gandhidham. Located on the Gulf of Kutch, it is one of major ports on west coast. Kandla was constructed in the 1950s as the chief seaport serving western India, after the partition of India from Pakistan left the port of Karachi in Pakistan. The Port of Deendayal is located on the Gulf of Kutch on the northwestern coast of India some 256 nautical miles North West of the Port of Karachi in Pakistan and over 430 nautical miles north-northwest of the Port of Mumbai (Bombay). It is the largest port of India by volume of cargo handled. Kandla history Deendayal Port Authority, India's busiest major port in recent years, is gearing to add substantial cargo handling capacity with private sector participation. Deendayal port Authority creates a new record by handling 127.10 million metric tons of cargo during the FY 2021-22, as against 117.566 million metric tons in FY 2020-21. Showing a growth of 8.11 %. Incidentally, DPA is the only major Indian port of handle more than 127 MMT cargo throughout and it has also registered the highest cargo throughput in its history. While the port has flagged off several projects related to infrastructure creation, DPA has successfully awarded the work of augmentation of liquid cargo handling capacity by revamping the existing pipeline network at the oil jetty area in Sept. 2021. Even as much of this growth has come from handling of crude oil imports, mainly for Essar Oil's Vadinar refinery in Gujarat, the port is also taking measures to boost non-POL cargo. Last fiscal, POL traffic accounted for 63 per cent of the total cargo handled at Deendayal Port, as against 59% in 2007-08. The Deendayal Port Authority had commissioned the Off-shore Oil Terminal facilities at Vadinar in the year 1978, for which M/s. Indian Oil Corporation Limited (IOCL) provided Single Bouy Mooring (SBM) system, having a capacity of 54 MMTPA, which was first of its kind in India. Further, significant. Quantum of infrastructural up-gradation has been affected & excellent maritime infrastructure been created at Vadinar for the 32 MMTPA Essar Oil Refinery in Jamnagar District. Monitoring of various environmental aspects of the Deendayal port by M/s Detox Corporation Pvt. Ltd. has been carried out through collection of samples, analysis of the same, comparing results with respect to the prescribed standards by GPCB/CPCB/MoEF& CC. The results shall address the identified impacts and suggest measures to minimize the environmental impact due to various operations at Deendayal Port. The environmental monitoring is carried out as per the Environment Management and Monitoring Plan submitted by Detox Corporation Pvt. Ltd.

2. Introduction

Air pollutants are added in the atmosphere from variety of sources that change the composition of atmosphere and affect the biotic environment. The concentration of air pollutants depend not only on the quantities that are emitted from air pollution sources but also on the ability of the atmosphere to either absorb or disperse these emissions. The air pollution concentration vary spatially and temporarily causing the air pollution pattern to change with different locations and time due to changes in meteorological and topographical condition. Air pollution occurs when harmful substances including particulates and biological molecules are introduced into earth's atmosphere. It may cause diseases, allergies or death of humans; it may also cause harm to other living organisms such as animals and food crops, and may damage the natural or built environment. Human activity and natural processes can both generate air pollution. A physical, biological or chemical alteration to the air in the atmosphere can be termed as pollution. It occurs when any harmful gases, dust, smoke enters into the atmosphere and makes it difficult for plants, animals and humans to survive as the air becomes dirty. The consequences of industrialization and the demand for improved quality of life has been increased exposure to air pollution (Vallero, 2014). An air pollutant is a substance in the air that can have adverse effects on humans and the ecosystem. The substance can be solid particles, liquid droplets, or gases. A pollutant can be of natural origin or man-made. Pollutants are classified as primary or secondary. Any gas could qualify as pollution if it reached a high enough concentration to do harm. Theoretically, that means there are dozens of different pollution gases. In practice, about ten different substances cause most concern. Heavy metals represent a class of omnipresent pollutants, with toxic potential, in some cases even at low exposure levels. They concentrate in each tropic level because of their weak mobility, so the concentration in plants is higher than in soil, in herbivore animals higher than in plants, in carnivores' tissues higher than in herbivore, the highest concentration being reached at the end of the tropic chain, at big predacious and human bodies.

Globally, one of the main contributors to emissions of atmospheric pollutants and a significant user of energy is the industrial sector (Conti et al. 2015).

The concentration of air pollutants depends not only on the quantities that are emitted from the polluting sources, but also on the ability of the atmosphere to either absorb or disperse such emissions (USEPA, 2008).

Nowadays, the shipping sector provides low-cost and reliable delivery services in the economic field (Arunachalam et al. 2015). Nevertheless, shipping-related activities have a considerable impact on air pollution, especially in coastal areas but also globally (Buccolieri et al. 2016). The primary air pollutants are PM, VOCs, NOx, O_3, SO_2, and CO (Bailey and Solomon 2004). As a consequence, a wide range of options toward "greener" seaports is needed (Bailey and Solomon 2004). Some of these measures are easy to adopt such as the regulation of fuel quality (by using low-sulfur alternative fuels), the speed reduction (Lack et al. 2011), and the use of alternative transportation equipment (Lai et al. 2011).

Clean air is the basic requirement of all living organisms. In recent times, due to population growth, urban sprawl, industrial development, and vehicular boom, the quality of air is deteriorating and being polluted. Pollutants of major public health concerns include particulate matter, carbon monoxide, ozone, nitrogen dioxide, and sulfur dioxide, which pose serious threats to human health and hygiene. In the present study, prime particulate pollutants (PM_{10}, $PM_{2.5}$), and gaseous pollutants (SO_2, and NO_2) were estimated at seven stations in and around Dahej Port, Gujarat, India (Soni and Jagruti Patel, 2017).

Among particulate pollutants, particulate matter (PM) is a ubiquitous entity, and is especially a grave problem due to its higher suspension rate into the atmosphere, and adverse health effects on plants, animals, humans, and materials in the form of visibility reduction, soiling of buildings, etc. (Horaginamani and Ravichandran, 2010; Chaurasia *et al*., 2013).

The sources of air pollutants include vehicles, industries, domestic sources and natural sources. Because of the presence of high amount of air pollutants in the ambient air, the health of the population and property is getting adversely affected. In order to arrest the deterioration in air quality, Govt. of India has enacted Air (Prevention and Control of Pollution) Act in 1981. The responsibility has been further emphasized under Environment (Protection) Act, 1986. It is necessary to assess the present and anticipated air pollution through continuous air quality survey/monitoring programs. Therefore, Central Pollution Control Board had started National Ambient Air Quality Monitoring (NAAQM) Network during 1984 - 85 at national level. The programme was later renamed as National Air Quality Monitoring Programme (NAMP).

2.1 Ambient Air Quality Monitoring

As per the Environmental Monitoring Plan of Deendayal Port Authority, Air monitoring was carried out at six identified locations at Deendayal Port and two locations at Vadinar Port.

Table: 1. Ambient Air Sampling Location

Sr. No.	Name of Location	Location Code	Latitude	Longitude	Remarks
1.	Marine Bhavan	AL-1	23° 0' 26.524"N	70° 13' 22.414"E	**DPA-Kandla**
2.	Oil Jetty	AL-2	23° 1' 45.613"N	70° 13' 11.052"E	
3.	Estate Office	AL-3	23° 1' 11.273"N	70° 12' 48.657"E	
4.	Gopalpuri Hospital	AL-4	23° 4' 53.551"N	70° 8' 7.047"E	
5.	Coal Storage Area	AL-5	22° 59' 31.812"N	70° 13' 9.979"E	
6.	Tuna Port	AL-6	22° 59' 15.291"N	70° 58' 57.018"E	
7.	Signal Building	AL-7	22° 26' 26.750"N	69° 40' 22.127"E	**DPA-Vadinar**
8.	Admin Building	AL-8	22° 26' 25.223"N	69° 40' 19.358"E	

- **Air Quality Monitoring Methodology**

Air quality is measured in all the stations, for 24 hour for Total Suspended Particulate Matter (TSPM), PM_{10}, $PM_{2.5}$, SO_2, NO_2, NH_3 & Benzene and Grab-sampling for CO & CO_2 measurements. The Air samplers are operated for a period of 24 hours and after a continuous operation of 8 hours for gaseous parameters. The absorbing reagents for SO_2:- Absorbing Reagent TCM (Potassium Tetrachloromercurate 0.04M): Mercuric Chloride, Potassium Chloride and EDTA used. For NO_2:- Absorbing Reagent Sodium Hydroxide (NAOH): Sodium Hydroxide and Sodium Arsenite used. For NH_3 need Conc. Sulphuric Acid and Distilled water was used. By replacing 3 times the reagents per day for each parameter namely, SO_2, NO_2, NH_3. The GFA filter paper and PTFE Membrane bound filter paper are used for a period of 24 hours to obtain one sample each of TSPM, PM_{10} & $PM_{2.5}$. The AAQ samples are collected two consecutive days a week as per CPCB guidelines, from all the eight locations as mentioned in the EMP.

2.2 Results

The ambient air quality monitoring data for six stations, viz. Marine Bhavan, Oil Jetty, Port Colony, Gopalpuri Hospital, Tuna Port and Nr. Coal Storage Area for the month of November 2022 are given in Tables 2 to 7. The ambient air quality monitoring data for two stations at Vadinar (Nr. Admin Building & Nr. Signal Building) are given in Tables 8 to 9.

The Movement of heavy transport with uncovered coal transportation, raw road around ambient location may be causes fugitive dust emission from dry conditions. Particulate Matter then enters the atmosphere through the action of wind, vehicular movement, or other activities. The dust produces tends to float in air and spread all around the vicinity. Direction and speed of wind affect the dispersion of the dust particulate matter. Humidity of air also has strong effect on the spreading of particulate matter. With increasing humidity, moisture particles eventually grow in size to a point where 'dry deposition' occurs, reducing PM_{10} concentrations in the atmosphere.

Location 1: Marine Bhavan (AL1)

Table 2 : Results of Air Pollutant Concentration at Marine Bhavan										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS Limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL1 – 1	01.11.2022	435	302	121	3.93	3.93	5.19	14.43	2.07	4.11
					6.04		23.66		6.33	
					1.81		14.43		3.91	
AL1 – 2	04.11.2022	344	228	106	3.32	2.52	17.31	12.70	2.42	3.72
					2.72		8.66		5.18	
					1.51		12.12		3.57	
AL1 – 3	08.11.2022	398	281	116	2.31	3.84	25.39	17.31	4.72	3.57
					6.34		17.89		2.42	
					2.88		8.66		3.57	
AL1 – 4	11.11.2022	445	315	124	3.63	6.35	17.89	13.08	4.03	3.61
					9.07		12.70		4.72	
					6.35		8.66		2.07	
AL1 – 5	15.11.2022	364	253	110	4.53	4.53	11.54	13.85	4.60	3.07
					6.35		19.62		2.88	
					2.72		10.39		1.73	
AL1 - 6	18.11.2022	442	315	121	8.46	4.84	23.08	16.54	3.22	4.37
					3.32		8.66		5.87	
					2.72		17.89		4.03	
AL1 - 7	22.11.2022	375	266	106	3.32	4.43	17.89	18.47	4.83	4.45
					7.55		25.97		5.87	
					2.42		11.54		2.65	
AL1 – 8	25.11.2022	483	350	129	4.53	4.63	23.66	21.55	3.22	3.68
					6.95		28.86		5.29	
					2.42		12.12		2.53	
AL1 – 9	29.11.2022	534	383	142	6.35	5.84	17.89	19.04	3.57	3.57
					8.46		25.97		4.95	
					2.72		13.27		2.19	
Monthly Average		424	299	119		4.55		16.33		3.79
Standard Deviation		61	48	12		1.12		3.03		0.44

Table 2 : Results of Air Pollutant Concentration at Marine Bhavan					
	Date	**C6H6 [µg/m3]**	**HC**	**CO [mg/m3]**	**CO2 [ppm]**
Sampling Period		**8 hr**		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**	**ppm**	**4.0 mg/m3**	**-**
AL1 – 1	01.11.2022	1.09	BQL	1.44	444
AL1 – 2	04.11.2022	1.2	BQL	1.54	374
AL1 – 3	08.11.2022	1.17	BQL	1.08	538
AL1 – 4	11.11.2022	1.1	BQL	1.14	470
AL1 – 5	15.11.2022	1.11	BQL	1.26	481
AL1 - 6	18.11.2022	1.1	BQL	1.64	500
AL1 - 7	22.11.2022	1.12	BQL	1.35	620
AL1 - 8	25.11.2022	1.16	BQL	1.69	511
AL1 - 9	29.11.2022	1.21	BQL	1.16	522
Monthly Average		**1.14**	**-**	**1.37**	**495.56**
Standard Deviation		**0.05**	**-**	**0.22**	**67.59**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

At Marine Bhavan, the overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 is attributed mainly by motor vehicle emission produced from various types of automobiles (both diesel and petrol driven). Moreover, the loading and unloading of Food Grains and Timber at Jetty no. 1 and 2 also contributes to the high levels of TSPM and PM_{10}. The mean TSPM value at Marine Bhavan was 424 µg/m^3, the mean PM_{10} value was 299 µg/m^3, and $PM_{2.5}$ value was 119 µg/m^3 which is above the permissible limit prescribed by NAAQS. The average values of SO_2, NO_2 and NH_3 were 4.55 µg/m^3, 16.33 µg/m^3 & 3.79 µg/m^3 respectively; these values were within the standard limit prescribed by NAAQS.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Marine Bhavan. The mean Benzene concentration was 1.14 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.37 mg/m^3, well below the permissible limit of 4.0 mg/m^3 prescribed by NAAQS.

Location 3: Oil Jetty (AL2)

Table 2 : Results of Air Pollutant Concentration at Oil Jetty										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS Limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL2 -1	01.11.2022	150	99	50	2.42	3.22	6.35	13.66	2.88	4.53
					4.53		13.27		6.79	
					2.72		21.35		3.91	
AL2 -2	04.11.2022	253	180	70	2.72	3.53	5.77	11.73	0.81	3.18
					3.32		17.89		4.03	
					4.53		11.54		4.72	
AL2 -3	08.11.2022	235	166	67	2.59	2.50	5.19	14.04	2.19	2.80
					3.46		13.27		2.65	
					1.44		23.66		3.57	
AL2 -4	11.11.2022	275	194	76	6.35	4.53	10.39	14.24	2.42	2.42
					4.53		20.20		3.80	
					2.72		12.12		1.04	
AL2 – 5	15.11.2022	245	169	71	3.02	4.53	8.66	14.04	3.57	2.38
					6.65		16.16		2.30	
					3.93		17.31		1.27	
AL2 – 6	18.11.2022	185	119	53	5.74	4.94	14.43	13.47	4.95	3.84
					2.72		17.31		3.57	
					6.35		8.66		2.99	
AL2 – 7	22.11.2022	373	252	109	3.02	4.03	20.20	14.24	3.80	3.80
					6.35		12.12		5.53	
					2.72		10.39		2.07	
AL2 -8	25.11.2022	292	199	86	1.81	3.83	14.43	14.43	3.57	4.76
					6.35		19.62		4.72	
					3.32		9.23		5.99	
AL1 – 9	29.11.2022	299	194	97	3.63	4.63	5.19	13.47	2.88	3.49
					7.55		23.66		4.95	
					2.72		11.54		2.65	
Monthly Average		256	175	75		3.97		13.70		3.47
Standard Deviation		65	45	19		0.79		0.81		0.85

Table 3 : Results of Air Pollutant Concentration at Oil Jetty					
	Date	**C_6H_6 [µg/m^3]**	***NMHC**	**CO [mg/m^3]**	**CO2 [ppm]**
Sampling Period		**8 hr**		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL2-1	01.11.2022	1.17	BQL	1.22	467
AL2-2	04.11.2022	1.01	BQL	1.53	451
AL2-3	08.11.2022	1.1	BQL	1.65	502
AL2-4	11.11.2022	1.19	BQL	1.04	447
AL2 –5	15.11.2022	1.24	BQL	1.27	634
AL2 –6	18.11.2022	1.16	BQL	1.22	531
AL2-7	22.11.2022	1.2	BQL	1.28	800
AL2-8	25.11.2022	1.06	BQL	1.89	1023
AL2-9	29.11.2022	1.22	BQL	1.46	576
Monthly Average		**1.15**	**-**	**1.40**	**603.44**
Standard Deviation		**0.08**	**-**	**0.26**	**193.07**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

Oil Jetty Area, the overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 was mainly by motor vehicle emission produced from various types of vehicles at Oil Jetty Area. The mean TSPM value at Oil Jetty was 256 µg/m^3. The mean PM_{10} value was 175 µg/m^3 and mean $PM_{2.5}$ value was 75 µg/m^3 which was above the permissible limit. The average values of SO_2, NO_2 and NH_3 were within the permissible limit prescribed by NAAQS. The mean concentration of SO_2, NO_2 and NH_3 were 3.97 µg/m^3, 13.70 µg/m^3 and 3.47 µg/m^3 respectively.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Oil Jetty. The mean Benzene concentration was 1.15 µg/m^3 which was well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.40 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 3: Kandla Colony – Estate Office (AL-3)

Table 4 : Results of Air Pollutant Concentration at Estate Office										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS Limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL3 – 1	01.11.2022	245	172	69	1.51	2.32	10.39	9.62	3.68	5.10
					3.32		13.27		7.02	
					2.12		5.19		4.60	
AL3 – 2	04.11.2022	577	445	130	4.53	2.32	5.19	10.39	3.57	2.49
					1.51		17.31		2.88	
					0.91		8.66		1.04	
AL3 – 3	08.11.2022	440	321	109	6.05	3.94	19.04	12.31	4.72	3.64
					2.59		12.12		2.42	
					3.17		5.77		3.80	
AL3 – 4	11.11.2022	518	403	111	3.32	4.23	18.47	10.58	1.38	2.42
					2.72		8.66		3.57	
					6.65		4.62		2.30	
AL3 – 5	15.11.2022	451	340	107	1.81	3.73	23.08	15.97	3.22	2.42
					6.04		14.43		2.30	
					3.32		10.39		1.73	
AL3 – 6	18.11.2022	459	346	112	4.53	4.43	16.16	15.97	5.76	4.14
					2.72		8.66		4.72	
					6.04		23.08		1.96	
AL3 – 7	22.11.2022	453	325	116	2.42	4.33	19.62	17.31	3.91	3.84
					4.23		23.66		5.18	
					6.35		8.66		2.42	
AL3 – 8	25.11.2022	337	252	83	6.04	3.93	15.00	15.58	3.80	3.91
					3.32		23.08		5.76	
					2.42		8.66		2.19	
AL1 – 9	29.11.2022	491	359	129	4.84	4.63	17.89	16.16	3.57	3.57
					6.95		24.24		5.18	
					2.12		6.35		1.96	
Monthly Average		441	329	107		3.76		13.77		3.50
Standard Deviation		98	80	20		0.87		3.00		0.91

Table 4 : Results of Air Pollutant Concentration at Estate Office					
Sampling Period	**Date**	**C_6H_6 [µg/m^3]**	***NMHC**	**CO [mg/m^3]**	**CO_2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL3 -1	01.11.2022	1.06	BQL	1.27	508
AL3 -2	04.11.2022	1.1	BQL	1.19	508
AL3 -3	08.11.2022	1.1	BQL	1.65	502
AL3 -4	11.11.2022	1.09	BQL	1.83	429
AL3 – 5	15.11.2022	1.09	BQL	1.76	813
AL3 – 6	18.11.2022	1.2	BQL	1.14	559
AL3 – 7	22.11.2022	1.19	BQL	2.18	1022
AL3 – 8	25.11.2022	1.11	BQL	2	1026
	29.11.2022	1.06	BQL	1.22	537
Monthly Average		**1.11**	**-**	**1.58**	**656.00**
Standard Deviation		**0.05**	**-**	**0.39**	**234.02**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 at Kandla Port Colony (Estate Office) was attributed by vehicle emission produced from trucks and heavy duty vehicles that pass through the road outside Kandla Port Colony. The mean TSPM values at Estate Office were 441 µg/m^3, the mean PM_{10} value was 329 µg/m^3, and $PM_{2.5}$ value was 107 µg/m^3 which was above the permissible limit prescribed by NAAQS. The average values of SO_2, NO_2 and NH_3 were 3.76 µg/m^3, 13.77 µg/m^3 and 3.50 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Kandla Port Colony. The mean Benzene concentration was 1.11 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide was 1.58 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 4: Gopalpuri Hospital (AL-4)

Table 5 : Results of Air Pollutant Concentration at Gopalpuri Hospital										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS Limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL4 -1	01.11.2022	107	67	34	1.21 3.02 2.42	2.22	5.77 10.39 4.62	6.93	2.42 4.14 1.04	2.53
AL4 -2	04.11.2022	177	117	54	0.91 4.53 1.21	2.22	5.19 8.66 16.16	10.00	1.61 2.42 3.45	2.49
AL4 -3	08.11.2022	148	101	44	1.15 2.88 2.59	2.21	6.93 17.31 5.19	9.81	1.73 2.42 0.92	1.69
AL4 -4	11.11.2022	184	111	68	1.51 3.63 2.72	2.62	6.93 14.43 17.31	12.89	1.04 2.42 3.45	2.30
AL4 – 5	15.11.2022	202	125	72	2.12 3.63 1.51	2.42	12.12 8.66 17.31	12.70	2.42 3.45 1.61	2.49
AL4 – 6	18.11.2022	233	153	78	1.21 4.84 2.72	2.92	8.66 17.89 12.12	12.89	2.42 1.61 3.45	2.49
AL4 – 7	22.11.2022	268	168	94	0.60 3.32 2.72	2.22	5.77 14.43 17.89	12.70	1.73 3.68 3.22	2.88
AL4 – 8	25.11.2022	202	142	56	2.12 5.14 3.02	3.42	14.43 17.89 5.19	12.50	2.07 4.03 2.88	2.99
AL1 – 9	29.11.2022	249	157	91	3.02 6.35 2.72	4.03	8.66 20.20 5.77	11.54	1.38 3.80 2.30	2.49
Monthly Average		197	127	66		2.70		11.33		2.49
Standard Deviation		50	32	20		0.65		2.05		0.37

Table 5 : Results of Air Pollutant Concentration at Gopalpuri Hospital					
Sampling Period	**Date**	**C_6H_6 [µg/m^3]**	***NMHC**	**CO [mg/m^3]**	**CO_2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL4 -1	01.11.2022	1.14	BQL	1.26	503
AL4 -2	04.11.2022	1.15	BQL	1.26	450
AL4 -3	08.11.2022	1.03	BQL	1.73	506
AL4 -4	11.11.2022	1.02	BQL	1.82	462
AL4 – 5	15.11.2022	1.09	BQL	1.04	1048
AL4 – 6	18.11.2022	1.14	BQL	1.32	543
AL4 – 7	22.11.2022	1.16	BQL	1.83	758
AL4 – 8	25.11.2022	1.22	BQL	1.8	816
AL4 – 9	29.11.2022	1.16	BQL	1.36	665
Monthly Average		**1.12**	**-**	**1.49**	**639.00**
Standard Deviation		**0.07**	**-**	**0.30**	**201.83**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 at Gopalpuri Hospital was attributed by vehicle emission produced from light motor vehicles of the colony residents. The mean TSPM values at Gopalpuri Hospital were 197 µg/m^3, the mean PM_{10} value was 127 µg/m^3 and $PM_{2.5}$ was 66 µg/m^3 which was exceed the standard limit. The average values of SO_2, NO_2 and NH_3 were 2.70 µg/m^3, 11.33 µg/m^3 and 2.49 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Gopalpuri Hospital. The mean Benzene concentration was 1.12 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon monoxide concentration was 1.49 mg/m^3 which is well below the permissible limit of 4.0 mg/m^3.

Location 5: Coal Storage Area (AL-5)

Table 6 : Results of Air Pollutant Concentration at Coal Storage Area										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS Limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL6 – 1	01.11.2022	779	598	175	2.72 6.65 3.63	4.33	6.35 25.97 17.31	16.54	3.68 8.17 3.34	5.06
AL6 – 2	04.11.2022	635	492	137	2.12 5.44 3.02	3.53	23.08 12.12 17.89	17.70	6.79 8.17 4.83	6.60
AL6 – 3	08.11.2022	538	412	125	8.94 3.46 2.59	5.00	23.66 12.12 29.43	21.74	2.53 2.07 7.02	3.88
AL6 – 4	11.11.2022	815	635	178	4.53 2.72 6.95	4.73	18.47 8.66 25.97	17.70	5.87 2.65 4.72	4.41
AL6 – 5	15.11.2022	792	614	176	6.35 9.07 4.53	6.65	18.47 10.39 12.12	13.66	4.72 3.68 3.22	3.88
AL6 – 6	18.11.2022	771	595	171	9.37 5.74 6.35	7.15	20.20 8.08 23.08	17.12	4.83 2.53 5.76	4.37
AL6 – 7	22.11.2022	706	543	156	4.84 6.04 2.72	4.53	10.39 23.66 21.35	18.47	4.83 5.99 4.26	5.03
AL6 – 8	25.11.2022	846	654	187	3.32 7.86 4.53	5.24	17.31 25.97 16.16	19.81	3.91 6.91 4.03	4.95
AL1 – 9	29.11.2022	801	621	172	5.14 9.07 2.72	5.64	16.16 28.86 9.81	18.28	3.57 6.22 3.11	4.30
Monthly Average		743	574	164		5.20		17.89		4.72
Standard Deviation		99	78	21		1.14		2.22		0.84

Table 6 : Results of Air Pollutant Concentration at Coal Storage Area					
Sampling Period	**Date**	**C_6H_6 [µg/m^3]**	***NMHC**	**CO [mg/m^3]**	**CO_2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL5 – 1	01.11.2022	1.1	BQL	1.12	483
AL5 – 2	04.11.2022	1.06	BQL	1.48	475
AL5 – 3	08.11.2022	1.08	BQL	1.66	421
AL5 – 4	11.11.2022	1.06	BQL	1.69	492
AL5 – 5	15.11.2022	1.06	BQL	1.06	702
AL5 – 6	18.11.2022	1.22	BQL	1.18	483
AL5 – 7	22.11.2022	1.11	BQL	1.86	564
AL5 – 8	25.11.2022	1.2	BQL	1.54	777
AL5 – 9	29.11.2022	1.22	BQL	1.89	895
Monthly Average		**1.12**	**-**	**1.50**	**588.00**
Standard Deviation		**0.07**	**-**	**0.31**	**164.11**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 at Coal Storage Area was comparatively highest among all the locations of Air Quality monitoring in Kandla Port. High values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 at this location was due to lifting of coal with grab and other coal handling processes near Berth no. 6 & 7. Moreover, the traffic was also heavy around this place for transport of coal thus emissions produced from heavy vehicles. The mean TSPM values at Coal storage were 743 µg/m^3, the mean PM_{10} value was 574 µg/m^3, and the $PM_{2.5}$ value was164 µg/m^3 which was above the permissible limit prescribed by NAAQS. The average values of SO_2, NO_2 and NH_3 were 5.20 µg/m^3, 17.89 µg/m^3 and 4.72 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Coal Storage Area. The mean Benzene concentration was1.12 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.50 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 6: Tuna Port (AL-6)

Table 7 : Results of Air Pollutant Concentration at Tuna Port										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS Limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL5 -1	01.11.2022	141	88	47	0.91	1.61	2.89	6.16	2.07	2.84
					2.72		12.12		4.03	
					1.21		3.46		2.42	
AL5 – 2	04.11.2022	232	166	64	1.51	2.22	6.35	7.89	1.38	2.76
					3.02		5.19		4.49	
					2.12		12.12		2.42	
AL5 – 3	08.11.2022	184	120	55	1.44	2.40	10.39	13.08	1.73	2.61
					3.46		11.54		2.65	
					2.31		17.31		3.45	
AL5 – 4	11.11.2022	233	153	78	2.12	2.32	11.54	11.54	1.27	1.57
					3.93		17.89		1.04	
					0.91		5.19		2.42	
AL5 – 5	15.11.2022	221	145	74	1.21	2.32	6.35	12.12	3.57	2.49
					3.32		12.12		2.30	
					2.42		17.89		1.61	
AL5 – 6	18.11.2022	248	162	83	1.81	2.01	17.31	17.12	2.30	10.21
					1.21		23.66		15.57	
					3.02		10.39		12.76	
AL5 – 7	22.11.2022	214	139	74	1.51	2.52	8.66	8.46	3.57	2.84
					2.72		12.70		2.88	
					3.32		4.04		2.07	
AL5 – 8	25.11.2022	255	175	77	2.72	3.02	8.66	8.08	3.45	3.30
					4.84		11.54		4.72	
					1.51		4.04		1.73	
AL1 – 9	29.11.2022	245	155	87	1.51	3.63	12.70	11.73	1.04	2.88
					6.04		17.31		5.18	
					3.32		5.19		2.42	
Monthly Average		219	145	71		2.45		10.69		3.50
Standard Deviation		36	27	13		0.58		3.37		2.56

Table 7 : Results of Air Pollutant Concentration at Tuna Port					
	Date	C_6H_6 [µg/m^3]	*NMHC	CO [mg/m^3]	CO_2 [ppm]
Sampling Period		8 hr		Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m3		4.0 mg/m3	-
AL6 -1	01.11.2022	1.12	BQL	1.43	543
AL6 – 2	04.11.2022	1.17	BQL	1.41	463
AL6 – 3	08.11.2022	1.13	BQL	1.39	410
AL6 – 4	11.11.2022	1.13	BQL	1.74	509
AL6 – 5	15.11.2022	1.17	BQL	1.08	911
AL6 – 6	18.11.2022	1.17	BQL	1.1	528
AL6 – 7	22.11.2022	1.06	BQL	1.88	565
AL6 – 8	25.11.2022	1.1	BQL	1.89	999
	29.11.2022	1.22	BQL	1.89	895
Monthly Average		1.14	-	1.53	647.00
Standard Deviation		0.05	-	0.33	222.45

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The mean TSPM values at Tuna Port was 219 µg/m^3, the mean PM_{10} value was 145 µg/m^3 and the mean $PM_{2.5}$ value was 71 µg/m^3 which was exceed the standard limit prescribed by NAAQS. The average values of SO_2, NO_2 and NH_3 were 2.45 µg/m^3, 10.69 µg/m^3 and 3.50 µg/m^3 respectively and were all within the standard limit prescribed by NAAQS.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Tuna Port. The mean Benzene concentration was 1.14 µg/m3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.53 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 7: Admin Building (Vadinar) (AL-7)

Table 8 : Results of Air Pollutant Concentration at Admin Building										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS Limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL7 -1	01.11.2022	150	98	51	2.20 4.84 3.52	3.52	9.53 16.51 5.72	10.59	5.36 2.81 7.66	5.28
AL7 -2	04.11.2022	177	115	61	3.08 7.03 3.96	4.69	17.78 21.60 26.04	21.81	2.81 8.93 6.64	6.13
AL7 -3	08.11.2022	193	113	73	6.15 8.79 3.96	6.30	6.99 20.96 6.35	11.43	3.83 10.47 8.17	7.49
AL7 -4	11.11.2022	200	121	78	3.96 5.28 8.79	6.01	17.78 22.23 5.72	15.24	10.47 5.87 4.08	6.81
AL7 -5	15.11.2022	179	108	69	1.76 5.71 8.35	5.28	7.62 26.04 20.33	18.00	3.06 5.87 7.91	5.62
AL7 -6	18.11.2022	223	121	96	2.64 4.40 6.59	4.54	8.89 16.51 19.69	15.03	5.62 8.17 3.32	5.70
AL1 -7	22.11.2022	162	104	57	4.84 7.03 3.96	5.28	14.61 5.72 23.50	14.61	13.02 8.68 5.62	9.10
AL1-8	25.11.2022	237	138	97	6.59 3.96 2.64	4.40	9.53 14.61 21.60	15.24	7.91 5.62 10.47	8.00
AL1-9	28.11.2022	203	112	87	3.96 2.20 4.84	3.66	6.99 14.61 19.69	13.76	5.62 7.91 4.60	6.04
Monthly Average		191	114	74		4.85		15.08		6.68
Standard Deviation		28	12	17		0.96		3.34		1.28

Table 8 : Results of Air Pollutant Concentration at Admin Building Vadinar					
Sampling Period	**Date**	**C_6H_6 [µg/m^3]**	***NMHC**	**CO [mg/m^3]**	**CO_2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL7 -1	01.11.2022	1.08	BQL	1.43	225
AL7 -2	04.11.2022	1.13	BQL	1.54	236
AL7 -3	08.11.2022	1.17	1.81	1.53	455
AL7 -4	11.10.2022	1.14	BQL	1.61	443
AL7 -5	15.10.2022	1.03	BQL	1.1	347
AL7 -6	18.10.2022	1.06	BQL	1.57	416
AL7 -7	22.10.2022	1.10	BQL	1.05	372
AL7 -8	25.10.2022	1.20	BQL	1.79	464
AL7 -9	28.10.2022	1.13	BQL	1.42	487
Monthly Average		**1.12**	**-**	**1.46**	**388**
Standard Deviation		**0.06**	**-**	**0.25**	**75**

*NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

At Admin Building, Vadinar the mean TSPM value was 191 µg/m^3, the mean PM_{10} value was 114 µg/m^{3}and the mean $PM_{2.5}$ value was 74 µg/m^3 which was slightly exceed the standard limit. The average values of SO_2, NO_2 and NH_3 concentrations were 4.85 µg/m^3, 15.08 µg/m^3 and 6.68 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Vadinar Port. The mean Benzene concentration was 1.12 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.46 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 8: Signal Building (Vadinar) (AL-8)

Table 9 : Results of Air Pollutant Concentration at Signal Building, Vadinar										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS Limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL8 -1	01.11.2022	113	74	38	3.96	4.40	6.99	13.34	2.30	7.15
					6.59		19.05		8.68	
					2.64		13.97		10.47	
AL8 -2	04.11.2022	146	93	49	2.64	4.40	14.61	15.88	5.36	6.13
					4.84		22.23		8.42	
					5.71		10.80		4.60	
AL8 -3	08.11.2022	124	82	42	3.08	3.52	14.61	16.73	5.62	5.62
					5.28		26.04		7.91	
					2.20		9.53		3.32	
AL8 -4	11.11.2022	175	105	67	2.20	4.40	8.26	13.76	8.93	9.02
					7.03		19.05		12.76	
					3.96		13.97		5.36	
AL8 -5	15.11.2022	152	97	52	3.52	4.98	5.72	13.13	6.89	7.57
					4.84		13.34		10.98	
					6.59		20.33		4.85	
AL8 -6	18.11.2022	176	111	61	3.08	3.81	15.24	17.57	7.15	8.42
					3.96		26.04		7.91	
					4.40		11.43		10.21	
AL8 -7	22.11.2022	214	118	93	3.52	5.71	5.72	12.91	7.91	8.25
					5.28		13.34		6.38	
					8.35		19.69		10.47	
AL8-8	25.11.2022	219	125	92	3.08	4.54	9.53	11.01	5.36	6.04
					4.84		17.78		8.17	
					5.71		5.72		4.60	
AL8-9	28.11.2022	154	97	57	5.71	3.81	10.80	16.94	7.15	8.76
					3.96		22.23		8.93	
					1.76		17.78		10.21	
Monthly Average		164	100	61		4.40		14.59		7.44
Standard Deviation		36	16	20		0.67		2.25		1.27

Table 9 : Results of Air Pollutant Concentration at Signal Building Vadinar					
		C_6H_6 [µg/m^3]		CO [mg/m^3]	CO_2 [ppm]
Sampling Period	Date	8 hr	*NMHC	Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m3		4.0 mg/m3	-
AL8 -1	01.11.2022	1.06	BQL	1.5	467
AL8 -2	04.11.2022	1.05	BQL	1.46	501
AL8 -3	08.11.2022	1.14	1.81	1.31	489
AL8 -4	11.11.2022	1.16	BQL	1.38	439
AL8 -5	15.11.2022	1.17	BQL	1.29	231
AL8 -6	18.11.2022	1.10	BQL	1.31	244
AL8 -7	22.11.2022	1.00	BQL	1.34	227
AL8 -8	25.11.2022	1.05	BQL	1.37	261
AL8 -9	28.11.2022	1.02	BQL	1.29	234
Monthly Average		1.16	-	1.46	442
Standard Deviation		0.05	-	0.27	63

* NMHC- Non- Methane Hydrocarbon
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

At Signal Building, Vadinar the mean TSPM value was 164 µg/m^3, the mean PM_{10} value was 100 µg/m^3 which was boundary line of the permissible limit, the mean $PM_{2.5}$ value was 61 µg/m^3 which was within the permissible limit. The average values of SO_2, NO_2 and NH_3 concentrations were 4.40 µg/m^3, 14.59 µg/m^3 and 7.44 µg/m^3 respectively and were all within the standard limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Vadinar Port. The mean Benzene concentration was 1.16 µg/m^3, well below the standard limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.46 mg/m^3, well below the standard limit of 4.0 mg/m^3.

Fig. No:-1 Average ambient air qulaity (PM) month of November-2022 at DPA and Vadinar Sampling Station

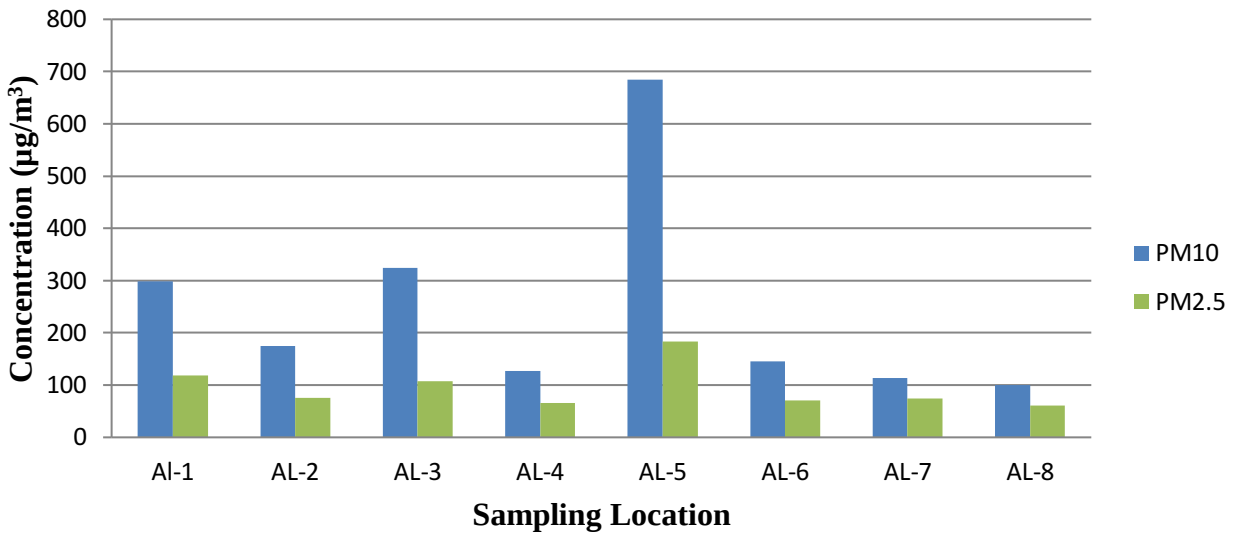


Fig. No:-2. Average ambient air qulaity (Gaseous) month of November-2022 at DPA and Vadinar sampling location

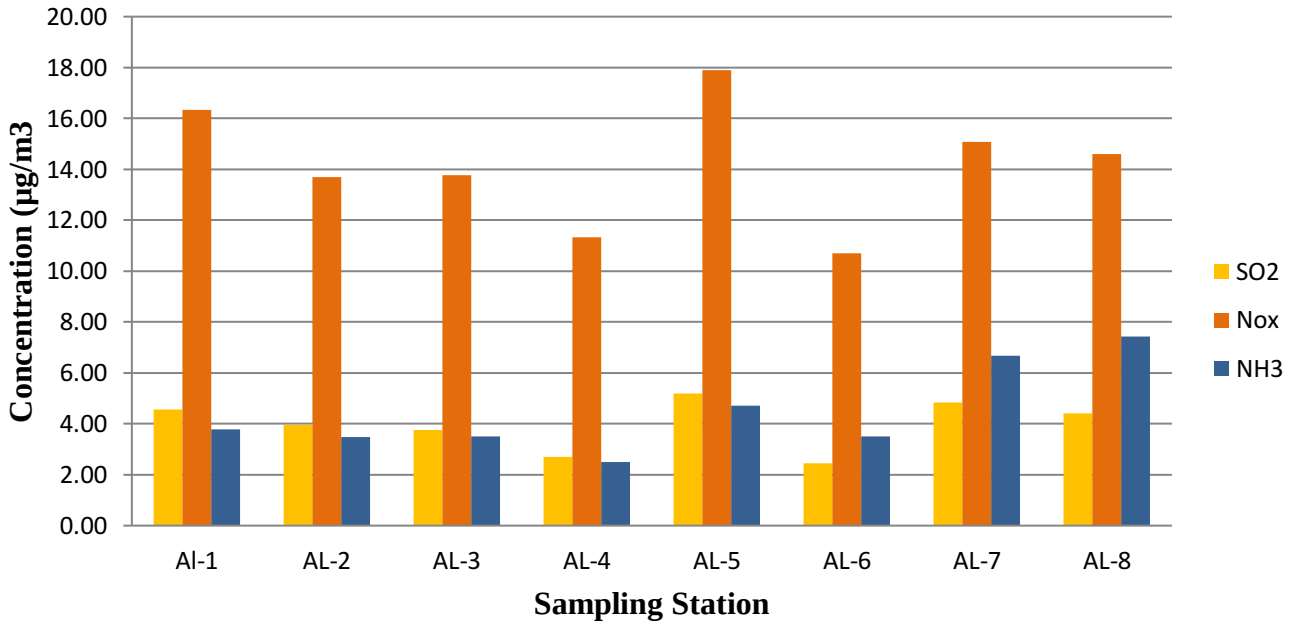


Fig. No:-3. Average ambient air qulaity (Gaseous) month of November-2022 at DPA and Vadinar sampling location

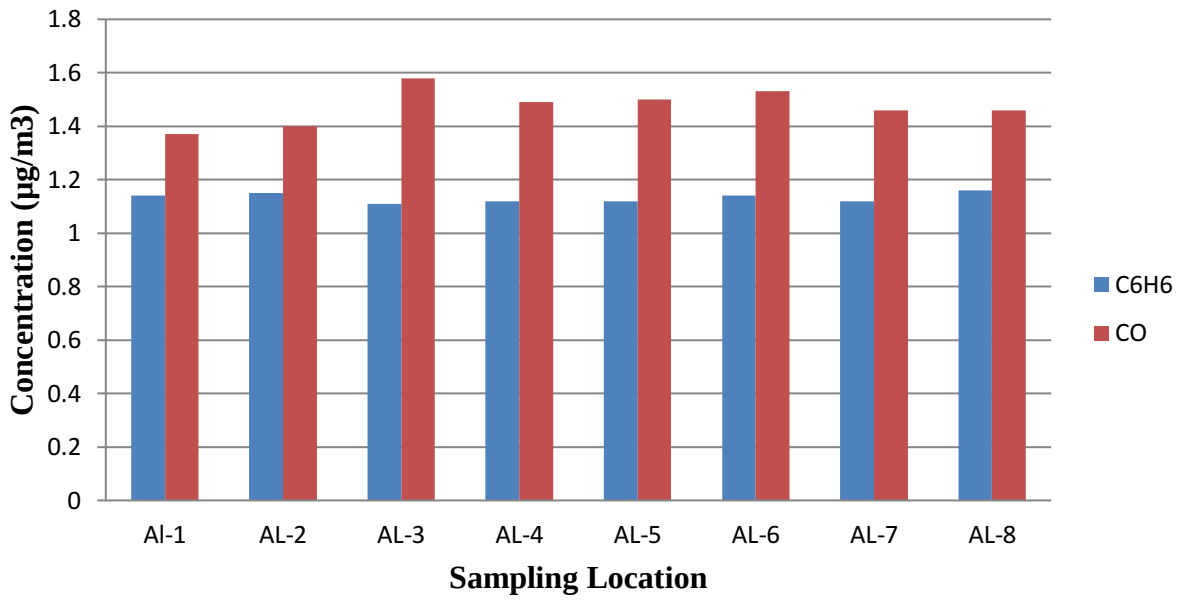
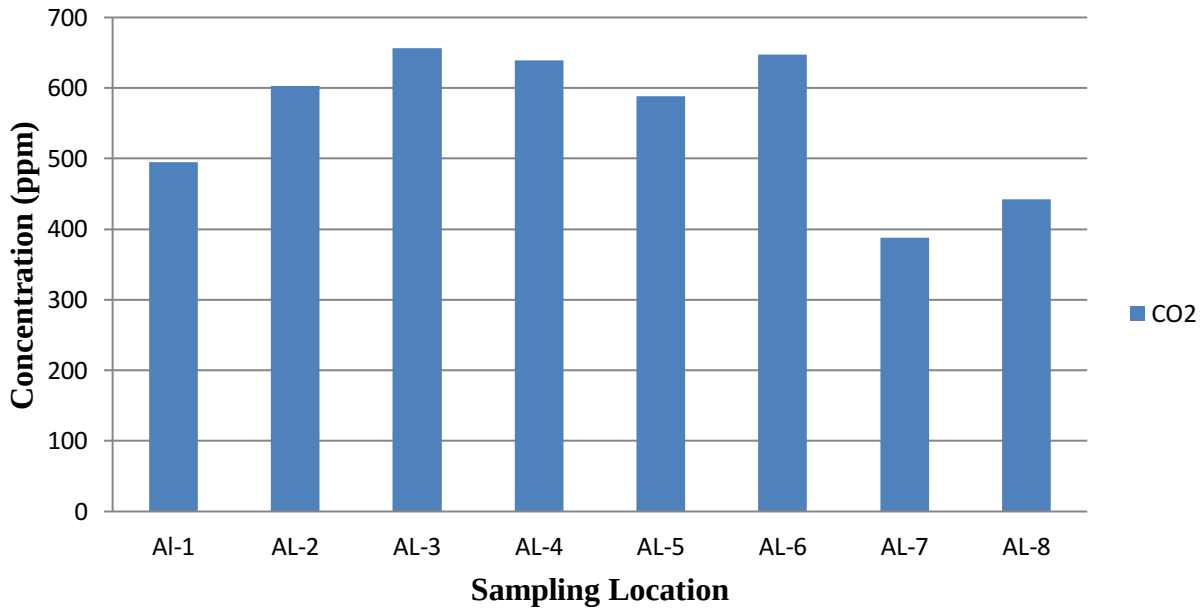


Fig. No:-4. Average ambient air qulaity (Gaseous) month of November-2022 at DPA and Vadinar sampling location



2.3 Observations and Conclusion

During the monitoring period, the overall Ambient Air Quality of the port area was found within permissible levels for various gaseous pollutants. However, Total Suspended Particulate matter as TSPM, Particulate matter as PM_{10} and $PM_{2.5}$ was found to exceed the limits at locations at all ambient air sampling location.

The concentration of PM_{10} and $PM_{2.5}$ were slightly exceeded at Gopalpuri and Tuna Port.

The mean concentration of PM_{10} and $PM_{2.5}$ were slightly exceeded at Admin building Vadinar & at Signal building Vadinar was very close to the standard limit.

4.1 Meteorological Data

Automatic Weather station (ID KAZPHOEN424) have been installed in Seva Sadan-3 at the Deendayal Port which records the data on Temperature (°C), Relative Humidity (%),Wind speed (m/s),Wind Direction (°), Solar radiation (w/m^2) and Rainfall mm.

Meteorological factors play an important role in environmental pollution studies particularly in pollutant transport irrespective of their entry into the environment. The wind speed and direction play a major role in dispersion of environment pollutants. Effects of pollution on receptors animate and inanimate depends on atmospheric condition.

Temperature

At Deendayal Port, the day time temperature was found range 21.1-32.9^{0}C. The average day time temperature was 27.92°C. The night time temperature was range from 20.0-29.7^{0}C. The mean night time temperature recorded was 25.47 °C.

Solar Radiation

The mean Solar Radiation in November month was 167.27 w/m^2. The maximum solar radiation was recorded 759.0 w/m^2 in 4th November, 2022 and the minimum solar radiation was recorded 1.80 w/m^2 in 30th November, 2022.

Rainfall

Rain fall of November month was recorded 0.00 mm.

Relative Humidity

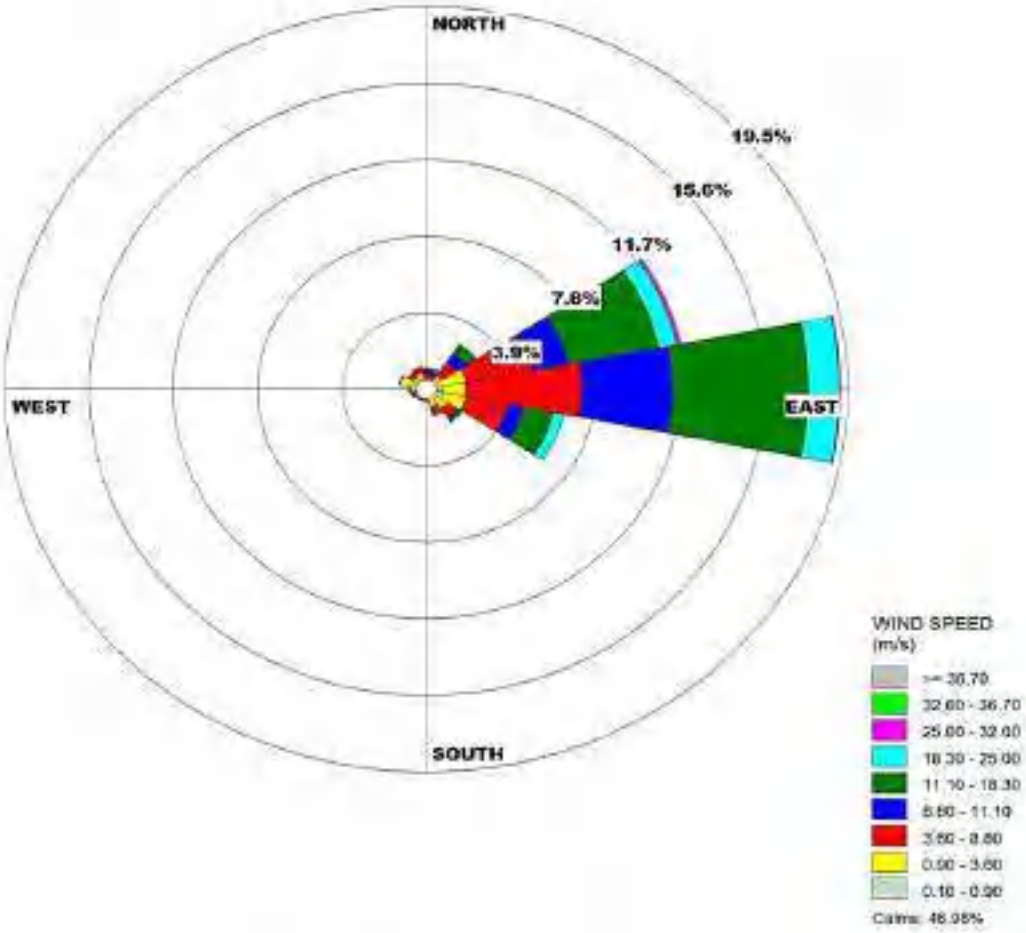
The mean Relative humidity was 69.00 % for the month of November. Maximum Relative humidity was recorded 99.0 % and minimum Relative humidity was recorded 34.0 %.

Wind Velocity and Wind Direction

Velocity and direction of wind have a significant role in the dispersion of air borne materials and therefore determines the air quality of the area. The average wind velocity for the entire month of November was 1.21 m/s. Maximum wind velocity was recorded 10.19 m/s. The wind direction was mostly North-East.

WIND ROSE PLOT:
M/s. Deendayal Port Authority (DPA)
Project Site, Sevasadan-3, Kandla Port.

DISPLAY:
Wind Speed
Direction (blowing from)



COMMENTS:	DATA PERIOD: Start Date: 01-11-2022 - 00:00 End Date: 30-11-2022 - 23:00	COMPANY NAME: M/s. Deendayal Port Authority (DPA)	
		MODELER: M/s. Eco Chem Sales & Services	
	CALM WINDS: 46.98%	TOTAL COUNT: 1438 hrs.	
	AVG. WIND SPEED: 4.33 m/s	DATE: 09-12-2022	PROJECT NO.:

4.0 Drinking Water Quality Monitoring

Drinking Water Quality Monitoring was carried out at twenty stations at Kandla, Vadinar & Township Area of Deendayal Port.

Table No:-10. Drinking Water Sampling Location

Sr. No.	Name of Location	Location Code	Latitude	Longitude
1.	Nirman Building	DL-1	23° 0' 27"N	70° 13' 21"E
2.	P & C Building	DL-2	23° 0' 33"N	70° 13' 20"E
3.	North Gate	DL-3	23° 0' 26.97"N	70° 13' 21.87"E
4.	KPT-Canteen	DL-4	23° 2' 17.2674"N	70° 13'18.2814"E
5.	West Gate	DL-5	23° 59' 40.48"N	70° 12' 50.96"E
6.	Wharf Area	DL-6	22° 59' 52.2"N	70° 13' 22.95"E
7.	Sevasadan-3	DL-7	23° 0' 22.55"N	70° 13' 15.34"E
8.	Workshop	DL-8	23° 0' 33.74"N	70° 13' 20.05"E
9.	Custom Building	DL-9	23° 1' 8.70"N	70° 12' 52.0"E
10.	Kandla Colony	DL-10	23° 11' 14.9"N	70° 12' 48.4"E
11.	KPT Hospital	DL-11	23° 1' 5.02"N	70° 12' 44.38"E
12.	A.O. Building	DL-12	23° 3' 42.89"N	70° 8' 41.5"E
13.	Gopalpuri School	DL-13	23° 5' 1.03"N	70° 7' 55.42"E
14	Gopalpuri Guest House	DL-14	23° 4' 43.14"N	70° 7' 51.92"E
15.	E-Type Quarters	DL-15	23° 4' 59.90"N	70° 7' 56.72"E
16.	F-Type Quarters	DL-16	23° 4' 38.45"N	70° 8' 8.63"E
17.	Gopalpuri Hospital	DL-17	23° 4' 54.09"N	70° 8' 7.5"E
18.	Tuna Port	DL-18	23° 58' 23.06"N	70° 5' 35.6"E
19.	Vadinar Jetty	DL-19	22° 25' 51.73"N	69° 41' 36.62"E
20.	Vadinar Colony	DL-20	22° 30' 26.25"N	69° 39' 45.03"E

4.1 Drinking Water Monitoring Methodology

Samples for physico-chemical analysis were collected in 2 Carboys and samples for microbiological parameters were collected in sterilized bottles. These samples were then analyzed in laboratory for various drinking water parameters at Kandla Lab/Surat.

The Sampling was done as per IS: 3025 Part-1, analysis was done as per IS: 3025/APHA standard methods and, the analysis results compare with IS 10500:2012. The water samples were analyzed for various parameters, viz. Color , Odor, Turbidity , Conductivity , pH , Chlorides , TDS, Total Hardness, Iron , Sulphate, Salinity , DO, BOD, Na, K, Ca, Mg, F, NO_3, NO_2, Mn, Cr-6, Cu, Cd, As, Hg, Pb, Zn, Bacterial Count (CFU) .

4.2 Results

The Drinking Water Quality monitoring data for 20 stations are given in below from table No. 11 to Table No. 17

Table 11: Drinking Water Quality Monitoring Parameters for Nirman Building, P & C Building and Main Gate (North) at Kandla.

Sr. No.	Parameter	Unit	Nirman Building 1	P & C Building	Main Gate North	Acceptable Limits as per IS 10500 :2012 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.35	7.33	7.41	7.35	6.5 to 8.5
2	Total Dissolved Solids	mg/l	690	670	670	690	2000
3	Turbidity	NTU	0	1	1	0	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	1229	1194	1211	NS*	NS*
7	Biochemical Oxygen	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	576.28	355.79	340.76	250	1000
9	Ca as Ca	mg/l	43.29	41.68	39.28	75	200
10	Mg as Mg	mg/l	58.8060	57.3480	56.3760	30	100
11	Total Hardness	mg/l	350	340	330	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.35	0.37	0.31	1	1.5
14	Sulphate as SO_4	mg/l	35.80	30.20	28.30	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	12.70	16.70	15.50	45	No Relaxation
17	Salinity	‰	1.04	0.64	0.62	NS*	NS*
18	Sodium as Na	mg/l	204.00	180.00	192.00	NS*	NS*
19	Potassium as K	mg/l	3.22	3.15	3.18	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe- 0.009 mg/l, Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu- 0.004 mg/l, Cd- 0.003 mg/l, As- 0.003mg/l, Hg- 0.001 mg/l, Pb- 0.006mg/l, Zinc- 0.021 mg/l).

Table 12: Drinking Water Quality Monitoring Parameters for Canteen, West Gate – I & Wharf Area at Kandla

Sr. No.	Parameter	Unit	Canteen	West Gate – I	Wharf Area	Acceptable Limits as per IS 10500 :	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.48	7.52	7.36	7.48	6.5 to 8.5
2	Total Dissolved Solids	mg/l	640	650	680	640	2000
3	Turbidity	NTU	0	1	0	0	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	1166	1152	1196	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	335.75	360.80	350.78	250	1000
9	Ca as Ca	mg/l	40.88	38.48	40.08	75	200
10	Mg as Mg	mg/l	62.6940	66.5820	53.4600	30	100
11	Total Hardness	mg/l	360	370	320	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.32	0.30	0.35	1	1.5
14	Sulphate as SO4	mg/l	31.20	28.30	26.00	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	6.60	11.40	5.80	45	No Relaxation
17	Salinity	‰	0.61	0.65	0.63	NS*	NS*
18	Sodium as Na	mg/l	202.00	200.00	-	NS*	NS*
19	Potassium as K	mg/l	3.38	3.48	3.16	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

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Table 13: Drinking Water Quality Monitoring Parameters for Sewa sadan–3, Workshop I and Custom Building at Kandla

Sr. No.	Parameter	Unit	Sewa Sadan – 3	Workshop	Custom Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.45	7.38	7.29	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	700	670	910	500	2000
3	Turbidity	NTU	0	1	1	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	1213	1164	1564	NS*	NS*
7	Biochemical	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	365.81	370.82	340.76	250	1000
9	Ca as Ca	mg/l	42.48	37.68	39.28	75	200
10	Mg as Mg	mg/l	59.2920	59.7780	53.9460	30	100
11	Total Hardness	mg/l	350	340	320	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.41	0.30	0.35	1	1.5
14	Sulphate as SO_4	mg/l	24.90	34.20	27.2	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	6.90	3.90	11.00	45	No Relaxation
17	Salinity	‰	0.66	0.67	0.62	NS*	NS*
18	Sodium as Na	mg/l	-	-	-	NS*	NS*
19	Potassium as K	mg/l	3.26	4.03	3.29	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l, Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 14: Drinking Water Quality Monitoring Parameters for Port Colony Kandla, Hospital Kandla and A.O. Building at Gandhidham.

Sr. No.	Parameter	Unit	Port Colony Kandla	Hospital Kandla	A.O. Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 :
1	pH	-	7.39	7.31	7.24	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	760	710	1060	500	2000
3	Turbidity	NTU	1	0	0	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	1328	1251	1821	NS*	NS*
7	Biochemical	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	335.75	345.77	365.81	250	1000
9	Ca as Ca	mg/l	41.68	42.48	40.88	75	200
10	Mg as Mg	mg/l	50.0580	54.4320	62.6940	30	100
11	Total Hardness	mg/l	310	330	360	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.35	0.32	0.46	1	1.5
14	Sulphate as SO_4	mg/l	28.10	24.50	24.50	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	20.20	7.40	15.60	45	No Relaxation
17	Salinity	‰	0.61	0.62	0.66	NS*	NS*
18	Sodium as Na	mg/l	192.80	193.60	194.50	NS*	NS*
19	Potassium as K	mg/l	4.13	4.18	3.26	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 15: Drinking Water Quality Monitoring Parameters for School Gopalpuri, Guest House) and E - Type Quarter at Gopalpuri, Gandhidham

Sr. No.	Parameter	Unit	Gopalpuri School	Guest House	E - Type Quarter	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.3	7.24	7.26	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	830	950	1030	500	2000
3	Turbidity	NTU	1	1	0	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	1435	1638	1769	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	355.79	350.78	340.76	250	1000
9	Ca as Ca	mg/l	39.28	43.29	39.28	75	200
10	Mg as Mg	mg/l	61.2360	61.2360	51.5160	30	100
11	Total Hardness	mg/l	350	360	310	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.45	0.42	0.47	1	1.5
14	Sulphate as SO_4	mg/l	24.90	26.00	30.20	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	7.10	8.30	12.60	45	No Relaxation
17	Salinity	‰	0.64	0.63	0.62	NS*	NS*
18	Sodium as Na	mg/l	199.00	193.80	193.00	NS*	NS*
19	Potassium as K	mg/l	3.90	3.26	3.18	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100 ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 16: Drinking Water Quality Monitoring Parameters for F-Type Quarter, Hospital Gopalpuri and Tuna Port.

Sr. No.	Parameter	Unit	F - Type Quarter	Hospital Gopalpuri	Tuna Port	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.28	7.42	7.51	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1050	990	600	500	2000
3	Turbidity	NTU	1	1	-	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	1796	1700	1044	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	345.77	360.80	380.85	250	1000
9	Ca as Ca	mg/l	38.48	40.88	32.87	75	200
10	Mg as Mg	mg/l	61.7220	62.6940	72.41	30	100
11	Total Hardness	mg/l	350	360	380	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.42	0.45	0.43	1	1.5
14	Sulphate as SO_4	mg/l	26.00	26.10	24.50	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	10.30	6.80	3.00	45	No Relaxation
17	Salinity	‰	0.62	0.65	0.69	NS*	NS*
18	Sodium as Na	mg/l	201.00	201.00	193.60	NS*	NS*
19	Potassium as K	mg/l	3.15	3.16	3.21	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified, BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6-0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 17: Drinking Water Quality Monitoring Parameters for Vadinar Jetty and Port Colony at Vadinar.

Sr. No.	Parameter	Unit	Vadinar Jetty	Port Colony Vadinar	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.4	7.43	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	320	300	500	2000
3	Turbidity	NTU	0.00	1.00	1	5
4	Odor	-	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	5	15
6	Conductivity	µs/cm	570	300	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	160.36	140.31	250	1000
9	Ca as Ca	mg/l	36.87	34.47	75	200
10	Mg as Mg	mg/l	43.25	52.00	30	100
11	Total Hardness	mg/l	270	300	200	600
12	Iron as Fe	mg/l	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.25	0.22	1	1.5
14	Sulphate as SO_4	mg/l	0.75	0.24	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	15.60	12.70	45	No Relaxation
17	Salinity	‰	0.29	0.25	NS*	NS*
18	Sodium as Na	mg/l	191.6	192.0	NS*	NS*
19	Potassium as K	mg/l	BQL	BQL	NS*	NS*
20	Manganese	mg/l	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

4.3 Results & Discussion

The colour of all drinking water samples was found Colourless and odour of the samples also agreeable. All parameters were found within the specified limit as per the Drinking water Standard.

pH

The pH is measure of the intensity of acidity or alkalinity and the concentration of hydrogen ion in water. At DPA Site the pH values for drinking water samples ranged from 7.24-7.52 and mean value was 7.36 while at Vadinar pH ranged from 7.40-7.43 and mean value was 7.42. All the sampling points showed pH values within the prescribed limit by Indian Standards.

Turbidity

The selected drinking water sample location turbidity range from 0-1NTU at all location of DPA and Vadinar in month of November. The Turbidity values were within the permissible limit at all sampling location prescribed limit by Indian standards.

Total Dissolved Solids (TDS)

Water has the ability to dissolve a wide range of inorganic and some organic minerals or salts such as potassium, calcium, sodium, bicarbonates, chlorides, magnesium, sulfates etc.

TDS values at DPA varied between 600-1060 mg/l. The average TDS value was found 792 mg/l. The minimum value for TDS was 600 mg/l at Hospital Gopalpuri and maximum was 980 mg/l at Tuna Port while at Vadinar TDS ranged from 280-300 mg/l and mean was 290.0 mg/l. The TDS values were within the permissible limit at all sampling location prescribed limit by Indian standards.

Conductivity

Electrical Conductivity is the ability of a solution to transfer (conduct) electric current. Conductivity is used to measure the concentration of dissolved solids which have been ionized in a polar solution such as water. The conductivity in the samples collected during the month of November DPA ranged from 1044.0 µs/cm at Tuna Port to1821.0 µs/cm at A.O. Building and mean value was 1381.72 µs/cm while at Vadinar ranged from 300-570 µs/cm and mean was 435 µs/cm.

BOD

BOD value in the studied area of DPA and Vadinar was found Below Quantification Limit (<2.0 mg/l). IS 10500:2012 does not show any standard values for BOD in drinking water.

Chlorides

Excessive chloride concentration increase rates of corrosion of metals in the distribution system. This can lead to increased concentration of metals in the supply. The Chloride value in the studied area of DPA ranged from 335.75-576.28 mg/l. The mean value was 365.53 mg/l. The minimum chloride was 335.75 mg/l at Port colony and maximum was 576.28 mg/l at Nirmal Building while at Vadinar location chloride ranged from 140.31-160.36 mg/l and mean was 150.33 mg/l. The Chloride was found within the Permissible limit of the Drinking Water Standard.

Calcium

Calcium is most abundant element on the earth crust and is very important for human cell physiology and bones. About 95% calcium in human body stored in bones and teeth. The high deficiency of calcium in humans may caused rickets, poor blood clotting, bones fracture etc. and the exceeding limit of calcium produced cardiovascular diseases.

The Calcium value in the studied area of DPA ranged from 32.87-43.29 mg/l. The mean value was 40.12 mg/l. The minimum calcium was 32.87 mg/l at Tuna Port and maximum was 43.29 mg/l at Gopalpuri Hospital while at Vadinar location Calcium ranged from 34.47-36.87 and mean was 35.67 mg/l. All the locations had calcium within the prescribed limits of 75-200 mg/L.

Magnesium

The magnesium value in the studied area of DPA ranged from 50.06-72.41 mg/l. The mean value was 59.24 mg/l. The minimum magnesium was 50.06 mg/l at Port Colony and maximum was 74.41 mg/l at Tuna Port while at Vadinar location magnesium ranged from 43.25-52.00 and mean was 47.61 mg/l. All the locations had magnesium within the prescribed limits of 30-100 mg/L.

Total Hardness

Total Hardness value in the studied area of DPA ranged from 310.0 mg/l at Port Colony to 380.0 mg/l at Tuna Port and mean value was 343.89 mg/l while at Vadinar location total hardness ranged from 270.0-300.00 mg/l and mean was 285.0 mg/l. The values of total

hardness were found within the Permissible limit of the Drinking Water Standard (200-600 mg/L). These results clear, that hardness of water is according to the IS standards and it is not harmful for local inhabitants.

Iron

Iron values in the studied area of DPA & Vadinar were Below Quantification Limit (0.009 mg/l) and hence well below the permissible limit as per Indian Standards are 0.3 mg/L.

Fluoride

Fluoride value in the studied area of DPA varied between 0.3-0.47 mg/l and mean was 0.38 mg/l. The minimum value was 0.3 mg/ at West gate workshop and maximum was 0.47 mg/l at E-Type and mean was 0.38 mg/l while at Vadinar location fluoride ranged from 0.22-0.25 mg/l and mean was 0.24 mg/l. The Fluoride values were well below the permissible limit as per Indian Standards is 1.0-1.5 mg/L. Moderate amounts lead to dental effects, but long-term ingestion of large amounts can lead to potentially severe skeletal problems.

Sulphate

Sulphate value in the studied area of DPA varied between 24.5–35.8 mg/l and mean was 27.83 mg/l. The minimum value was 24.5 mg/ at A.O. Building, Hospital Kandla and Tuna Port and maximum was 35.8 mg/l at Nirmal Building while at Vadinar location Sulphate ranged from 0.24-0.75 mg/l and mean was 0.50 mg/l. All the sampling points showed Sulphate values within the prescribed limits by Indian Standards (200-400 mg/L). Sulphate content in drinking water exceeding the 400 mg/L imparts bitter taste.

Nitrites (NO_2) and Nitrates (NO_3)

The all values of Nitrite were found BQL (<0.05 mg/l) and Nitrate were well within the permissible limit of the Drinking water Standard.

Salinity

Salinity in drinking water in the present samples collected at DPA ranged from 0.61 ‰ at Canteen to 1.04 ‰ at Nirmal Building and average salinity was 0.66 ‰ while at Vadinar sampling location salinity ranged from 0.25-0.29 ‰. There are no prescribed Indian standards for salinity in Drinking water**.**

Sodium and Potassium Salts

Sodium values in the samples collected at DPA ranged from 180 - 204 mg/l and average was 195.74 mg/l while at Vadinar sodium ranged from 191.6- 192.0 mg/l and average was191.8 mg/l . Potassium salts ranged at DPA ranged from 3.15 to 4.18 mg/l while average was 3.42 mg/l while at Vadinar sampling locations potassium were BQL (<2.0 mg/l). There are no prescribed limits of Sodium and Potassium in Indian standards for Drinking water.

Heavy Metals in Drinking Water

In the present study period drinking water samples were analyzed for Mn, Cr, Cu, Cd, As, Hg, Pb and Zn. All these heavy metals were well Below the Quantification limits prescribed by the Indian Standards.

Bacteriological Study

Analysis of the bacteriological parameter (E-coli and total coliform) at all location shows that Bacteria were not detectable. This shows that drinking water samples were safe for human consumption as per tested parameters.

4.4 Conclusions

These results were compared with permissible limits as prescribed in IS 10500:2012 – Drinking Water Specification. It was seen from the analysis data that during the study period at selected sampling location the water was safe for human consumption as per analyzed parameters at all drinking water monitoring stations.

5.0 Noise Level Monitoring

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. Noise Monitoring was done at 13 stations at Kandla, Vadinar and Township area.

5.1 Method of Monitoring

Sampling was done at all stations for 24 hour period. Data was recorded using automated sound level meter. The intensity of sound was measured in sound pressure level (SPL) and common unit of measurement is decibel (dB).

5.2 Results

Table 18: Noise Monitoring data for ten locations of Deendayal Port and three locations of Vadinar Port

Sr. No.	Location	Day Time Average Noise Level (SPL) in dB(A)	Night Time Average Noise Level (SPL) in dB(A)
	Sampling Time	**6:00 am to 10:00 PM**	**10:00PM to 6:00 AM**
1	Marine Bhavan	60.8	51.9
2	Nirman Building 1	69.9	52.0
3	Tuna Port	53.2	45.4
4	Main Gate North	63.3	51.9
5	West Gate I	67.7	58.1
6	Canteen Area	68.2	51.2
7	Main Road	66.3	52.2
8	ATM Building	69.1	51.1
9	Wharf Area /Jetty Area	70.4	61.7
10	Port & Custom Office	54.7	50.2
Vadinar Port			
11	Entrance Gate of Vadinar Port	55.0	53.5
12	Nr. Port Colony, Vadinar	60.6	57.6
13	Nr. Vadinar Jetty	52.5	51.0

5.3 Conclusions

Transportation systems are the main source of noise pollution in urban areas. Construction of buildings, highways, and roads cause a lot of noise, due to the usage of air compressors, bulldozers, loaders, dump trucks, and pavement breakers. Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships.

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. The Day Time Noise Level (SPL) in all 10 locations at Deendayal Port Authority ranged from 53.2 dB(A) to 70.4 dB(A) while at Vadinar port 3 location ranged from 52.5 dB(A) to 60.6 dB(A) which was within the permissible limits of 75 dB(A) for the industrial area for the daytime. The Night Time Average Noise Level (SPL) in all locations of Deendayal Port Authority ranged from 45.4 dB to 61.7 dB(A) while at Vadinar port ranged from 52.5 dB (A) to 60.6 dB(A) which was within the permissible limits of 70 dB(A) for the industrial area for the night time.

6.0 Soil Monitoring

Sampling and analysis of soil samples were undertaken at six locations within the study area (Deendayal Port and Vadinar Port) as a part of EMP. The soil sampling locations are initially decided based on the locations as provided in the tender document of the Deendayal Port.

Table No.:-19. Soil Sampling Location

Sr. No.	Name of Location	Location Code	Latitude	Longitude	Remarks
1.	Tuna Port	SL-1	22° 58' 10.18"N	70° 6' 3.7"E	Near main gate of Port
2.	IFFCO Plant	SL-2	23° 26' 8.37"N	70° 13' 4.4"E	10 m away from main gate
3.	Khori creek	SL-3	22° 58' 10.18"N	70° 6' 3.7"E	Sand from creek after tide
4.	Nakti Creek	SL-4	23° 2' 1.10"N	70° 9' 33.6"E	
5.	DPA admin site	SL-5	22° 26' 30.9"N	69° 40' 37.03"E	Vadinar
6.	DPA colony	SL-6	22° 23' 57.09"N	69° 42' 49.42"E	

6.1 Methodology

The soil samples were collected in the month of November 2022. The samples collected from the all locations are homogeneous representative of each location. At random locations were identified at each location and soil was dug from 30 cm below the surface. It was uniformly mixed before homogenizing the soil samples. The samples were filled in polythene bags, labeled in the field with number and site name and sent to laboratory for analysis.

6.2 Results

Table-20: Chemical Characteristics of Soil in the Study Area for Tuna port, IFFCO, Khori Creek, Nakti Creek, DPA admin site, DPA colony.

Sr. No.	Parameter	Unit	Station Name					
			SL1	SL2	SL3	SL4	SL5	SL6
			Tuna Port	IFFCO Plant	Khori Creek	Nakti Creek	DPA Admin Site	DPA Colony
			Near main gate of Port	10 m away from main	Sand from creek after tide		Vadinar	
1	Texture		Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	pH	-	7.79	7.80	7.54	7.58	8.14	7.54
3	Electrical Conductivity	µs/cm	35000.0	36100.0	26,820.00	12,700.0	155.0	594.0
4	Phosphorus	mg/kg	10.3	10.5	9.19	8.49	6.00	4.80
5	Moisture	%	15.9	20.3	20.90	3.50	7.20	10.10
6	Total Organic	%	4.04	1.7	3.64	7.80	2.30	2.00
7	Alkalinity	mg/kg	900.0	1000.0	800.0	500.0	800.0	600.0
8	Total Nitrogen	%	BQL	BQL	BQL	BQL	BQL	BQL
9	Sulphate	mg/kg	820.00	982.00	1,080.00	810.00	30.0	70.0
10	Chloride	mg/kg	15598.0	14275.0	12,600.00	2,950.00	140.00	525.00
11	Calcium	mg/kg	2,605.00	2,505.00	31,600.00	3,086.00	1,729.00	1,849.00
12	Sodium	mg/kg	5657	7136.0	7,649.00	4,675.00	33.02	116.90
13	Potassium	mg/kg	552	694	708.00	437.00	44.60	44.52
14	Copper as Cu	mg/kg	27.4	15.5	30.50	14.50	54.10	31.60
15	Lead as Pb	mg/kg	7.4	7.4	9.50	6.30	74.10	75.30
16	Nickel as Ni	mg/kg	39.40	32.70	44.40	27.20	30.30	32.00
17	Zinc as Zn	mg/kg	62.4	77.40	79.20	56.50	50.60	86.00
18	Cadmium as Cd	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (TN: 0.001%, Cd: 1.0mg/kg)

6.3 Discussion

- DPA Kandla soil sampling data shows that value of pH ranges from 7.54 at Khori Creek to 7.80 at IFFCO Plant while the average value was 7.68. At Vadinar sampling location pH were 7.54 at DPA colony and 8.14 at DPA Admin Site.
- The Electrical Conductivity of DPA Kandla soil sample ranged from 12700.0 µs/cm at Nakti Creek (Sand from creek after tide) to 36100 µs/cm at IIFCO Plant and mean was 27655 µs/cm while Vadinar soil sampling location conductivity were 155 µs/cm at DPA Admin Site and 594 µs/cm at DPA Colony site.
- Total organic Carbon of DPA Kandla soil sample ranged from 1.7 % at IFFCO Plant to 7.80 % at Nakti Creek (Sand from creek after tide) and mean was 4.30 % while Vadinar soil sample were 2.0 % at DPA Colony and 2.30 % at DPA admin Site.
- The concentration of Phosphorus in the soil samples of DPA Kandla varies from 8.49 mg/kg at Nakti Creek (Sand from creek after tide) and 10.5 mg/kg at IIFCO Plant and mean was 9.62 mg/kg while the Vadinar soil sample for Phosphorus were 4.80 mg/kg at DPA Colony and 6.00 mg/kg at DPA Admin Site.
- Chloride in soil sample of DPA ranged from 2950.00 mg/kg at Nakti Creek (Sand from creek after tide) to 15598 mg/kg at Tuna Port and mean was11356 mg/kg while Vadinar soil sample were 140 mg/kg at DPA admin and 525 mg/kg at DPA Colony.
- The Concentration of Potassium in the soil samples of DPA Kandla ranged from 437 mg/kg at Nakti creek and 708 mg/kg at Khori Creek and mean was 597.75 mg/kg while the Vadinar soil sample for Potassium were 44.52 mg/kg at DPA Colony Site and 44.60 mg/kg at DPA Admin Site.
- The concentration of Sodium in the soil samples of DPA Kandla ranged from 4675.0 mg/kg at Nakti creek and 7649.0 mg/kg at Khori Creek and mean was 6279 mg/kg while the Vadinar soil sample for Sodium were 33.00 mg/kg at DPA Admin Site and 117 mg/kg at DPA Colony.

These differences in NPK in soil at different locations are due to the dissimilar nature of soil at each of the locations. Samples SL3 & SL4 (Khori Creek & Nakti Creek) were coastal soil; where as other locations are inland locations and have different chemical properties.

Heavy Metals in the Soil

Traces of Copper, Lead, Nickel and Zinc were observed in the soil samples collected from all the four locations of Deendayal Port Authority Kandla and two locations of Vadinar Port. Cadmium metal was below detection limit in the Soil.

6.4 Conclusion

The soils of Deendayal Port Authority Kandla and Vadinar Port appears to be neutral to basic with varying levels of Chloride, Sulphate, NPK and Calcium. As the nature of soil at different locations are different with respect to its proximity to the sea, the samples showed high degree of variations in their chemical properties.

7.0 Sewage Treatment Plant Monitoring

This involves safe collection of waste water (spent/used water) from wash areas, bathroom, industrial units, etc., waste from toilets of various buildings and its conveyance to the treatment plant and final disposal in conformity with the requirement and guidelines of State Pollution Control Board and other statutory bodies.

7.1 Methodology for STP Monitoring

To monitor the working efficiency of Sewage Treatment Plant (STP), STP Inlet and Outlet Samples were collected once a week. Locations selected are namely Gopalpuri Township, Deendayal Port and Vadinar. Samples were collected in 1 lit. Carboys and were analyzed in laboratory for various parameters.

A new STP with an improved capacity of 1 MLD is being constructed at Gopalpuri Colony.

Table No. 21. Sewage Treatment Plant

Sr. No.	Location of STP	Types of Treatment	STP Capacity	Treated water Utilization
1.	Gopalpuri Township	MBBR	450 KLD	Plantation and Gardening
2.	Deendayal Port, Kandla	MBBR	600 KLD	Discharge to marine through pipeline, Plantation, Gardening
3.	Vadinar Port Colony	MBBR	1.5 MLD	Plantation and Gardening

7.2 Results

Table 22: Sewage Water Monitoring at Kandla STP (1st Week)

Date of Sampling	03.11.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.55	7.42	6.5 - 8.5
2	Total Suspended Solids	mg/l	100.6	46.8	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	80.8	30.3	100
5	BOD @ 27 °C	mg/l	22	11	30
Aeration Tank					
6	MLSS	mg/l	14.0		
7	MLVSS	%	99.73		

Table 23: Sewage Water Monitoring at Kandla STP (2nd Week)

Date of Sampling	10.11.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.41	7.36	6.5 - 8.5
2	Total Suspended Solids	mg/l	127	52.6	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	90.9	40.4	100
5	BOD @ 27 °C	mg/l	23	11	30
Aeration Tank					
6	MLSS	mg/l	18.0		
7	MLVSS	%	85.00		

Table 24: Sewage Water Monitoring at Kandla STP (3rd Week)

Date of Sampling	17.11.2022

Sr. No.	Parameters	Unit	Results		CPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.48	7.29	6.5 - 8.5
2	Total Suspended Solids	mg/l	86.4	22.9	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	101	50.5	100
5	BOD @ 27 °C	mg/l	26	14	30
Aeration Tank					
6	MLSS	mg/l	20.0		
7	MLVSS	%	98.0		

Table 25: Sewage Water Monitoring at Kandla STP (4th Week)

Date of Sampling	24.10.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.41	7.29	6.5 - 8.5
2	Total Suspended Solids	mg/l	164.2	58.7	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	171.7	30.3	100
5	BOD @ 27 °C	mg/l	43	10	30
Aeration Tank					
6	MLSS	mg/l	20.0		
7	MLVSS	%	89.0		

Table 26: Sewage Water Monitoring at Gopalpuri STP (1st Week)

Date of Sampling	03.11.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.47	7.31	6.5 - 8.5
2	Total Suspended Solids	mg/l	121.2	61	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	111.1	60.6	100
5	BOD @ 27 °C	mg/l	32	13	30
Aeration Tank					
6	MLSS	mg/l	22.0		
7	MLVSS	%	97.16		

Table 27: Sewage Water Monitoring at Gopalpuri STP (2nd Week)

Date of Sampling	10.11.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.35	7.27	6.5 - 8.5
2	Total Suspended Solids	mg/l	189	67.9	100
3	Residual Chlorine	mg/l			-
4	COD	mg/l	141.4	60.6	100
5	BOD @ 27 °C	mg/l	37	15	30
Aeration Tank					
6	MLSS	mg/l	16.0		
7	MLVSS	%	89.6		

Table 28: Sewage Water Monitoring at Gopalpuri STP (3rd Week)

Date of Sampling	17.11.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Gopalpuri STP I/L	Gopalpuri STP O/L	
1	pH	-	7.41	7.36	6.5 - 8.5
2	Total Suspended Solids	mg/l	127	52.6	100
3	Residual Chlorine	mg/l			-
4	COD	mg/l	90.9	40.4	100
5	BOD @ 27 °C	mg/l	23	11	30
Aeration Tank					
6	MLSS	mg/l	08.0		
7	MLVSS	%	98.0		

Table 29: Sewage Water Monitoring at Gopalpuri STP (4th Week)

Date of Sampling	24.11.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Gopalpuri STP I/L	Gopalpuri STP O/L	
1	pH	-	7.48	7.28	6.5 - 8.5
2	Total Suspended Solids	mg/l	110.2	42.1	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	78	40	100
5	BOD @ 27 °C	mg/l	24.0	12.0	30
Aeration Tank					
6	MLSS	mg/l	18.0		
7	MLVSS	%	90.0		

Table 30: Sewage Water Monitoring at Vadinar STP (1st Week)

Date of Sampling	03.11.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar STP O/L	
1	pH	-	7.35	7.25	6.5 - 8.5
2	Total Suspended Solids	mg/l	74.9	39.5	100
3	Residual Chlorine	mg/	-	<0.5	-
4	COD	mg/l	101	40.4	100
5	BOD @ 27 °C	mg/l	26.0	10.0	30

Table 31: Sewage Water Monitoring at Vadinar STP (2nd Week)

Date of Sampling	10.11.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar STP O/L	
1	pH	-	7.38	7.21	6.5 - 8.5
2	Total Suspended Solids	mg/l	69.6	40.3	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	131.3	50.5	100
5	BOD @ 27 °C	mg/l	32.0	7.0	30

Table 32: Sewage Water Monitoring at Vadinar STP (3rd Week)

Date of Sampling	17.11.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar O/L	
1	pH	-	7.51	7.42	6.5 - 8.5
2	Total Suspended Solids	mg/l	38.6	16.9	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	80.8	20.2	100
5	BOD @ 27 °C	mg/l	24.0	12.0	30

Table 33: Sewage Water Monitoring at Vadinar STP (4th Week)

Date of Sampling	24.11.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar STP O/L	
1	pH	-	7.61	7.42	6.5 - 8.5
2	Total Suspended Solids	mg/l	76.9	33.3	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	131.3	20.2	100
5	BOD @ 27 °C	mg/l	20.0	8.0	30

Table No. 34. General Standards for discharge of Environmental Pollutant Part-A

Sr. No.	Parameter	Inland Surface Water	Land Irrigation	Marine Coastal Areas
1.	pH	5.5-9.0	5.5-9.0	5.5-9.0
2.	Total Suspended Solids (mg/l)	100	200	100
3.	Residual Chlorine (mg/l)	1.0	-	1.0
4.	BOD (mg/l)	30	100	100
5.	COD (mg/l)	250	-	250

Sources:-CPCB

7.3 Results & Discussion

The STP Sample carried out to evaluate the efficiency and performance of the wastewater treatment plant at Gopalpuri, Kandla and Vadinar STP. The performance of these plants is an essential parameter to monitor because the treated sewage water is discharged for irrigation purposes and discharge into marine. Wastewater samples were collected from different unit operations of the plant i.e, the inlet, aeration tank and the final treated outlet. These samples were analyzed for various physico-chemical characteristics such as pH, TSS, Residual Chlorine, COD, BOD, MLSS and MLVS.

The final treated outlet observed pH values were within the allowed range at STP Gopalpuri, STP Kandla & STP Vadinar ranged from 7.22 -7.35, 7.29-7.42 & 7.21-7.42 respectively. The wastewater treatment makes it suitable for irrigation. These values are below the allowed limit of the GPCB.

- The final treated outlet observed Total suspended solid values at Gopalpuri, DPA Kandla & Vadinar ranged from 27.10-67.90 mg/l, 22.90-58.70 mg/l & 16.60-40.30 mg/l respectively. These values are below the allowed limit of the GPCB.
- The final treated outlet observed Residual Chlorine values were <0.5 at Gopalpuri, DPA Kandla & Vadinar. These values are below the allowed limit of the CPCB.
- The final treated outlet observed COD values were at Gopalpuri, DPA Kandla & Vadinar ranged from 40.40-60.60 mg/l, 30.30-50.50 mg/l & 20.20-50.50 mg/l respectively. These values are below the allowed limit of the CPCB.

- The main focus of wastewater treatment plants is supposed to reduce the BOD in the effluent discharged to natural waters. Wastewater treatment plants are designed to function as bacteria farms, where bacteria are fed oxygen and organic waste. The final treated outlet observed BOD values were at Gopalpuri, DPA Kandla & Vadinar ranged from 12.0-16.0 mg/l, 10.0-14.0 mg/l & 7.0-12.0 mg/l respectively. These values are below the allowed limit of the GPCB.

7.4 Conclusions:

All parameters for STP outlet are within limit prescribed by CPCB. After the final treatment, it is found that the treated water is satisfactory.

8.0 Marine Water Monitoring

Marine Water Quality

The Forty Second Amendment to the Constitution in 1976 underscored the importance of 'green thinking'. Article 48A enjoins the state to protect and improve the environment and safeguard the forests and wildlife in the country. Further, Article 51A (g) states that the "fundamental duty of every citizen is to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures".

Policy Statement for Abatement of Pollution (1992) has suggested developing relevant legislation and regulation, fiscal incentives, voluntary agreements and educational programs and information campaigns. It emphasizes the need for integration by incorporating environmental considerations into decision making at all levels by adopting frameworks namely, pollution prevention at source, application of best practicable solution, ensure polluter pays for control of pollution, focus on heavily polluted areas and river stretches and involve public in decision-making. The National Conservation Strategy and Policy Statement on Environment and Development, (1992) aimed at "integrating environmental concerns with developmental imperatives to meet the challenges by redirecting the thrust of our developmental process so that the basic needs of our people could be fulfilled by making judicious and sustainable use of natural resources." The priorities mentioned in this policy document include the sustainable use of land and water resources, prevention and control of pollution and preservation of biodiversity.

The National Water Policy, (2002) contains provisions for developing, conserving, sustainable utilizing and managing this important water resources and need to be governed by national perspectives.

Sampling Stations

The monitoring of marine environment for the study of biological and ecological parameters was carried out on 01st & 02nd November-2022 in harbor regions of DPA & Vadinar during Neap tide period of New moon phase of Lunar Cycle. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 8th & 9th November-2022 in harbor regions of DPA & Vadinar during Spring tide period first quarter of Lunar Cycle.

Plankton samples from sub surface layer was collected both during high tide period and low tide period from 3 water quality monitoring stations of DPA harbor area and two stations in Nakti creek and one station in Khori creek. The same sampling schedule was repeated during consecutive spring tide and neap tide in same month. Plankton samples from sub surface layer was collected both during high tide period and low tide period from 1 water quality monitoring stations near Vadinar jetty area during spring tide and neap tide in this month. Collected water samples were processed for estimation

of Chlorophyll- a, Pheophytin- a, qualitative & quantitative evaluation of phytoplankton, qualitative & quantitative evaluation zooplanktons (density and their population).

Sampling Locations

Offshore monitoring requirement	Number of locations
Offshore Installations	3 in Kandla creek 2 in Nakti creek 1 in Khori creek 1 near Vadinar Jetty 1 near 1st SBM
Total Number of locations	**8**

8.1 Marine Water Quality and Results

Marine water quality of marine waters of Deendayal Port Harbor waters, Khori & Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each month. The results of marine water quality from table no 35 to 42. *During low tide DPA-6 Nakti-II location monitoring was not possible due to non-availability of marine water.*

Table 35: Marine Water Quality Monitoring Parameters for Location Near DPA Colony

Sr. No.	Parameters	Unit	Kandla Creek Near DPA Colony (1)			
			23°0'58"N 70°13'22."E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.61	7.58	7.55	7.46
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	19.0	19.9	20.4	19.0
5	Turbidity	NTU	38	35	42	35
6	Total Dissolved Solids	mg/l	34152.0	30868.0	30941.0	31974.0
7	Total Suspended Solids	mg/l	639.6	600.6	646.4	595.6
8	Total Solids	mg/l	34791.6	31468.6	31587.4	32569.6
9	DO	mg/l	5.8	5.6	5.7	5.5
10	COD	mg/l	88.0	79.0	82.0	86.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	1.06	0.82	0.99	0.91
13	Phosphate	mg/l	0.48	0.31	0.09	0.04
14	Sulphate	mg/l	3580	3407	3708.0	3658
15	Nitrate	mg/l	4.70	0.50	0.75	0.42
16	Nitrite	mg/l	<0.05	<0.05	BQL	BQL
17	Calcium	mg/l	521.04	440.88	561.12	480.96
18	Magnesium	mg/l	1773.9	1749.6	1701	1773.9
19	Sodium	mg/l	8011.0	8399.0	8396.0	8699.0
20	Potassium	mg/l	299.0	385.0	391.0	395.0
21	Iron	mg/l	BQL	BQL	0.88	0.57
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 36: Marine Water Quality Monitoring Parameters for Location Near Passenger Jetty One at Kandla

Sr. No.	Parameters	Unit	Near passenger Jetty One (2)			
			23° 0'18 "N 70°13'31"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.43	7.28	7.33	7.41
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	20.8	20.4	19.9	18.6
5	Turbidity	NTU	43	48	36	41
6	Total Dissolved Solids	mg/l	35468.0	37102.0	34662.0	33398.0
7	Total Suspended Solids	mg/l	679.7	665.5	703.7	663.8
8	Total Solids	mg/l	36147.7	37767.5	35365.7	34061.8
9	DO	mg/l	5.9	6.2	5.6	5.2
10	COD	mg/l	86.0	94.0	90.0	92.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	1.26	0.86	1.33	0.85
13	Phosphate	mg/l	0.29	0.13	0.33	0.19
14	Sulphate	mg/l	3571	3470	4072	3407
15	Nitrate	mg/l	3.40	2.70	1.17	4.36
16	Nitrite	mg/l	<0.05	<0.05	BQL	BQL
17	Calcium	mg/l	561.12	601.20	601.2	521.04
18	Magnesium	mg/l	1701	1603.8	1749.6	1701
19	Sodium	mg/l	9142.0	9345.0	9247.0	9219.0
20	Potassium	mg/l	370.0	385.0	370.0	380.0
21	Iron	mg/l	0.47	BQL	1.76	0.30
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Nitrite: 0.05mg/lCu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 37: Marine Water Quality Monitoring Parameters for location Near Coal Berth

Sr. No.	Parameters	Unit	Near Coal Berth			
			22°59'12"N 70°13'40"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.37	7.51	7.53	7.25
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	18.6	18.1	19.5	20.8
5	Turbidity	NTU	33	42	38	45
6	Total Dissolved Solids	mg/l	39222.0	37586.0	37123.0	36668.0
7	Total Suspended Solids	mg/l	540.2	638.4	620.6	580.2
8	Total Solids	mg/l	39762.2	38224.4	37743.6	37248.2
9	DO	mg/l	7.3	6.4	7.1	6.5
10	COD	mg/l	81.0	874.0	88.0	84.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.56	0.98	0.69	1.76
13	Phosphate	mg/l	0.06	0.56	0.12	0.61
14	Sulphate	mg/l	4222	3458	2981	3758
15	Nitrate	mg/l	2.20	4.60	2.68	4.70
16	Nitrite	mg/l	<0.05	<0.05	BQL	BQL
17	Calcium	mg/l	480.96	641.28	641.28	721.44
18	Magnesium	mg/l	1628.1	1628.1	1676.7	1603.8
19	Sodium	mg/l	8346.0	9380.0	9245.0	9814.0
20	Potassium	mg/l	391.0	300.0	392.0	384.0
21	Iron	mg/l	BQL	BQL	BQL	1.34
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 38: Marine Water Quality Monitoring Parameters for location Khori creek at Kandla

Sr. No.	Parameters	Unit	Khori creek			
			Near 15/16 Berth			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.48	7.27	7.34	7.21
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	20.4	19.5	18.6	17.7
5	Turbidity	NTU	35	31	43	39
6	Total Dissolved Solids	mg/l	32557.0	34294.0	30473.0	33329.0
7	Total Suspended Solids	mg/l	641.2	616.3	594.7	731.2
8	Total Solids	mg/l	33198.2	34910.3	31067.7	34060.2
9	DO	mg/l	7.6	6.3	7.3	6.8
10	COD	mg/l	85.0	96.0	92.0	96.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.78	1.04	1.39	1.18
13	Phosphate	mg/l	0.44	0.67	0.35	0.42
14	Sulphate	mg/l	4047	3646	3157	3170
15	Nitrate	mg/l	3.70	1.10	1.34	5.20
16	Nitrite	mg/l	<0.05	<0.05	BQL	BQL
17	Calcium	mg/l	561.12	480.96	480.96	561.12
18	Magnesium	mg/l	1725.3	1676.7	1701	1628.1
19	Sodium	mg/l	9112.0	8436.0	7966.0	8696.0
20	Potassium	mg/l	299.0	385.0	382.0	377.0
21	Iron	mg/l	0.44	BQL	0.17	0.31
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	0.02
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 39: Marine Water Quality Monitoring Parameters for location Nakti Creek near Tuna Port

Sr. No.	Parameters	Unit	Nakti Creek Near Tuna Port			
			22°57'49."N 70° 7'0.67"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.41	7.36	7.48	7.23
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	19.0	18.6	19.0	19.5
5	Turbidity	NTU	45	36	40	42
6	Total Dissolved Solids	mg/l	30214.0	28996.0	31047.0	31957.0
7	Total Suspended Solids	mg/l	642.7	526.2	682.5	606.8
8	Total Solids	mg/l	30856.7	29522.2	31729.5	32563.8
9	DO	mg/l	8.1	7.5	6.4	7.2
10	COD	mg/l	94.0	112.0	98.0	100.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	1.12	1.20	1.42	1.22
13	Phosphate	mg/l	0.71	0.37	0.46	0.12
14	Sulphate	mg/l	4172	3846	3445	3433
15	Nitrate	mg/l	1.50	1.70	5.12	1.69
16	Nitrite	mg/l	<0.05	<0.05	BQL	BQL
17	Calcium	mg/l	440.88	641.28	601.2	521.04
18	Magnesium	mg/l	1725.3	1555.2	1701	1773.9
19	Sodium	mg/l	8639.0	9143.0	8655.0	7939.0
20	Potassium	mg/l	395.0	386.0	384.0	386.0
21	Iron	mg/l	BQL	0.33	0.34	0.18
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 40: Marine Water Quality Monitoring Parameters for location Nakti Creek Near NH-8A at Kandla

Sr. No.	Parameters	Unit	Nakti Creek Near NH-8A			
			23° 02'01"N 70° 09'31"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.45	Sampling not possible during Low Tide	7.45	Sampling not possible during Low Tide
2	Color	-	Agreeable		Agreeable	
3	Odor	-	Agreeable		Agreeable	
4	Salinity	‰	19.9		20.8	
5	Turbidity	NTU	45		44	
6	Total Dissolved Solids	mg/l	30288.0		32796.0	
7	Total Suspended Solids	mg/l	529.6		595.7	
8	Total Solids	mg/l	30817.6		33391.7	
9	DO	mg/l	7.4		6.9	
10	COD	mg/l	118.0		110.0	
11	BOD	mg/l	BQL		BQL	
12	Silica	mg/l	1.02		0.16	
13	Phosphate	mg/l	0.75		0.46	
14	Sulphate	mg/l	4109		4961	
15	Nitrate	mg/l	2.70		3.52	
16	Nitrite	mg/l	<0.05		BQL	
17	Calcium	mg/l	681.36		641.28	
18	Magnesium	mg/l	1506.6		1628.1	
19	Sodium	mg/l	9280.0		8528.0	
20	Potassium	mg/l	427.0		427.0	
21	Iron	mg/l	BQL		0.54	
22	Chromium	mg/l	BQL		BQL	
23	Copper	mg/l	BQL		BQL	
24	Arsenic	mg/l	BQL		BQL	
25	Cadmium	mg/l	BQL		0.01	
26	Mercury	mg/l	BQL		BQL	
27	Lead	mg/l	BQL		BQL	
28	Zinc	mg/l	BQL		BQL	

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 41: Marine Water Quality Monitoring Parameters for locations Nr. Vadinar Jetty

Sr. No.	Parameters	Unit	Nr.Vadinar Jetty			
			22°26'25.26"N 69°40'20.41"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.43	7.26	7.36	7.29
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	20.4	20.8	19.0	19.9
5	Turbidity	NTU	39	42	38	42
6	Total Dissolved Solids	mg/l	35265.0	37685.0	36325.0	36681.0
7	Total Suspended Solids	mg/l	585.3	590.8	681.4	657.6
8	Total Solids	mg/l	35850.3	38275.8	37006.4	37338.6
9	DO	mg/l	5.7	5.4	6.3	5.8
10	COD	mg/l	87.0	89.0	96.0	92.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.55	0.45	0.36	0.28
13	Phosphate	mg/l	0.18	0.42	0.33	0.19
14	Sulphate	mg/l	3608	3558	3683	3645
15	Nitrate	mg/l	2.35	1.09	1.00	2.43
16	Nitrite	mg/l	<0.05	<0.05	BQL	BQL
17	Calcium	mg/l	480.96	601.20	521.04	480.96
18	Magnesium	mg/l	1603.8	1652.4	1676.7	1749.6
19	Sodium	mg/l	9448.0	7368.0	7810.0	8912.0
20	Potassium	mg/l	371.0	354.0	452.0	456.0
21	Iron	mg/l	BQL	BQL	0.31	BQL
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	0.29	BQL	0.77	0.35

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 42: Marine Water Quality Monitoring Parameters for locations Nr. Vadinar SPM

Sr. No.	Parameters	Unit	Nr. Vadinar SPM			
			22°30'56.15"N 69°42'12.07"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.37	7.22	7.41	7.35
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	19.0	17.7	19.5	18.6
5	Turbidity	NTU	37	40	37	39
6	Total Dissolved Solids	mg/l	39961.0	39198.0	42642.0	40730.0
7	Total Suspended Solids	mg/l	545.5	493.6	714.3	657.9
8	Total Solids	mg/l	40506.5	39691.6	43356.3	41387.9
9	DO	mg/l	6.1	5.5	5.6	6.1
10	COD	mg/l	95.0	98.0	96.0	94.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.47	0.37	0.34	0.30
13	Phosphate	mg/l	1.08	0.19	0.46	0.28
14	Sulphate	mg/l	3495	3796	3745	4008
15	Nitrate	mg/l	3.86	2.18	4.95	2.10
16	Nitrite	mg/l	<0.05	<0.05	BQL	BQL
17	Calcium	mg/l	561.12	400.80	681.36	641.28
18	Magnesium	mg/l	1628.1	1676.7	1555.2	1628.1
19	Sodium	mg/l	8473.0	10386.0	9131.0	8526.0
20	Potassium	mg/l	452.0	406.0	413.0	441.0
21	Iron	mg/l	BQL	BQL	0.24	BQL
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	0.28	BQL	0.40	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l)

8.2 Results & Discussion for Marine water samples

Marine water quality of Deendayal Port Harbor waters, Khori and Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each month. The Heavy metal analyzed and mostly found below quantification limit.

pH

During spring tide the pH values was ranged from 7.27-7.61 at DPA Kandla and 7.22-7.43 at Vadinar while during Neap Tide pH values was ranged from 7.21-7.55 at DPA Kandla and 7.29-7.41 at Vadinar.

Color and Odor

All marine samples for Odor and Color were found agreeable at all sampling locations.

Turbidity

During spring tide the Turbidity values was ranged from 31-48 NTU at DPA Kandla and 37-42 NTU at Vadinar while during Neap Tide Turbidity values was ranged from 35-45 NTU at DPA Kandla and 37-42 NTU at Vadinar. Turbidity is the amount of particulate matter that is suspended in water. Turbidity measures the scattering effect that suspended solids have on light: the higher the intensity of scattered light, the higher the turbidity (Yap et al, 2011). Materials that cause water to be turbid include clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, plankton and microscopic organisms (Lawler, 2004). The turbidity affects the amount of light penetrating to the plants for photosynthesis.

Total Dissolved Solids (TDS)

TDS values in the studied area during Spring Tide varied between 28966- 39222 mg/l at DPA Kandla and 35265-39961 mg/l at Vadinar while during Neap Tide TDS values was varied 30473-37123 mg/l at DPA Kandla and 36325-42642 mg/l at Near Vadinar.

Calcium

Calcium value in the studied area during Spring Tide varied between 440.9-681.4 mg/l at DPA Kandla and 400.8-601.2 mg/l at Vadinar while during Neap Tide calcium values between 481.0-721.4 mg/l at DPA Kandla and 481.0-681.4 mg/l at Vadinar.

Magnesium

Magnesium value in the studied area during Spring Tide varied between 1506.6-1773.9 mg/l at DPA Kandla and 1603.8-1676.7 mg/l at Vadinar while during Neap Tide magnesium values between 1603.80-173.9 mg/l at DPA Kandla and 1555.2 -1749.60 at Vadinar. Calcium and magnesium both play an important role in antagonizing the toxic effects of various ions and neutralizing the excess acid produced (Narayan R. et. al., 2007)

Nitrate

Nitrate value in the studied area during Spring Tide varied between 0.5-4.7 mg/l at DPA Kandla and 1.09-3.86 mg/l at Vadinar while during Neap Tide Nitrate values between 0.42-5.2 mg/l at DPA Kandla and 1.0-4.95 at Vadinar.

The variations were observed due to variation in phytoplankton excretion, oxidation of ammonia, reduction of nitrate and by recycling of nitrogen and bacterial decomposition of planktonic detritus (Asha and Diwakar, 2007).

Iron

Iron values in the studied area during Spring Tide ranged from 0.33-0.47 mg/l at DPA Kandla and at Vadinar were BQL (<0.10) while during Neap Tide Iron values ranged from 0.17-1.76 mg/l at DPA Kandla and 0.24-0.31 mg/l at Vadinar.

Sulphates

Sulphate values in the studied area during Spring Tide ranged from 3407-4222 mg/l at DPA Kandla and 3495-3796 mg/l at Vadinar while during Neap Tide the Sulphate values was varied 2981-4961 mg/l at DPA Kandla and 3645-4008mg/l at Vadinar.

Salinity

Salinity values in the studied area during Spring Tide varied ranged 18.11 to 20.82 ‰ at DPA Kandla and 17.65 to 20.82 ‰ at Vadinar while during Neap Tide the Salinity values was varied 17.65 to 20.82 ‰ at DPA Kandla and 18.55 to 19.92 ‰ at Vadinar.

Sodium and Potassium Salts

During Spring Tide the Sodium values ranged from 8011-9380 mg/l at DPA Kandla & 7368-10386 mg/l at Vadinar and Potassium salts ranged from 299-427 mg/l at DPA Kandla & 354-452 mg/l at Vadinar while during Neap Tide the Sodium values was ranges from 7939-

9814 mg/l at DPA Kandla & 7810-9131 mg/l at Vadinar and Potassium salts ranged from 370-427 mg/l at DPA Kandla & 413-456 mg/l at Vadinar.

DO

The DO refers to the amount of oxygen dissolved in the water and it is particularly important in limnology {(aquatic ecology) (Weiss 1970)}. The fate and behavior of DO is of critical importance to marine organisms in determining the severity of adverse impacts (Best et al. 2007). The major factor controlling dissolved oxygen concentration is biological activity: photosynthesis producing oxygen while respiration and nitrification consume oxygen (Best et al. 2007). From the studied samples, DO in marine water during Spring Tide was found in ranges from 5.6-8.1 mg/l at DPA Kandla and 5.4-6.1 mg/l at Vadinar while during Neap Tide 5.2-7.3 mg/l at DPA Kandla and 5.6-6.3 mg/l at Vadinar.

BOD

BOD in marine water at all sampling location in the studied samples were found BQL (<2.0 mg/l).

Heavy Metals in Marine Water

In the present study period marine water samples were analyzed for Cr, Cu, Cd, As, Hg, Pb and Zn. Maximum heavy metals parameters were well Below the Quantification limits.

9.3 Conclusion

In the present study period marine water samples were analyzed and found inline as per Primary Water Quality criteria for class-IV WATERS (For Harbour Waters).

9.0 Marine Sediments

The deep-sea ocean floor is made up of sediment. This sediment is composed of tiny particles such as fine sand, silt, clay, or animal skeletons that have settled on the ocean bottom. Over long periods of time, some of these particles become compressed and form stratified layers. Scientists that study these layers look at particle size, particle composition, and origin to help them create historical records of the deep ocean floor. This process is called weathering. Weathering can be either mechanical or chemical. Mechanical weathering can occur as ice, wind, or water wears away the rock's surface. Chemical weathering can occur as rocks are dissolved by a chemical such as acid rain. The particles created as a result of weathering are called terrigenous sediments. These particles are transported to the ocean by wind and by rivers and streams. Once the particles enter the ocean, they are dispersed by waves, currents, and tides. The heaviest and largest particles that reach the oceans, such as sand, settle very quickly to the bottom as a result of gravity. Sand is deposited near the coast whereas the smaller silt and clay particles are transported farther distances offshore before they settle to the bottom. Sediments are an important component of aquatic ecosystems because they provide nutrients and habitat for aquatic organisms (Benhamed et al. 2016). However, human activities result in accumulation of toxic substances such as heavy metals in marine sediments. Heavy metals are well-known environmental pollutants due to their toxicity, persistence in the environment, and bioaccumulation. Metals affect the ecosystem because they are not removed from water by self-purification, but accumulate in sediments and enter the food chain (Astakhov et al. 2015).

Sediment samples were collected with Van Veen Grab from the six locations in Kandla Port Waters and two locations in Vadinar Port. Benthic surface grab samplers look like giant metal jaws. They dig into the bottom and take a bite of the sediment. These samplers are good for collecting softer, sandy or silty sediments that do not contain rocks. A box corer is a cross between a surface sampler and a sediment corer. It is a special device that is used to collect an undisturbed sample of the very top surface layers and the sediment underneath. Samples were collected and preserved in silver foil in ice box to prevent the contamination/decaying of the samples.

10.1 Results

The Sediment Quality results are given in below from table no. 43 & 44.

Table 43: Results of Analysis of Sediment of Kandla & Vadinar Port (Neap Tide)

Sr. No.	Parameters	Unit	DPA – 1	DPA - 2	DPA - 3	DPA - 4	DPA - 5	Jetty	SPM
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	1.32	0.6	0.1	0.1	0.16	1.14	1.59
3	Organic Carbon	mg/kg	0.76	0.35	0.07	0.06	0.09	0.66	0.91
4	Inorganic Phosphate	mg/kg	89.00	90.00	101.00	92.00	100.00	90.00	100.00
5	Moisture	%	3.90	2.37	4.12	3.00	4.10	3.40	4.00
6	Aluminum	mg/kg	ND	ND	ND	ND	ND	ND	ND
7	Silica	mg/kg	7.30	7.68	8.90	9.30	9.10	8.90	9.60
8	Phosphate	mg/kg	5.20	4.99	4.09	5.25	9.00	3.28	10.40
9	Sulphate	mg/kg	759.00	849.00	555.00	496.00	768.00	732.00	496.00
10	Nitrite	mg/kg	0.11	0.11	0.10	0.10	0.12	0.10	0.11
11	Nitrate	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
12	Calcium	mg/kg	2765.00	1523.00	861.00	961.00	981.00	1162.00	2485.00
13	Magnesium	mg/kg	1372.00	1300.00	1020.00	1263.00	1032.00	1089.00	2065.00
14	Sodium	mg/kg	2410.0	2760.0	2644.0	2940.0	2722.0	1394.00	1082.00
15	Potassium	mg/kg	404.00	459.00	390.00	510.00	447.00	811.0	560.0
16	Chromium	mg/kg	61.30	71.90	66.00	53.30	56.40	42.80	49.70
17	Nickel	mg/kg	26.80	31.70	29.00	23.00	24.10	13.80	29.20
18	Copper	mg/kg	17.40	19.40	17.80	15.50	15.80	13.80	47.10
19	Zinc	mg/kg	43.40	55.80	49.80	41.80	46.00	32.00	64.30
20	Cadmium	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
21	Lead	mg/kg	5.20	6.20	5.70	9.80	8.40	12.00	BQL
22	Mercury	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
23	Arsenic	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL

*ND - Not Detected, BQL: Below Quantification Limit (NO3:10.0mg/kg, Cd: 1.0mg/kg, Hg: 1.0mg/kg, As: 1.0mg/kg).

Table 44 : Results of Analysis of Sediment of Kandla & Vadinar Port (Spring Tide)

Sr. No.	Parameters	Unit	DPA – 1	DPA - 2	DPA - 3	DPA - 4	DPA - 5	Jetty	SPM
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	0.91	0.50	1.52	0.37	0.27	1.45	1.68
3	Organic Carbon	mg/kg	0.52	0.29	0.87	0.21	0.15	0.83	0.97
4	Inorganic Phosphate	mg/kg	98.00	90.00	80.00	78.00	100.00	88.00	90.00
5	Moisture	%	17.00	8.70	15.00	6.60	4.80	14.24	13.14
6	Aluminum	mg/kg	ND	ND	ND	ND	ND	ND	ND
7	Silica	mg/kg	7.20	8.26	9.02	5.50	7.80	9.20	10.02
8	Phosphate	mg/kg	7.87	9.29	6.16	5.75	9.49	11.61	10.80
9	Sulphate	mg/kg	745.00	862.00	585.00	490.00	510.00	590.00	396.00
10	Nitrite	mg/kg	0.11	0.12	0.12	0.11	0.10	0.10	0.11
11	Nitrate	mg/kg	BQL	BQL	12.00	16.6	26.2	BQL	BQL
12	Calcium	mg/kg	1723.00	1057.00	1320.00	1220.00	1390.00	1907.00	1643.00
13	Magnesium	mg/kg	1044.00	716.00	1090.00	690.00	896.00	1563.00	2320.00
14	Sodium	mg/kg	2733.00	2720.00	2578.00	2107.00	1558.00	1042.00	952.00
15	Potassium	mg/kg	302.00	332.00	378.0	357.0	87.8	384.00	325.00
16	Chromium	mg/kg	38.00	24.40	51.70	16.10	60.00	48.90	69.20
17	Nickel	mg/kg	15.60	9.50	21.70	6.00	24.70	19.70	28.30
18	Copper	mg/kg	7.80	BQL	11.30	31.40	16.40	12.10	19.90
19	Zinc	mg/kg	30.10	21.90	35.70	13.70	44.90	31.50	51.90
20	Cadmium	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
21	Lead	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
22	Mercury	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
23	Arsenic	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL

*ND - Not Detected, BQL: Below Quantification Limit (NO3:10.0 mg/kg,Cd: 1.0 mg/kg, Hg: 1.0mg/kg, As: 1.0mg/kg)

9.2 Discussion of Marine Sediment samples

Marine Sediments of Deendayal Port Harbor waters, Khori and Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each month. The Heavy metal analyzed and found below quantification limit.

9.3 Conclusion

The sediment types are majority Sandy loamy. Also maximum heavy metals parameters found below Quantification limit wise, Pb, Cd, Hg , As, Al was not Detected and Nitrate for some locations.

10.0 INTRODUCTION:

10.1 Sampling Stations:

The monitoring of marine environment for the study of biological and ecological Parameters was carried out on 01st November 2022 in harbour region of DPA at Kandla Creek, and on 02nd November 2022 in creeks near by the port during Neap tide. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 08th November, 2022 in harbour region of DPA at Kandla Creek and on 09th November, 2022 in creeks near by the port during spring tidal condition.

Plankton samples from sub surface layer was collected both during high tide period and low tide period from 3 water quality monitoring stations of DPA harbour area and two stations in Nakti creek and one station in Khori creek. Sampling at second sampling station of Nakti creek was possible only during high tide period.

Plankton samples from sub surface layer were collected during high tide period and low tide period from monitoring station near Vadinar Jetty at Path Finder Creek during Neap tide on 01/11/2022 and Spring tide period on 08/11/2022.Collected water samples were processed for estimation of Chlorophyll- a, Pheophytin- a, qualitative and quantitative evaluation of phytoplankton, qualitative and quantitative evaluation of zoo plankton density and their population.

TABLE 43. SAMPLING LOCATIONS

monitoring requirement	**Number of locations**
Kandla creek	3 in Kandla creek
Nakti creek	2 in Nakti creek
Khori Creek	1 in Khori creek
Vadinar jetty	1 near Vadinar Jetty
SPM	1 near I stSPM
Total Number of locations	**8**

Sampling methodology adopted:

A marine sampling is an estimation of the body of information in the population. The theory of the sampling design is depending upon the underlying frequency distribution of the population of interest. The requirement for useful water sampling is to collect a representative sample of suitable volume from the specified depth and retain it free from contamination during retrieval.

50 litres of the water sample were collected from Sub surface by using bucket. From the collected water sample 1 litres of water sample was taken in an opaque plastic bottle for chlorophyll estimation, thereafter plankton samples were collected by using filtration assembly with Nylobolt cloth of 20µm mesh size. . During low tide DPA-6 Nakti-II location monitoring was not possible due to non-availability of marine water.

Samples Processing for chlorophyll estimation:

Samples for chlorophyll estimation were preserved in ice box on board in darkness to avoid degradation in opaque container covered with aluminium foil. Immediately after reaching the shore after sampling, 1 litre of collected water sample was filtered through GF/F filters (pore size 0.45 µm) by using vacuum filtration assembly. After vacuum filtration the glass micro fiber filter paper was grunted in tissue grinder, macerating of glass fiber filter paper along with the filtrate was done in 90% aqueous Acetone in the glass tissue grinder with glass grinding tube. Glass fiber filter paper will assist breaking the cell during grinding and chlorophyll content was extracted with 10 ml of 90% Acetone, under cold dark conditions along with saturated magnesium carbonate solution in glass screw cap tubes. After an extraction period of 24 hours, the samples were transferred to calibrated centrifuge tubes and adjusted the volume to original volume with 90% aqueous acetone solution to make up the evaporation loss. The extract was clarified by using centrifuge in closed tubes. The clarified extracts were then decanted in clean cuvette and optical density was observed at wavelength 664, 665 nm. By using corrected optical density, Chlorophyll-a value was calculated as given in (APHA, 2017).

PLANKTON:

The entire area open water in the sea is the pelagic realm. Pelagic organisms live in the open sea. In contrast to the pelagic realm, the benthic realm comprises organisms and zone of the bottom of the sea. Vertically the pelagic realm can be dividing into two zones based on light penetration; upper photic or euphotic zone and lower dark water mass, aphotic zone below the photic zone.

The term plankton is a general term for organisms which have such limited powers of locomotion that they are at the mercy of the prevailing water movement. Plankton is subdivided to phytoplankton and zooplankton. Phytoplanktons are free floating organisms that are capable of photosynthesis and zooplankton is the various free-floating animals.

Pelagic zone, represents the entire ocean water column from the surface to the deepest depths, is home to a diverse community of organisms. Differences in their locomotive ability categorize the organisms in the pelagic realm into two, ***plankton*** and ***nekton*** (Lalli and Parsons, 1997). ***Plankton*** consists of all organisms drifting in the water and is unable to swim against water currents, whereas ***Nekton*** includes organisms having strong locomotive power. Ecological studies on the plankton community, which form the base of the aquatic food chain, help in the better understanding of the dynamics and

functioning of the marine ecosystem. The term 'Plankton' first coined by Victor Hensen (1887), Plankton, (Greek word: *planktos*meaning "passively drifting or wandering") is defined as drifting or free-floating organisms that inhabit the pelagic zone of water. Based on their mode of nutrition planktonic organisms are categorised into phytoplankton (organisms having an autotrophic mode of nutrition) and zooplankton (organisms having a heterotrophic mode of nutrition).

Phytoplankton in the marine environment:

Phytoplanktons are free floating unicellular, filamentous and colonial eutrophic organisms that grow in aquatic environments whose movement is more or less dependent upon water currents. These micro flora acts as primary producers as well as the basis of food chain, source of protein, bio-purifier and bio-indicators of the aquatic ecosystems of which diverse array of the life depends .They are considered as an important component of aquatic flora, play a key role in maintaining equilibrium between abiotic and biotic components of aquatic ecosystem.

The phytoplankton includes a wide range of photosynthetic and phototrophic organisms. Marine phytoplankton is mostly microscopic and unicellular floating flora, which are the primary producers that support the pelagic food-chain. The two most prominent groups of phytoplankton are Diatoms (Bacillariophyceae) and Dinoflagellates (Dinophyceae).The phytoplankton those normally captured in the net from the Gulf of Kutch is normally dominated by these two major groups; Diatoms and Dinoflagellates. Phytoplankton also include numerous and diverse collection of extremely small, motile algae which are termed micro flagellates (naked flagellates) as well as and Cyanophytes (Blue-green algae).

Algae are an ecologically important group in most aquatic ecosystems and have been an important component of biological monitoring programs. Algae are ideally suited for water quality assessment because they have rapid reproduction rates and very short life cycles, making them valuable indicators of short-term impacts.

Aquatic populations are impacted by anthropogenic stress, resulting in a variety of alterations in the biological integrity of aquatic systems. Algae can serve as an indicator of the degree of deterioration of water quality, and many algal indicators have been used to assess environmental status.

Zooplankton in the marine environment:

Zooplankton includes a taxonomically and morphologically diverse community of heterotrophic organisms that drift in the waters of the world's oceans. Qualitative and quantitative studies on zooplankton community are a prerequisite to delineate the ecological processes active in the marine ecosystem. Zooplankton community plays a pivotal role in the pelagic food web as the primary consumers of phytoplankton and act as the food source for organisms in the higher trophic levels, particularly the economically essential groups such as fish larvae and fishes. They also function in the cycling of elements in the marine ecosystem. The dynamics of the zooplankton community, their reproduction, and growth and survival rate are all significant factors determining the recruitment and

abundance of fish stocks as they form an essential food for larval, juvenile and adult fishes (Beaugrand et al., 2004). Zooplankton grazing in the marine environment controls the primary Production and helps in determining the pelagic ecosystem (Banse, 1995). Through grazing in surface waters and following the production of sinking faecal matters and also by the active transportation of dissolved and particulate matter to deeper waters via vertical migration, they help in the transport of organic carbon to deep ocean layers and thus act as key drivers of 'biological pump' in the marine ecosystem. Zooplankton grazing and metabolism also, transform particulate organic matter into dissolved forms, promoting primary producer community, microbial demineralization, and particle export to the ocean's interior.

The categorisation of zooplankton into various ecological groups is based on several factors such as duration of planktonic life, size, food preferences and habitat. As they vary significantly in size from microscopic to metazoic forms, the classification of zooplankton based on size has paramount importance in the field of quantitative plankton research.

Based on the duration of planktonic life, zooplankton are categorised into Holoplankton (organisms which complete their entire lifecycle as plankton) and Meroplankton (organisms which are planktonic during the early part of their lives such as the larval stages of benthic and nektonic organisms). Tychoplankton are organisms which live a brief planktonic life, such as the benthic crustaceans (Cumaceans, mysids, isopods) which ascend to the water column at night for feeding and certain ectoparasitic copepods, they leave the host and spend their life as plankton during their breeding cycle.

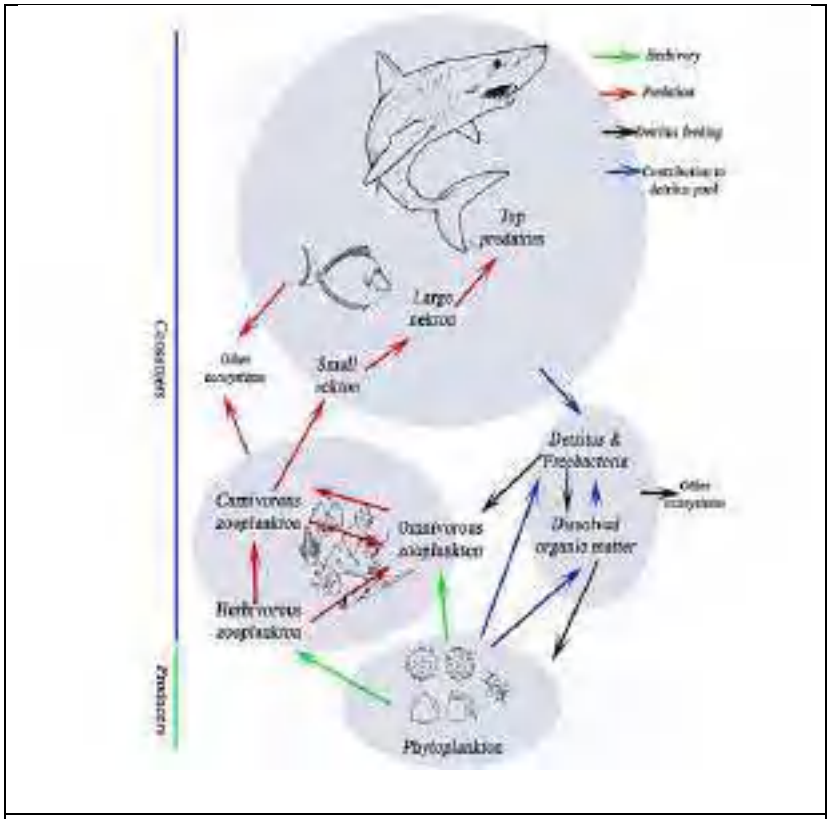
Zooplankton can be subdivided into holoplankton, i.e., permanent members of the plankton (e.g., Calanoid copepods), and meroplankton, i.e., temporary members in the plankton e.g., larvae of fish, shrimp, and crab). The meroplankton group consists of larval and young stages of animals that will adopt a different lifestyle once they mature. In contrast to phytoplankton which consist of a relatively smaller variety of organisms, Zooplankton are extremely divers, consist of a host of larval and adult forms representing many animal phylum.

Among the zooplankton one group always dominate than others; members of sub class copepods (Phylum Athropoda) and Tintinids (Phylum Protozoa) among the net planktons. These small animals are of vital importance in marine ecosystem as one of the primary herbivores animals in the sea, and it is they provide vital link between primary producer (autotrophs) and numerous small and large marine consumers.

As their community structure and function are highly susceptible to changes in the environmental conditions regular monitoring of their distribution as well as their interactions with various physicochemical parameters is inevitable for the sustainable management of the ecosystem (Kusum et al., 2014). Of all the marine zooplankton groups, copepods mainly Calanoid copepods are the

dominant groups in marine subtropical and tropical waters and exhibit considerable diversity in morphology and habitats they occupy (Madhupratap, 1991 ;)

It has been well established that potential of pelagic fishes viz. finfishes, crustaceans, molluscs and marine mammals either directly or indirectly depend on zooplankton. The herbivorous zooplanktons are efficient grazers of the phytoplankton and are referred to as living machines transforming plant material into animal tissue. Hence they play an essential role as the intermediaries for nutrients/energy transfer between primary and tertiary trophic levels. Due to their large density, shorter lifespan, drifting nature, high group/species diversity and different tolerance to the stress, they used as the indicator organisms for the physical, chemical and biological processes in the aquatic ecosystem (Ghajbhiye, 2002).



Simplified marine food web

Spatial distribution of Plankton:

A characteristic of plankton population is that they tend to occur in patches, which are varying spatially on a scale of few meters to far as few kilo metres in distance. They also vary in time scale, season as well as vertically in the water column. It is this patchiness and its constant changes in time and spot, that has made it so difficult for plankton biologist to learn about the ecology of plankton. The biological factors that causes this patchiness is due to the ability of zooplankton to migrate vertically and graze out the phytoplankton at a rapid rate that can create patchiness. Similarly the active swimming ability by certain zooplankton organisms can cause to aggregate in dense group.

At its most extreme, because the water in which plankton is suspended is constantly moving, each sample taken by the plankton biologists remain a different volume of water, so each sample is unique and replicate does not exist.

Plankton in the month of Novemberalso exhibit vertical patchiness. Physical factors contribute to this type of patchiness include light intensity, nutrients and density gradients in the water column.

Phytoplankton in particular tends to be unequally distributed vertically, which leads to the existence of different concentration of a chlorophyll value between photic zone and below the photic zone.

Methodology adopted for Plankton sampling:

Preservation and storage:

Both filtered plankton and those collected from the plankton net were preserved with 5% buffered formalin and stored in 1L plastic container for further processing in the laboratory.

Sample concentration:

The collected plankton samples were concentrated by using centrifuge and made up to 50 ml with 5% formalin -Glycerine mixture.

Taxonomic evaluation:

Before processing, the sample was mixed carefully and a subsample was taken with a calibrated Stempel-pipette. 1 ml of the concentrated plankton samples were transferred on a glass slide with automatic pipette. The plankton sample on the glass slides were stained by using Lugol's iodine and added glycerin to avoid drying while observation. The plankton samples were identified by using Labex triangular Research microscope with photographic attachment. Microphotographs of the plankton samples were taken for record as well as for confirming the identification. The bigger sized zooplankton was observed through dissecting stereomicroscope with magnification of 20-30 x. Plankton organisms in the whole slide were identified to the lowest taxon possible. A thorough literature search was conducted for the identification of the different groups of phytoplankton and zooplankton that were encountered

Cell counts by drop count method:

The common glass slide mounted with a 1ml of concentrated phytoplankton/zooplankton sample in glycerol and covered with cover slip 22 mm x 60 mm was placed under the compound microscope provided with a mechanical stage. The plankton was then counted from the microscopic field of the left top corner of the slide. Then slide is moved horizontally along the right side and plankton in each microscopic field was thus counted. When first microscopic field row was finished the next consecutive row was adjusted using the mechanical device of the stage. In this way all the plankton present in entire microscopic field are counted. From this total number in 1ml of the concentrated plankton, total amount of phytoplankton in the original volume of sample filtered was calculated as units/L and Zooplankton as N/m^3.

BENTHIC ORGANISMS:

Benthos is those organisms that are associated with the sea bed or benthic habitats. Epi- benthic organisms live attached to a hard substratum or rooted to a shallow depth below the surface. In fauna organisms live below the sediment–water interface. Interstitial organisms live and move in pore water among sedimentary grains.

Because the benthic organisms are often collected and separated on sieves, a classification based on the overall size is used. Macro benthos include organisms whose shortest dimension is greater than or equal to 0.5 mm. Meio benthos are smaller than 0.5mm but larger than 42µ in size.

The terms such as macro fauna and Meio fauna generally have little relevance with taxonomic classification. The terms Meio fauna and macro fauna depend on the size. Meio fauna were considered as good bioassay of community health and rather sensitive indicators of environmental changes

SAMPLING METHODOLOGY ADOPTED FOR SUB TIDAL REGION:

Van veen sampler ($0.09m^2$) was used for sampling bottom sediments. Two sets of sediments were sampled from each location, one for macro fauna and other for Meio fauna. The macro fauna in the sediments were sieved on board to separate out the organisms. The fixation of Meio fauna is normally done by bulk fixation of the sediment sample. The bulk fixation is done by using 10% formalin (Buffered with borate). The organisms were preserved with seawater as diluting agent.

Sample sieving:

Sediments samples were sieved to extract the organisms. Sieving was performed carefully as possible to avoid any damage to the animals. The large portion of the sediment was split in to smaller portions and mixed with sea water in a bucket. The cohesive lumps were broken down by continuous stirring. The disaggregated sediments were then passed through the sieves.

Sample staining:

Sorting of the Meio fauna from the sieve is difficult task especially in the preserved material, because organisms are not easily detectable. To facilitate the animal detection the entire sample retained on the sieve after sieving operation were stained by immersing the sieve in a flat bottom tub with 1% Rose Bengal stain; a protein stain. A staining period of 10-30 minutes is sufficient for sample detection.

DIVERSITY INDICES:

On the whole, diversity indices provide more information about community composition than simply species richness (number of species present); they also, take the relative abundances of different species into account. Based on this fact, diversity indices therefore depend not only on species richness but on the evenness, or equitability, with which individuals are distributed among the different species (Magurram, A. E. (1988)

A diversity index is a measure of species diversity within a community that consists of co-occurring populations of several (two or more) different species. It includes two components: richness and evenness. Richness is the measure of the number of different species within a sample showing that more the types of species in a community, the higher is the diversity or greater is the richness. Evenness is the measure of relative abundance of the different species with in a community.

The basic idea of diversity index is to obtain a quantitative estimate of biological variability that can be used to compare biological entities composed of discrete components in space and time (Carol H. R. *etal*. 1998). Biodiversity is commonly expressed through indices based on species richness and species abundances (Whittaker 1972, Lande 1996, Purvis and Hector 2000). Biodiversity indices are a non-parametric tool used to describe the relationship between species number and abundance. The most widely used bio diversity indices are Shannon Weiner index and Simpson's index.

A diversity Index is a single statistic that incorporates information on richness and evenness. Any study intended to interpret causes and effect of adverse impact on Biodiversity of communities require suitable measures to evaluate specie richness and Diversity. The former is number of species in community, while latter is a function of relative frequency of different species. Species richness is the iconic measure of biological diversity (Magurran, 2004). Several indices have been created to measure the diversity of species; however, the most widely used in the last decades are the Shannon (1948) and Simpson (1949) (Buzas and Hayek 1996; Gorelick 2006), with the components of diversity: richness (*S)* and evenness (*J)*

Simpson's diversity index

Simpson's index (**D**) is a measure of diversity, which takes into account both species richness, and evenness of abundance among the species present. The Simpson index is one of the meaningful and robust biodiversity measures available. (Magurran , 2004).

The formula for calculating D is presented as:

$$D = \frac{\sum n_i(n_i - 1)}{N(N-1)}$$

Where n_i = the total number of organisms of each individual species

N = the total number of organisms of all species

The value of D ranges from 0 to 1. With this index, 0 represents infinite diversity and, 1, no diversity. When D increases diversity decreases. Simpson's index is therefore usually expressed as 1-D or 1/D. (Magurran, 2004)

Low species diversity suggests:

- relatively few successful species in the habitat
- the environment is quite stressful with relatively few ecological niches and only a few organisms are really well adapted to that environment

- food webs which are relatively simple
- change in the environment would probably have quite serious effects

High species diversity suggests:

- a greater number of successful species and a more stable ecosystem
- more ecological niches are available and the environment is less likely to be hostile complex food webs
- environmental change is less likely to be damaging to the ecosystem as a whole

Species richness indices

The species richness***(S)*** is simply the number of species present in an ecosystem. Species richness Indices of species richness are widely used to quantify or monitor the effects of anthropogenic disturbance. A decline in species richness in may be concomitant with severe or chronic human-induced perturbation (Fair Fair weather 1990) Species richness measures have traditionally been the mainstay in assessing the effects of environmental degradation on the biodiversity of natural assemblages of organisms (Clarke &Warwick, 2001)

Species richness is the iconic measure of biological diversity (Magurran, 2004). The species richness***(S)*** is simply the number of species present in an ecosystem. This index makes no use of relative abundances. The term species richness was coined by Mc Intosh (1967) and oldest and most intuitive measure of biological diversity (Magurran, 2004).

Margalef's diversity index is a species richness index. Margalef's Species richness index (d), or indices that describe the evenness of the distribution of the numbers of individuals among species, were derived.

The value of a diversity index increases both when the number of types increases and when evenness increases. For a given number of types, the value of diversity index is maximised when all types are equally abundant [Rosenzweig, M. L. (1995)]

Shannon-Wiener's index:

An index of diversity commonly used in plankton community analyses is the Shannon-Wiener's index **(H),** which emphasizes not only the number of species (richness or variety), but also the apportionment of the numbers of individuals among the species (Odum 1971 and Reish 1984). Shannon-Wiener's index **(H**) reproduces community parameters to a single numberby using an equation.

Shannon and Weiner index represents entropy. It is a diversity index taking into account the number of individuals as well as the number of taxan. It varies from 0 for communities with only single taxa to high values for community with many taxan each with few individuals. This index can also determine the pollution status of a water body. Normal values range from 0 to 4. This index is a combination of species present and the evenness of the species. Examining the diversity in the range

of polluted and unpolluted ecosystems, Wilham and Dorris (1968) concluded that the values of the index greater than

3 indicate clean water, values in the range of 1 to 3 are characterized by moderate pollution and values less than 1 are characterized as heavily polluted

10.2:- RESULTS:

$$H' = -\sum_{i=1}^{s} \frac{n_i}{N} \ln\left(\frac{n_i}{N}\right)$$

CHLOROPHYLL-a:

In the sub surface water chlorophyll-a was varying from 0.472-0.969 mg/m^3 with an average value 0.645 mg/m^3 in harbour region of DPA in Kandla Creek during sampling done in spring tide period of November 2022. In the nearby creeks chlorophyll-a was varying from 0.359-0.717 mg/m^3 with an average value 0.552 mg/m^3 Pheophytin –a level was below detectable limit- the all the sampling stations during springtide. Even though the plankton diversity and abundance were more during the spring tide sampling,the chlorophyll-content was detected lesser than expected because, the phytoplankton communities were mainly represented by diatoms *Skeletonema* sp. *Coscinodiscus sp.* and *Chaetoceros* sp.

In the sub surface water chlorophyll-a was varying from 0.338-0.547 mg/m^3 with an average value 0.437 mg/m^3 in harbour region of DPA in Kandla Creek during sampling done in Neap tide period of November2022. In the nearby creeks chlorophyll-a was varying from 0.205- 0.440mg/m^3 with an average value 0.370 mg/m^3. Pheophytin–a level was below detectable limit- the all the sampling stations. During neap tide sampling phytoplankton communities were mainly represented by *Coscinodiscus sp. and Ditylum sp.*

In the sub surface water chlorophyll-a was varying from 0.598-0.968 mg/m^3 in harbour region of DPA OOT in path finder Creek during sampling done in spring tide period of November 2022. In the sub surface water chlorophyll-a was varying from 0.709 - 0.987mg/m^3 in harbour region of DPA OOT in path finder Creek during sampling done in Neap Tide period of November 2022

TABLE:-45 VARIATIONS IN CHLOROPHYLL–a PHEOPHYTIN-a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPA HARBOUR AREA IN KANDLA CREEK ,NEAR BY CREEKS AND DPA OOT JETTY IN PATH FINDER CREEK AND SPM NEAR VADINARDURING SPRING TIDE IN NOVEMBER 2022

Sr. No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPA HARBOUR AREA KANDLA CREEK					
1	KPT1	High tide	0.969	BDL	64.92
		Low tide	0.647	BDL	43.35
2	KPT 2	High tide	0.511	BDL	34.24
		Low tide	0.521	BDL	34.91
3	KPT 3	High tide	0.749	BDL	50.18
		Low tide	0.472	BDL	31.62
CREEKS					
4	KPT-4 Khori-I	High tide	0.638	BDL	42.75
		Low tide	0.359	BDL	24.05
5	KPT-5 Nakti-I	High tide	0.717	BDL	48.04
		Low tide	0.493	BDL	33.03
6	KPT-6 Nakti-II	High tide	ND	ND	ND
PATHFINDER CREEK VADINAR					
7	VADINAR-I jetty	High tide	0.968	BDL	64.86
8		Low tide	0.732	BDL	49.04
9	SPM	High tide	0.953	BDL	63.85
10		Low tide	0.598	BDL	

BDL: Below Detectable Limit., ND: Not detected

TABLE:-46. VARIATIONS IN CHLOROPHYLL–a PHEOPHYTIN-a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPA HARBOUR AREA, NEAR BY CREEKS AND DPA OOT JETTY IN PATH FINDER CREEK AND SPM NEAR VADINARDURING NEAP TIDE IN NOVEMBER 2022

Sr.No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPA HARBOUR AREA KANDLA CREEK					
1	KPT1	High tide	0.547	BDL	
		Low tide	0.450	BDL	
2	KPT 2	High tide	0.338	BDL	
		Low tide	0.409	BDL	
3	KPT 3	High tide	0.354	BDL	
		Low tide	0.523	BDL	
CREEKS					
4	KPT-4 Khori-I	High tide	0.440	BDL	
		Low tide	0.408	BDL	
5	KPT-5 Nakti-I	High tide	0.205	BDL	
		Low tide	0.426	BDL	
6	KPT-6 Nakti-II	High tide	ND	ND	ND
PATHFINDER CREEK VADINAR					
7	VADINAR-I jetty	High tide	0.799	BDL	
8		Low tide	0.709	BDL	
9	SPM	High tide	0.857	BDL	
10		Low tide	0.987	BDL	

BDL: Below Detectable Limit.ND: Not detected

PHYTOPLANKTON POPULATION:

For the evaluation of the Phytoplankton population in DPA harbour area and within the immediate surroundings of the port, sampling was conducted from 5 sampling locations (3 in harbour area and two in Nakti creek) during high tide period and low tide period of spring tide and neap tide.

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by, Diatoms, blue green algae and Dinoflagellates during spring tide period. Diatoms were represented by 26 genera, Blue green algae were represented by 2 genera and Dinoflagellates were represented by 6 genera during the sampling conducted in spring tide in November, 2022. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 39-243units/ L during high tide period and115-199 units/L during low tide of Spring Tide. During spring tide sampling phytoplankton communities were dominated by *Skeletonema* sp almost forming a bloom in the Kandla creek and other nearby creek area and abundant population of *Coscinodiscus sp.* and *Chaetoceros* sp.

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by Diatoms, Blue green algae and DinoflagellatesduringNeap tide period. Diatoms were represented by 24 genera, Blue green algae were represented 2 genera and Dinoflagellates with 5 genera during the sampling conducted in Neap tide in November, 2022. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 43-299 units/ L during high tide period and 143-193 units/L during low tide of Neap Tide. During Neap tide sampling phytoplankton communities were dominated by, *Ditylum sp and Coscinodiscus sp.*

For the evaluation of the Phytoplankton population in DPA OOT jetty area in Path Finder creek sampling was conducted from two sampling locations; Jetty area and SPM area during high tide period and low tide of spring tide and Neap tide period.

The phytoplankton community of the sub surface water in the path finder creeks was represented by Diatoms, Blue green algae and Dinoflagellates during spring tide period. Diatoms were represented by 25 genera, Blue Green algae by 5 genera and Dinoflagellates by 6 genera during the sampling conducted in spring tide in November, 2022. Phytoplankton of the sampling stations at sub surface path finder creek near OOT Jetty area was 209 units/L during high tide period and 177 units/L during low tide of Spring Tide. Phytoplankton of the sampling stations at sub surface layer in the SPM area was varying from 206 units/ L during high tide period and 131 units/ L during low tide of Spring Tide.

The phytoplankton community of the sub surface water in the path finder creeks was represented by Diatoms, Blue green and Dinoflagellates during Neap tide period. Diatoms were represented by 32 genera and Blue green algae by 4 genera and Dinoflagellates by 6 genera during the sampling conducted in Neap tide in November, 2022. Phytoplankton of the sampling stations at sub surface path finder creek near OOT Jetty was varying from 244units/ L during high tide period and 200

units/L during low tide of Neap Tide. Phytoplankton of the sampling stations at sub surface path finder creek near SPM area was varying from 259 units/L during high tide period and 294 units/L during low tide of Neap Tide.

Species Richness Indices and Diversity Indices:

Margalef's diversity index (Species Richness)

Margalef's diversity index (Species Richness) of phytoplankton communities in the Kandla creek and nearby creeks sampling stations was varying from 2.184- 4.688 with an average of 3.346 during the sampling conducted in High tide period of spring tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek region and nearby creeks was varying from1.963- 3.589 with an average of 2.835during the consecutive low tide period.

Margalef's diversity index (Species Richness) of phytoplankton communities in the stations in Kandla creek and nearby creeks was varying from 2.393-4.279 with an average of 3.586during the sampling conducted in High tide period of Neap tide. While Margalef's diversity index (Species Richness) of phytoplankton communities in the Kandla creek region and nearby creeks was varying from 2.821-3.86 with an average of 3.357during consecutive low tide.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations was 4.867 at OOT jetty area and 4.129 at SPM area during the sampling conducted in High tide period of spring tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the path finder creek near OOT jetty was 4.443 and 3.692 at SPM during the consecutive low tide period.

Margalef's diversity index (Species Richness) of phytoplankton communities in the stations was 4.73 at OOT jetty area and 4.139 at SPM area during the sampling conducted in High tide period of Neap tide. While Margalef's diversity index (Species Richness) of phytoplankton communities in the path finder creek near OOT jetty was 4.152 and SPM area was 5.454 during the consecutive low tide period.

Shannon-Wiener's index:

Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.786- 1.034 between selected sampling stations with an average value of 0.925 during high tide period of spring tideat Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.790-0.915 between selected sampling stations with an average value of 0.855 during consecutive low tide at Kandla creek and nearby creeks.

Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.867–1.022 between selected sampling stations with an average value of 0.932 during high tide period of neap tide at Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton

communities in the sampling stations was in the range of 0.926- 1.001 between selected sampling stations with an average value of 0.951during consecutive low tide at Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton communities in the stations was1.037 at OOT jetty area and 0.946 at SPM area during the sampling conducted in High tide period of spring tide. While Shannon-Wiener's Index (H) of phytoplankton communities in the path finder creek near OOT jetty was 1.043 and 0.982 at SPM during the consecutive low tide period of spring tide.

Shannon-Wiener's Index (H) of phytoplankton communities in the stations was 0.998 at OOT jetty area and1.035 at SPM area during the sampling conducted in High tide period of Neap tide. While Shannon-Wiener's Index (H) of phytoplankton communities in the path finder creek near OOT jetty was 0.942 and at SPM area was1.036 during the consecutive low tide period.

Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon-Wiener's index increases as both the richness and the evenness of the community increase. This result indicates that diversity of phytoplankton of Kandla Harbour region and nearby creeks is less but with abundant population of few, with relatively few ecological niches and only very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson's diversity index:

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks, which was varying from 0.778-0.851 between selected sampling stations with an average of 0.823 during high tide period of spring tide. Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks except few, which was varying from 0.787-0.842 between selected sampling stations with an average of 0.814 during consecutive low tide.

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations except few in Kandla Harbour region and nearby creeks, during high tide period and low tide period during Neap tide also, which was varying from 0.813-0.874 with an average value of 0.847 between selected sampling stations during high tide period and 0.840-0.871 varying from with an average value of 0.858 between selected sampling stations during consecutive low tide period Low species diversity suggests a relatively few successful species in this habitat.

Simpson diversity index (1-D) of phytoplankton communities in the stations was0.863 at OOT jetty area and 0.820 at SPM area during the sampling conducted in High tide period of spring tide at Path finder creek. While Simpson diversity index (1-D) of phytoplankton communities in the path finder creek near OOT jetty was 0.876 and 0.867 at SPM during the consecutive low tide period in the path finder creek.

Simpson diversity index (1-D) of phytoplankton communities in the stations was 0.838 at OOT jetty area and 0.881 at SPM area during the sampling conducted in High tide period of Neap tide at Path

finder Creek. While Simpson diversity index (1-D) of phytoplankton communities in the path finder creek near OOT jetty was 0.832 and at SPM area was 0.867 during the consecutive low tide period.

Table:-47 4PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND , NEAR BY CREEKS DURING SPRING TIDE IN NOVEMBER 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% Of diversity	Margalef's diversity index (Species Richness)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	207	26/34	76.47	4.688	1.034	0.8511
	2	183	22/34	64.71	4.031	1.005	0.8437
	3	193	13/34	38.24	2.28	0.811	0.7778
	4	243	18/34	52.94	3.095	0.9391	0.8192
	5	193	21/34	61.76	3.8	0.9777	0.8281
	6	39	9/34	26.47	2.184	0.786	0.8178
LOW TIDE	1	178	14/34	41.18	2.509	0.8042	0.787
	2	199	20/34	58.82	3.589	0.8982	0.8075
	3	115	14/34	41.18	2.74	0.8696	0.8365
	4	154	18/34	52.94	3.375	0.915	0.8416
	5	163	11/34	32.35	1.963	0.7895	0.7957

Table:-48 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND NEAR BY CREEKS DURING NEAP TIDE IN NOVEMBER 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	216	24/31	77.42	4.279	0.98	0.8568
	2	229	22/31	70.97	3.865	0.958	0.853
	3	228	22/31	70.97	3.868	1.022	0.8743
	4	299	23/31	74.19	3.859	0.8667	0.8127
	5	254	19/31	61.29	3.251	0.8929	0.8307
	6	43	10/31	32.26	2.393	0.8712	0.8571
LOW TIDE	1	183	18/31	58.06	3.263	0.9504	0.8636
	2	143	15/31	48.39	2.821	0.946	0.8666
	3	178	21/31	67.74	3.86	1.001	0.8708
	4	193	19/31	61.29	3.42	0.931	0.84
	5	193	19/31	61.29	3.42	0.9259	0.8469

Table:-49 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND, NEAR BY CREEKS DURING SPRING TIDE IN NOVEMBER2022

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Species Composition % (Group level)
HIGH TIDE	Sub surface	6	BLUE GREEN ALGAE	0-8	2/34	5.88
			DIATOMS	38-238	26/34	76.47
			DINOFLAGELLATES	0-11	6/34	17.65
			TOTAL PHYTO PLANKTON	**39-243**	**34**	
LOW TIDE	Sub surface	5	BLUE GREEN ALGAE	1-6	2/34	5.88
			DIATOMS	110-190	26/34	76.47
			DINOFLAGELLATES	1-7	6/34	17.65
			TOTAL PHYTO PLANKTON	**115-199**	**34**	

TABLE:-50 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND, NEAR BY CREEKS DURING NEAP TIDE IN NOVEMBER 2022

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Species Composition % (Group level)
HIGH TIDE	Sub surface	6	BLUE GREEN ALGAE	0-6	2/31	6.45
			DIATOMS	43-293	24/31	77.42
			DINOFLAGELLATES	0-9	5/31	16.13
			TOTAL PHYTO PLANKTON	**43-299**	**31**	
LOW TIDE	Sub surface	5	BLUE GREEN ALGAE	2-6	2/31	6.45
			DIATOMS	133-186	24/31	77.42
			DINOFLAGELLATES	3-8	5/31	16.13
			TOTAL PHYTO PLANKTON	**143-193**	**31**	

TABLE:-51 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA OOT AT PATH FINDER CREEK , VADINAR &NEAR BY SPM, DURING SPRING TIDE IN NOVEMBER 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	209	27/36	75.00	4.867	1.037	0.863
	SPM	206	23/36	63.89	4.129	0.946	0.820
LOW TIDE	Jetty	177	24/36	66.67	4.443	1.043	0.876
	SPM	131	19/36	52.78	3.692	0.982	0.867

TABLE:-52 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING NEAP TIDE IN NOVEMBER 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	244	27/42	64.29	4.73	0.998	0.838
	SPM	259	24/42	57.14	4.139	1.035	0.881
LOW TIDE	Jetty	200	23/42	54.76	4.152	0.942	0.832
	SPM	294	32/42	76.19	5.454	1.036	0.867

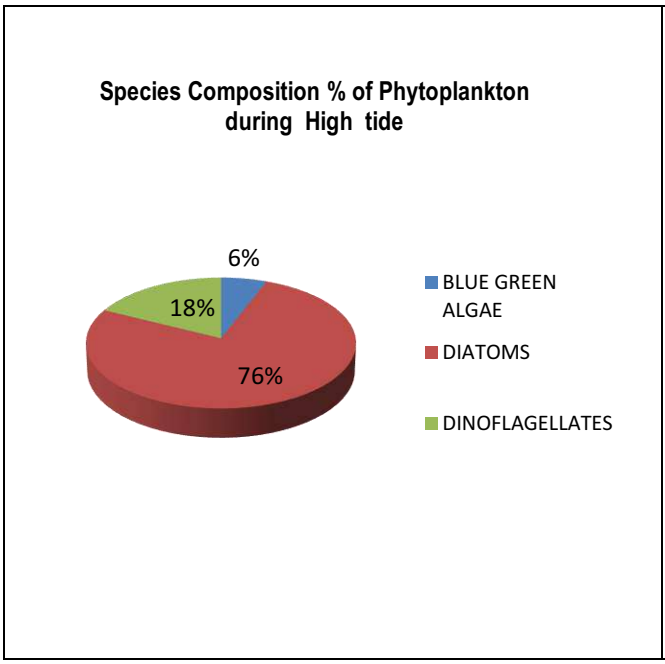
TABLE:-53 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPAOOT AT PATH FINDER CREEK, VADINAR & NEAR BY SPM, DURING SPRING TIDE IN NOVEMBER 2022

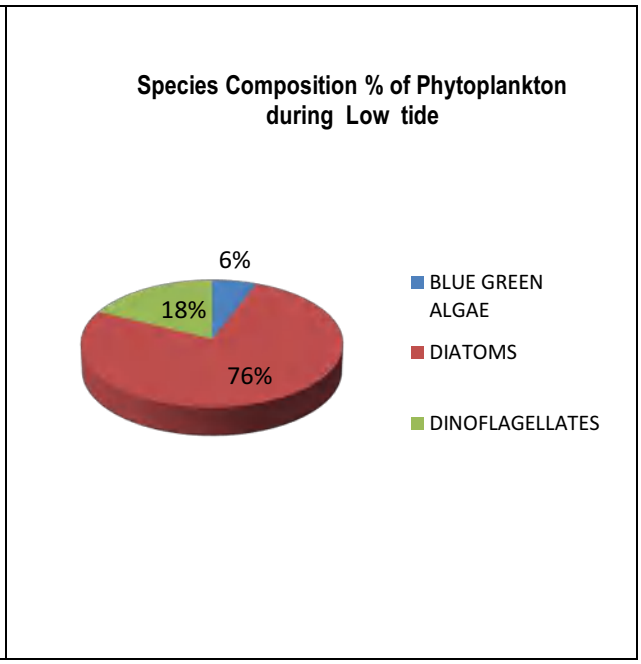
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	BLUE GREEN ALGAE	14-20	5/36	13.89
			DIATOMS	180-192	25/36	69.44
			DINOFLAGELLATES	3-6	6/36	16.67
			TOTAL PHYTO PLANKTON	**206-209**	**36**	
LOW TIDE	Sub surface	2	BLUE GREEN ALGAE	12-19	5/36	13.89
			DIATOMS	118-156	25/36	69.44
			DINOFLAGELLATES	1-2	6/36	16.67
			TOTAL PHYTO PLANKTON	**131-177**	**36**	

Table:- 54 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPA OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING NEAP TIDE IN NOVEMBER 2022

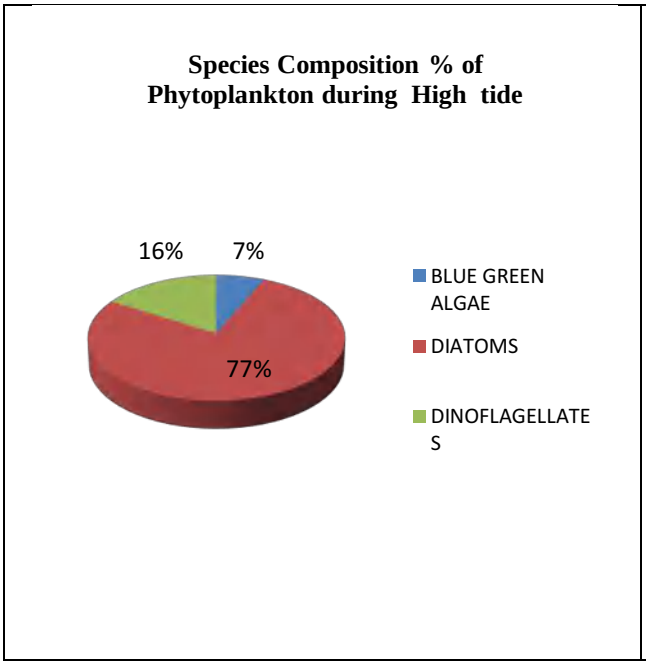
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Species Composition % (Group level)
HIGH TIDE	Sub surface	2	BLUE GREEN ALGAE	5-7	4/42	9.52
			DIATOMS	238-248	32/42	76.19
			DINOFLAGELLATES	1-4	6/42	14.29
			TOTAL PHYTO PLANKTON	**244-259**		
LOW TIDE	Sub surface	2	BLUE GREEN ALGAE	4-8	4/42	9.52
			DIATOMS	194-282	32/42	76.19
			DINOFLAGELLATES	2-4	6/42	14.29
			TOTAL PHYTO PLANKTON	**200-294**		

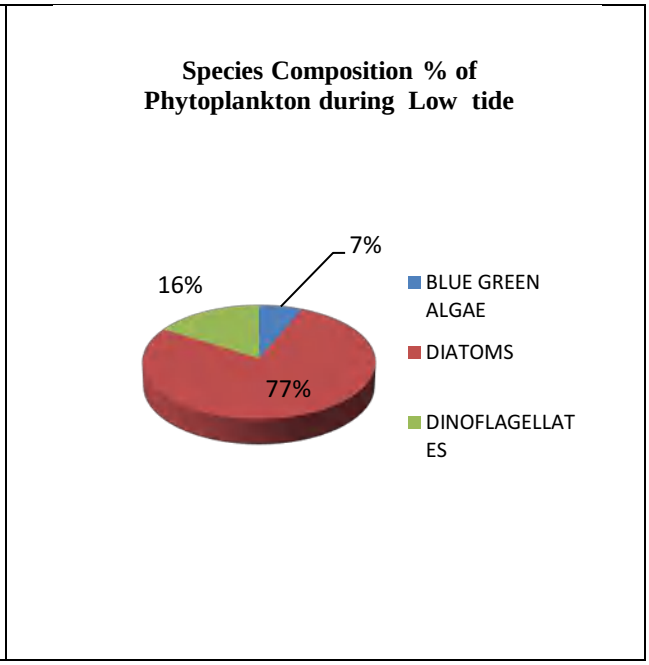
Species Composition % of Phytoplankton during High tide and Low tide period during spring tide in Kandla creek and nearby creeks



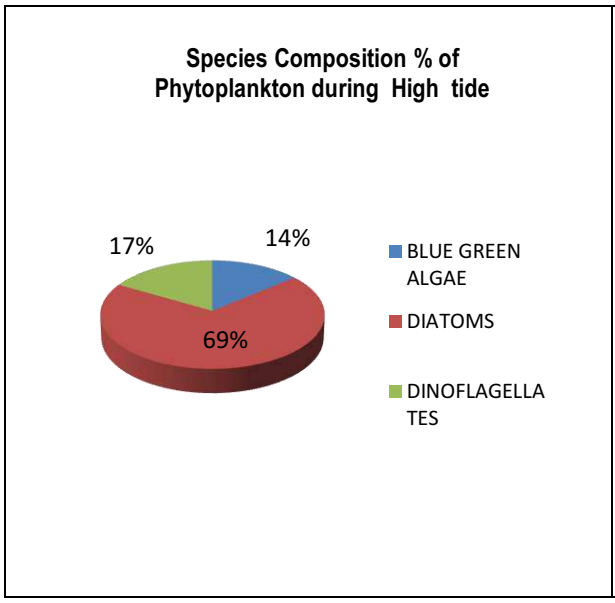


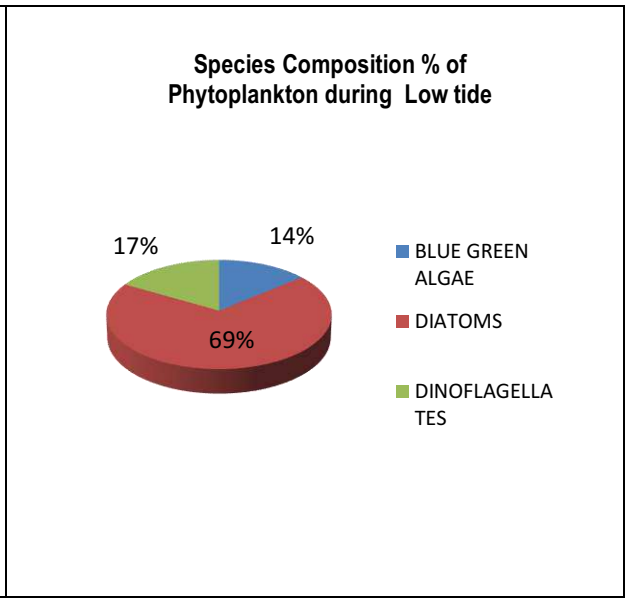
Species Composition % of Phytoplankton during High tide and Low tide period during Neap tide in Kandla creek and nearby creeks



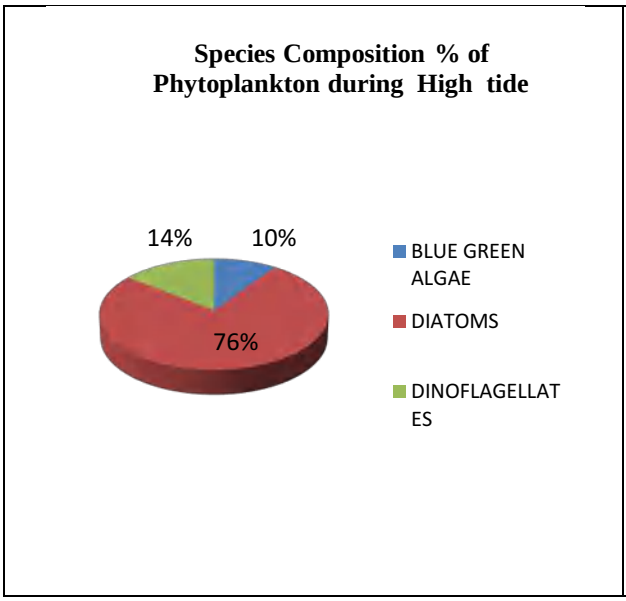


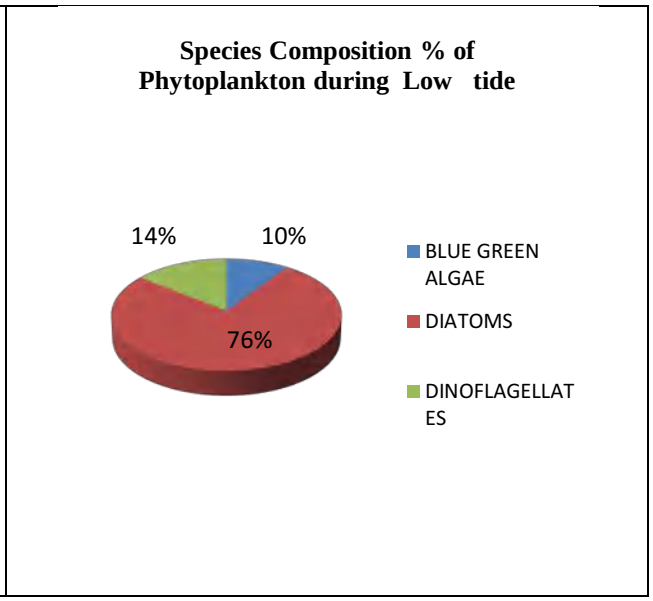
Species Composition % of Phytoplankton during High tide and Low tide period during spring tide in Path Finder Creek, Vadinar





Species Composition % of Phytoplankton during High tide and Low tide period during Neap tide in Path Finder Creek, Vadinar





ZOOPLANKTON POPULATION:

For the evaluation of the Zooplankton population in DPA harbour area and within the immediate surroundings of the port sampling was conducted from 6 sampling locations (3 in harbour area and two in Nakti creek and one in Khoricreek) during high tide period and low tide period of spring tide and Neap tide in November, 2022. The Zooplankton community of the sub surface water in the harbour and nearby creeks during spring tide was representedby mainly six groups;Tintinnids, Copepods,Arrow worms,Mysids, Urochordata,Ciliates and 8 larval forms.The Zooplankton community of the sub surface water in the harbour and nearby creeks during neap tide was represented by mainly six groups;Tintinnids, Copepods,Arrow worms, Mysids, Urochordata, Ciliatesand 6 larval forms.

Zooplankton of the sampling stations at sub surface layer in the DPA harbour area and nearby creek was varying from 25-128 $x10^3$ N/m^3 during high tide and 103-144$x10^3$ N/m^3 during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPA harbour area and nearby creek was varying from 19-114$x10^3$ N/m^3 during high tide and 76-106$x10^3$ N/ m^3 during low tide of Neap Tide period.

For the evaluation of the Zooplankton population in DPA OOT jetty area in Path Finder creek and SPM in Vadinar selected 2 sampling locations (1 in jetty area and one near SPM).

During spring tide sampling plankton sample were collected at Jetty area and near SPM during consecutive high tide period and low tide period. During Neap tide sampling Plankton samples were collected from jetty area and SPM during consecutive high tide period and low tide period.

The Zooplankton community of the sub surface water in the path finder creek during spring tide was represented by mainly four groups Tintinnids, Copepods, Urochordata, Ciliatesand 4 larval forms. While the Zooplankton community of the sub surface water in the path Finder creeks at Jetty region and SPM during neap tide was represented by four groups, Tintinnids, Copepods, Arrow worms, Urochordataand 5 larval forms.

Zooplankton of the sampling stations at sub surface layer in the DPA OOT Jetty area of path finder creek was 91$x10^3$ N/m^3 during high tide and 86$x10^3$ N/m^3 during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPA SPM area of path finder creek was 101$x10^3$ N/m^3 during high tide and 70$x10^3$ N/ m^3 during low tide of spring Tide period.

Zooplankton of the sampling stations at sub surface layer in the DPA OOT jetty area in path finder creek was recorded 87$x10^3$ N/m^3 during high tide and 65$x10^3$ N/ m^3 during consecutive low tide period of Neap tide. Zooplankton of the sampling stations at sub surface layer in the DPASPM area in path finder creek was recorded 64$x10^3$ N/m^3during high tide and 87$x10^3$ N/ m^3 during consecutive low tide period of Neap Tide.

Species Richness Indices and Diversity Indices:

Margalef's diversity index (Species Richness)

Margalef's diversity index (Species Richness) of Zooplankton communities in the stations Kandla creek region and nearby creeks was varying from 2.175- 5.186 with an average of 3.450 during the sampling conducted in High tide period. Margalef's diversity index (Species Richness) of Zooplankton communities varying from 2.373-3.823 with an average of 3.261 during the sampling conducted in low tide period during Spring tide.

Margalef's diversity index (Species Richness) of Zooplankton communities in the Kandla creek region and nearby creeks sampling stations were varying from1.358-3.858 with an average of 2.930 during the sampling conducted in high tide and varying from 2.289- 4.618 with an average of 3.513 during the sampling conducted in low tide during Neap tide period.

Margalef's diversity index (Species Richness) of Zooplankton communities in the sampling stationnear jettyat Path Finder Creek, Vadinar during the sampling conducted inconsecutive high tide period and low tide of spring tide was recorded as 1.995 and 1.796 respectively. Margalef's diversity index (Species Richness) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive high tide period and low tide of spring tide was recorded as 2.600 and 2.118 respectively.

Margalef's diversity index (Species Richness) of Zooplankton communities near Jetty at Path finder creek were varying from 3.807 and 2.396 respectivelyduring the sampling conducted in consecutive high tide period and Low tide period of Neap tide. While Margalef's diversity index (Species Richness) of Zooplankton communities near SPM at Path finder creek were varying from 2.645-3.135 respectively during the consecutive high tide and low tide period.

Shannon-Wiener's index:

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.778-1.164 between selected sampling stations with an average value of0.939 during high tide period of spring tide. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.795-1.015 between selected sampling stations with an average value of0.938 during consecutive low tide period.

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.490-0.914 between selected sampling stations with an average value of 0.805 during high tide period of Neap tide. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range 0.797-1.041 of between selected sampling stations with an average value of 0.928 during consecutive low tide period.

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.816-0.793 respectively. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.834-0.808 respectively.

Shannon-Wiener's Index (H) of Zooplankton communities near jetty at Path finder creek was varying from 0.956-0.755 respectively during the sampling conducted consecutive high tide period and low tide period of Neap tide. While Shannon-Wiener's Index (H) of Zooplankton communities near SPM at Path finder creek was varying from 0.775-0.751during the consecutive high tide and low tide period.

Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon-Wiener's index increases as both the richness and the evenness of the community increase. This result indicates that diversity of Zooplankton of Kandla Harbour region and nearby creeks stations is slightly high with very minimum diverse population but very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson's diversity index:

Simpson diversity index (1-D) of Zooplankton communities was below 0.9 most of sampling stations in the Kandla Harbour region and nearby creeks during high tide and low tide of spring tide period except few stations, which was varying from 0.780-0.909 between selected sampling stations with an average of 0.837 during high tide period and was varying from 0.785- 0.864 with an average value of 0.837 between selected sampling stations during low tide.

Simpson diversity index (1-D) of Zooplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks during high tide and low tide period of Neap tide except few, which was varying from 0.591-0.827 between selected sampling stations with an average of 0.753 during high tide period and was varying from 0.793-0.852 with an average value of 0.820 between selected sampling stations during consecutive low tide. This species diversity suggests a relatively few successful species in this habitat during November, 2022 sampling.

Simpson diversity index (1-D) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.821 and 0.815 respectively. Simpson diversity index (1-D) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.812 and 0.828 respectively.

Simpson diversity index (1-D) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of Neap tide was recorded as 0.836- 0.766 respectively. Simpson diversity index (1-D) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.768 and 0.719 respectively.

TABLE:-55 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND NEAR BY CREEKS DURING SPRING TIDEIN NOVEMBER 2022

Tide	Sampling Station	Abundance In Nx10^3/ m^3	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	124	26/33	78.79	5.186	1.164	0.9089
	2	114	18/33	54.55	3.589	0.8655	0.7802
	3	102	16/33	48.48	3.243	0.9207	0.8189
	4	128	17/33	51.52	3.298	0.9062	0.8124
	5	107	16/33	48.48	3.21	0.997	0.8686
	6	25	8/33	24.24	2.175	0.7777	0.83
LOW TIDE	1	117	16/33	48.48	3.15	0.9709	0.8609
	2	144	20/33	60.61	3.823	0.9468	0.8238
	3	121	19/33	57.58	3.753	1.015	0.8639
	4	108	16/33	48.48	3.204	0.9609	0.8505
	5	103	12/33	36.36	2.373	0.7949	0.7853

TABLE:-56 ZOOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA HARBOUR AREAAT KANDLA CREEK AND NEAR BY CREEKS DURING NEAP TIDE INNOVEMBER 2022

Tide	Sampling Station	Abundance In No x10^3/ m^3	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	82	18/32	56.25	3.858	0.9017	0.7814
	2	99	16/32	50.00	3.264	0.9138	0.8273
	3	89	13/32	40.63	2.673	0.8264	0.7763
	4	114	18/32	56.25	3.589	0.8478	0.7645
	5	98	14/32	43.75	2.835	0.8503	0.7766
	6	19	5/32	15.63	1.358	0.4901	0.5906
LOW TIDE	1	79	11/32	34.38	2.289	0.797	0.7932
	2	76	21/32	65.63	4.618	1.041	0.8516
	3	106	21/32	65.63	4.289	1.026	0.8446
	4	90	15/32	46.88	3.111	0.9087	0.8177
	5	100	16/32	50.00	3.257	0.865	0.7939

Table:-57 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA HARBOUR AREAATKANDLA CREEK AND NEAR BY CREEKS DURING SPRING TIDE IN NOVEMBER 2022

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^3/ m^3$ Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	tintinnids	9-26	11/33	33.33
			Copepods	11-51	9/33	27.27
			Arrow worms	0-1	1/33	3.03
			Mysids	0-2	1/33	3.03
			Urochordata	1-6	2/33	6.06
			Ciliates	0-2	1/33	3.03
			Larval forms	4-50	8/33	24.25
			TOTAL ZOOPLANKTON N/ M^3	**25-128**	**33**	
LOW TIDE	Sub surface	5	Tintinnids	18-33	11/33	33.33
			Copepods	37-49	9/33	27.27
			Arrow worms	0-4	1/33	3.03
			Mysids	0-2	1/33	3.03
			Urochordata	0-2	2/33	6.06
			Ciliates	0-2	1/33	3.03
			Larval forms	41-65	8/33	24.25
			TOTAL ZOOPLANKTON N/M^3	**103-144**	**33**	

TABLE:-58 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA HARBOUR AREA IN KANDLA CREEK AND, NEAR BY CREEKS DURING NEAP TIDE IN NOVEMBER 2022

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton x10$^{3/}$/ m^3 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinnids	0-14	10/32	31.25
			Copepods	6-49	10/32	31.25
			Arrow worms	0	1/32	3.13
			Mysids	0-6	2/32	6.25
			Urochordata	0-4	2/32	6.25
			Ciliates	0-2	1/32	3.13
			Larval forms	13-50	6/32	18.74
			TOTAL ZOOPLANKTON N/M^3	**19-114**	**32**	
LOW TIDE	Sub surface	5	tintinnids	4-17	10/32	31.25
			Copepods	25-45	10/32	31.25
			Arrow worms	0-2	1/32	3.13
			Mysids	0-6	2/32	6.25
			Urochordata	0-5	2/32	6.25
			Ciliates	0-1	1/32	3.13
			Larval forms	27-47	6/32	18.74
			TOTAL ZOOPLANKTON N/M^3	**76-106**	**32**	

Table:-59 ZOOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING SPRING TIDE IN NOVEMBER 2022

Tide	Sampling Station	Abundance In x10^{3}N / m^3	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	91	10/20	50.00	1.995	0.816	0.821
	SPM	101	13/20	65.00	2.6	0.834	0.812
LOW TIDE	Jetty	86	9/20	45.00	1.796	0.793	0.815
	SPM	70	10/20	50.00	2.118	0.808	0.828

TABLE:-60 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURINGNEAP TIDE IN NOVEMBER 2022

Tide	Sampling Station	Abundance In N$x10^3/m^3$	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	87	18/21	85.71	3.807	0.956	0.836
	SPM	64	12/21	57.14	2.645	0.775	0.768
LOW TIDE	Jetty	65	11/21	52.38	2.396	0.755	0.766
	SPM	87	15/21	71.43	3.135	0.751	0.719

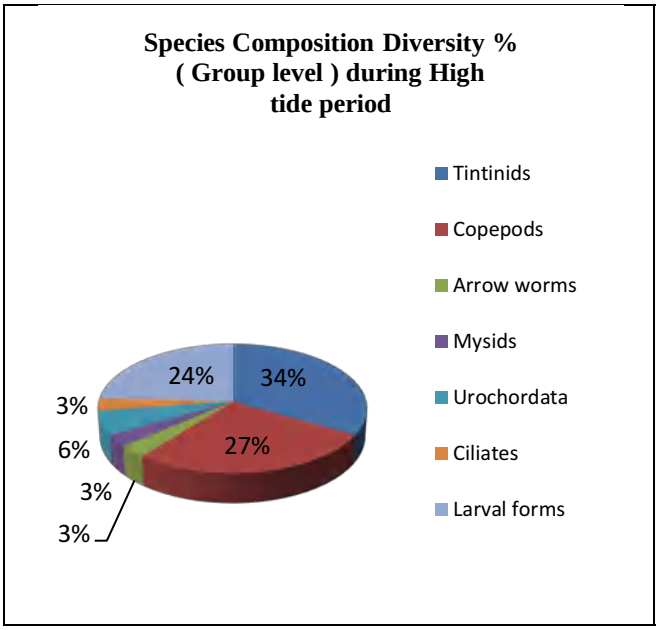
Table:-61 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA OOT AREAAND PATH FINDER CREEK AND NEAR BY SPM DURING SPRING TIDE IN NOVEMBER 2022

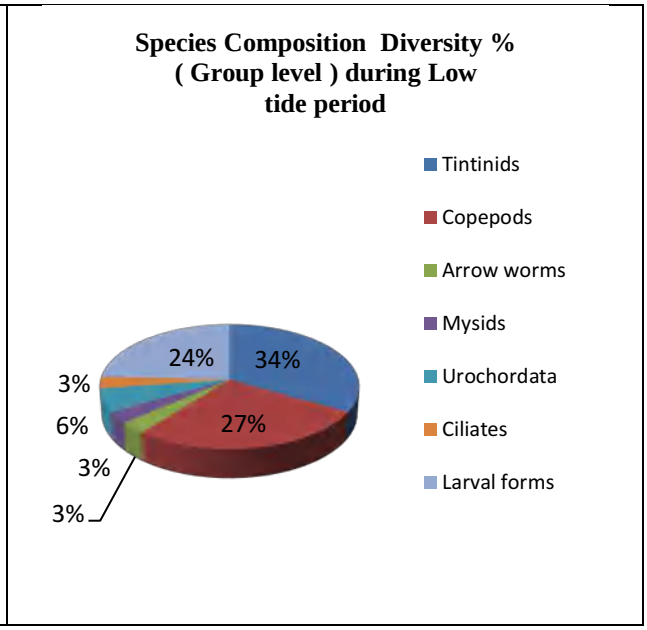
Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^3/m^3$ Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	Tintinnids	24-32	5/20	25.00
			Copepods	28-38	8/20	40.00
			Urochordata	1-2	2/20	10.00
			Ciliates	0-1	1/20	5.00
			Larval forms	30-36	4/20	20.00
			TOTAL ZOOPLANKTON	**91-101**	**20**	
LOW TIDE	Sub surface	2	Tintinnids	17-21	5/20	25.00
			Copepods	30-37	8/20	40.00
			Urochordata	0	2/20	10.00
			Ciliates	0	1/20	5.00
			Larval forms	19-32	4/20	20.00
			TOTAL ZOOPLANKTON	**70-86**	**20**	

TABLE:-62 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING NEAP TIDE IN NOVEMBER 2022

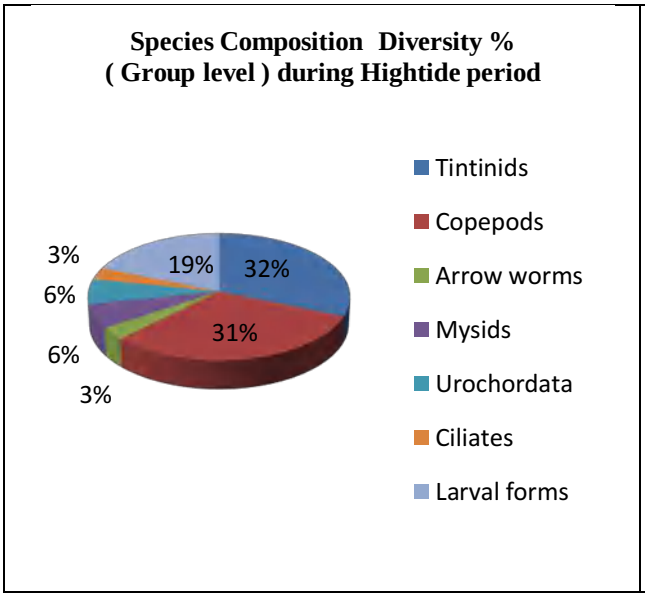
Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^3/ m^3$ Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	tintinnids	9-16	7/21	33.33
			Copepods	23-34	6/21	28.57
			Arrow worms	0	1/21	4.76
			Urochordata	0-2	2/21	9.52
			Larval forms	32-35	5/21	23.82
			TOTAL ZOOPLANKTON	**64-87**	**21**	
LOW TIDE	Sub surface	2	tintinnids	6-9	7/21	33.33
			Copepods	29	6/21	28.57
			Arrow worms	0-1	1/21	4.76
			Urochordata	0-3	2/21	9.52
			Larval forms	27-48	5/21	23.82
			TOTAL ZOOPLANKTON	**65-87**	**21**	

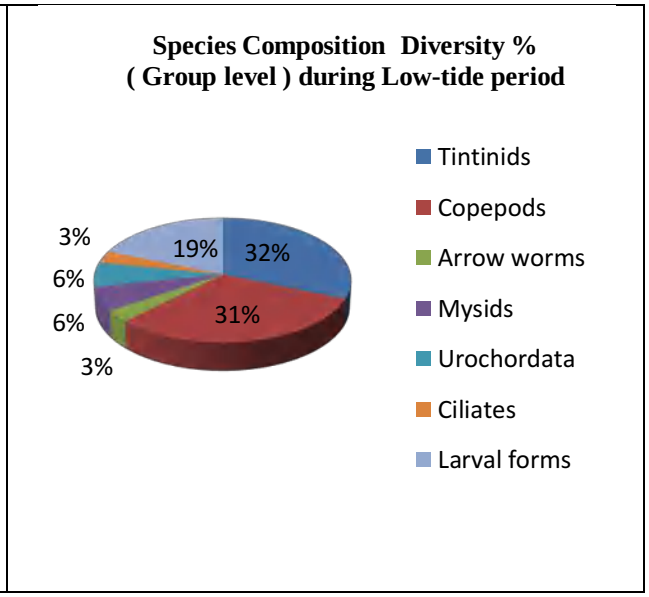
Species Composition % of Zooplankton during High tide and Low tide period of spring tide In Kandla Creek and nearby Creeks



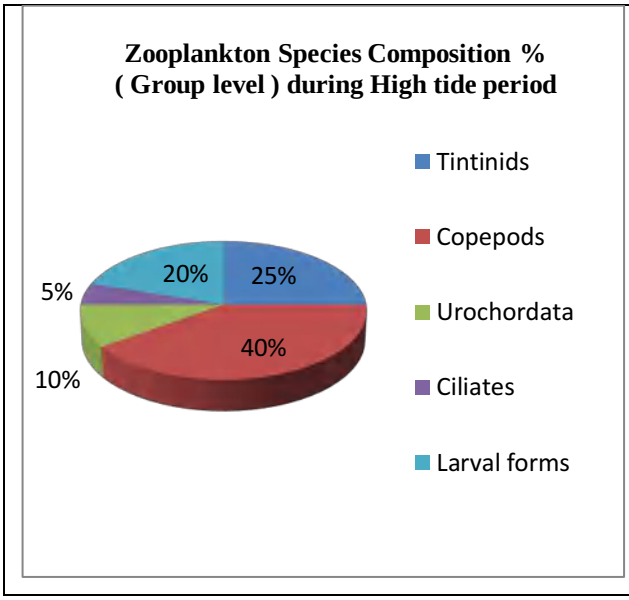


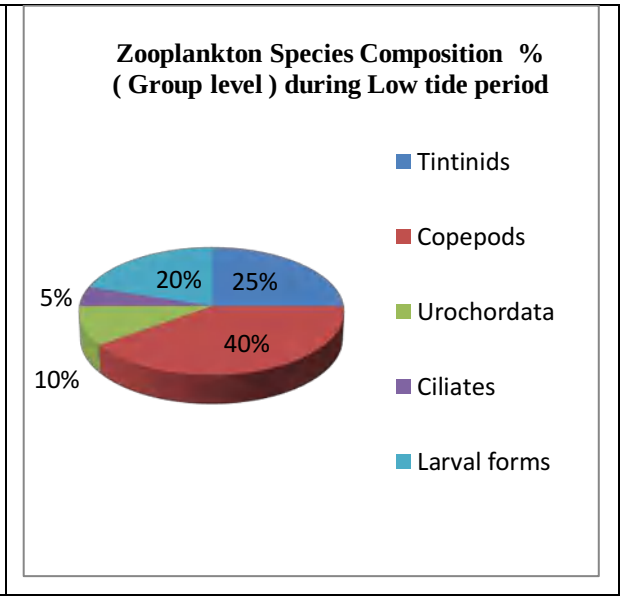
Species Composition % of Zooplankton during High tide and Low tide period of Neap tide In Kandla Creek and nearby Creeks



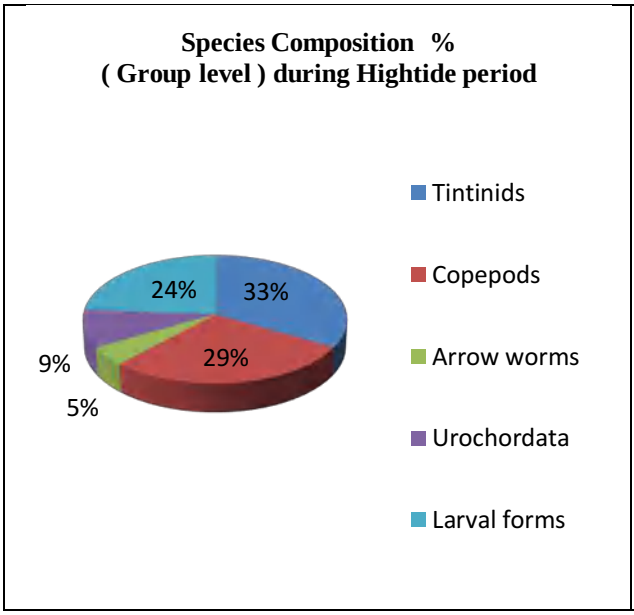


Species Composition % of Zooplankton during High tide and Low tide period of Spring tide In Path Finder Creek and near Jetty





Species Composition % of Zooplankton during High tide and Low tide period of Neap tide In Path Finder Creek near jetty and nearby SPM



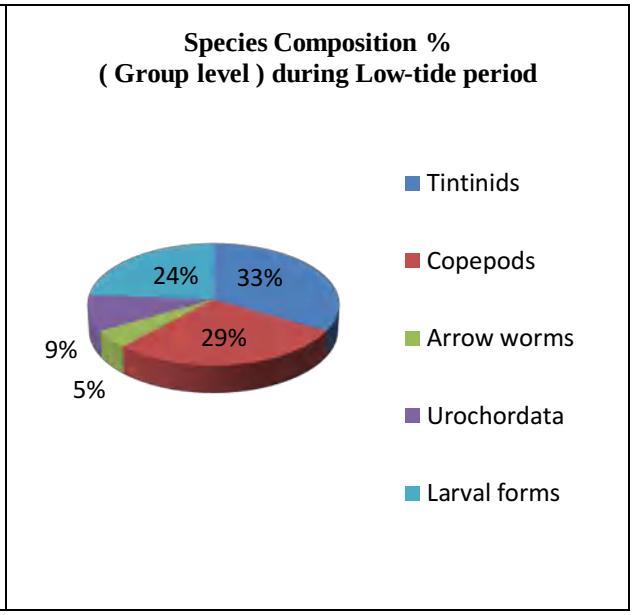


TABLE:-63 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS OF DPA HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING NEAP TIDE OF NOVEMBER 2022

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
Cyanophyceae	Nostocales	Oscillatoriaceae	*Oscillatoria sp.*	B1	Very sparse
	Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B2	Very sparse
Coscinodiscophyceae	Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D1	Abundant
	Chaetocerotales	Chaetocerotaceae	*Bacteriastrum sp*	D2	Very sparse
			Chaetoceros sp.	D3	Scattered
	Corethrales	Corethraceae	*Corethron* sp	D4	Very sparse
	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D5	Dominant
	Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D6	Very sparse
		Streptothecaceae	*Helicotheca sp*	D7	Very sparse
	Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D8	Sparse
	Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D9	Dominant
	Thalassiosirales	Thalassiosiraceae	*Planktoniella*sp	D10	Very sparse
		Skeletonemataceae	*Skeletonema*sp	D11	Abundant
	Triceratiales	Triceratiaceae	*Odontella* sp.	D12	Very sparse
			Triceratium sp.	D13	Very sparse
Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria* sp.	D14	Very sparse
			Nitzschia sp	D15	Sparse
			Pseudo-nitzschia sp.	D16	Very sparse
	Naviculales	Pleurosigmataceae	*Pleurosigma* sp.	D17	Very sparse
	Surirellales	Entomoneidaceae	*Entomoneis sp.*	D18	Very sparse
Fragilariophyceae	Fragilariales	Fragilariaceae	*Asterionellopsis sp*	D19	Scattered
			*Fragilaria*sp	D20	Very sparse
			*Synedra*sp	D21	Very sparse

	Striatellales	Striatellaceae	*Grammatophora sp*	D22	Very sparse
	Thalassionematales	Thalassionemataceae	*Thalassionema sp.*	D23	Sparse
			Thalassiothrix sp.	D24	Very sparse
Noctilucea / Noctiluciphyceae (Dinokaryota)	Noctilucales	Noctilucaceae	*Noctiluca* sp.	DF1	Sparse
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF2	Very sparse
	Gonyaulacales	Pyrophacaceae	*Pyrophacus sp.*	DF3	Very sparse
		Ceratiaceae	*Ceratium furca*	DF4	Very sparse
			Ceratium tripos	DF5	Very sparse

TABLE:-64 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPA HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING SPRING TIDE OF NOVEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
Cyanophyceae	Nostocales	Oscillatoriaceae	*Oscillatoria sp.*	B1	Very sparse
	Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B2	Very sparse
Coscinodiscophyceae	Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D1	Sparse
	Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp.	D2	Abundant
	Corethrales	Corethraceae	*Corethron* sp	D3	Very sparse
	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D4	Abundant
	Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D5	Sparse
	Leptocylindrales	Leptocylindraceae	*Leptocylindrus sp*	D6	Very sparse
	Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D7	Scattered
	Thalassiosirales	Thalassiosiraceae	*Planktoniella*sp	D8	Very sparse
		Lauderiaceae	*Lauderia* sp	D9	Very sparse
		Skeletonemataceae	*Skeletonema*sp	D10	Dominant
	Triceratiales	Triceratiaceae	*Odontella* sp.	D11	Very sparse
			Triceratium sp.	D12	Very sparse
Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria* sp.	D13	Very sparse
			Nitzschia sp	D14	Very sparse
			Pseudo-nitzschia sp.	D15	Very sparse
	Naviculales	Naviculaceae	*Navicula* sp.	D16	Very sparse
		Plagiotropidaceae	*Plagiotropis sp*	D17	Very sparse
		Pleurosigmataceae	*Pleurosigma* sp.	D18	Sparse
	Surirellales	Entomoneidaceae	*Entomoneis sp.*	D19	Very sparse
		Surirellaceae	*Surirella sp.*	D20	Very sparse
Fragilariophyceae	Fragilariales	Fragilariaceae	*Asterionellopsis sp*	D21	Sparse

			*Fragilaria*sp	D22	Very sparse
			*Synedra*sp	D23	Sparse
	Striatellales	Striatellaceae	*Grammatophora sp*	D24	Very sparse
	Thalassionematales	Thalassionemataceae	*Thalassionema sp.*	D25	Scattered
			Thalassiothrix sp.	D26	Sparse
Noctilucea / Noctiluciphyceae (Dinokaryota)	Noctilucales	Noctilucaceae	*Noctiluca* sp.	DF1	Sparse
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF2	Very sparse
	Gonyaulacales	Ceratiaceae	*Ceratium breve*	DF3	Very sparse
			Ceratium furca	DF4	Very sparse
			Ceratium fusus	DF5	Very sparse
			Ceratium tripos	DF6	Very sparse

TABLE:-65 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPA OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINARDURING NEAP TIDE OF NOVEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
Cyanophyceae	Nostocales	Oscillatoriaceae	*Lyngbya sp.*	B1	Very sparse
			Oscillatoria sp.	B2	Very sparse
			Spirulina sp.	B3	Very sparse
	Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B4	Very sparse
Coscinodiscophyceae	Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D1	Scattered
	Chaetocerotales	Chaetocerotaceae	*Chaetoceros*sp	D2	Scattered
	Corethrales	Corethraceae	*Corethron* sp	D3	Very sparse
	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D4	Dominant
	Hemiaulales	Bellerocheaceae	*Bellerochea*sp	D5	Very sparse
		Hemiaulaceae	*Cerataulina sp.*	D6	Very sparse
			Eucampia sp	D7	Very sparse
		Streptothecaceae	*Helicotheca sp*	D8	Very sparse
	Leptocylindrales	Leptocylindraceae	*Leptocylindrus sp*	D9	Very sparse
	Lithodesmiales	Lithodesmiaceae	*Ditylumsp*	D10	Abundant
	Rhizosoleniales	Rhizosoleniaceae	*Dactyliosolen sp.*	D11	Very sparse
			Rhizosolenia sp.	D12	Sparse
	Thalassiosirales	Skeletonemataceae	*Skeletonema sp.*	D13	Abundant
		Lauderiaceae	*Lauderia sp*	D14	Very sparse
		Thalassiosiraceae	*Planktoniella*sp	D15	Very sparse
	Triceratiales	Triceratiaceae	*Odontellasp*	D16	Very sparse
			*Triceratium*sp	D17	Very sparse
Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria*sp.	D18	Abundant
			Nitzschia sp	D19	Very sparse

			*Pseudo-nitzschia*sp	D20	Scattered
	Naviculales	Naviculaceae	*Meuniera sp.*	D21	Very sparse
			Navicula sp	D22	Very sparse
		Pinnulariaceae	*Pinnulariasp*	D23	Very sparse
		Pleurosigmataceae	*Pleurosigma* sp	D24	Very sparse
	Surirellales	Entomoneidaceae	*Entomoneis sp.*	D25	Very sparse
		Surirellaceae	*Surirella*sp	D26	Very sparse
Fragilariophyceae	Climacospheniales	Climacospheniaceae	*Climacosphenia sp.*	D27	Very sparse
	Fragilariales	Fragilariaceae	*Asterionellopsis sp.*	D28	Very sparse
			Synedra sp.	D29	Very sparse
	Striatellales	Striatellaceae	*Striatella*sp	D30	Very sparse
	Thalassionematales	Thalassionemataceae	*Thalassionema sp.*	D31	Sparse
			Thalassiothrix sp.	D32	Sparse
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Very sparse
	Dinophysales	Dinophysaceae	*Dinophysis sp.*	DF2	Very sparse
	Gonyaulacales	Pyrophacaceae	*Pyrophacus sp.*	DF3	Very sparse
		Ceratiaceae	*Ceratium furca*	DF4	Very sparse
			Ceratium fusus	DF5	Very sparse
			Ceratium tripos	DF6	Very sparse

TABLE:-66 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPAOOT AREA AT PATH FINDER CREEKAND NEARBY SPM AT VADINAR DURING AND SPRING TIDE OF NOVEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
Cyanophyceae	Chroococcales	Chroococcaceae	*Merismopedia sp.*	B1	Very sparse
	Nostocales	Oscillatoriaceae	*Lyngbya sp.*	B2	Very sparse
			Oscillatoria sp.	B3	Sparse
	Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B4	Very sparse
	Stigonematales	Stigonemataceae	*Stigonema sp.*	B5	Very sparse
Coscinodiscophyceae	Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D1	Sparse
	Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp.	D2	Dominant
	Corethrales	Corethraceae	*Corethron* sp	D3	Very sparse
	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D4	Abundant
	Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D5	Very sparse
		Hemiaulaceae	*Cerataulina sp.*	D6	Very sparse
		Streptothecaceae	*Helicotheca sp*	D7	Very sparse
	Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D8	Scattered
	Leptocylindrales	Leptocylindraceae	*Leptocylindrus sp*	D9	Very sparse
	Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D10	Abundant
	Thalassiosirales	Thalassiosiraceae	*Planktoniella*sp	D11	Very sparse
		Lauderiaceae	*Lauderia* sp	D12	Very sparse
	Triceratiales	Triceratiaceae	*Odontella* sp.	D13	Sparse
			Triceratium sp.	D14	Very sparse
Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria* sp.	D15	Scattered
			Nitzschia sp	D16	Very sparse
			Pseudo-nitzschia sp.	D17	Sparse
	Naviculales	Pinnulariaceae	*Pinnulariasp*	D18	Very sparse

		Pleurosigmataceae	*Pleurosigma* sp.	D19	Very sparse
	Surirellales	Entomoneidaceae	*Entomoneis sp.*	D20	Very sparse
		Surirellaceae	*Surirella sp.*	D21	Very sparse
Fragilariophyceae	Fragilariales	Fragilariaceae	*Asterionellopsis sp*	D22	Sparse
			*Synedra*sp	D23	Very sparse
	Thalassionematales	Thalassionemataceae	*Thalassionema sp.*	D24	Sparse
			Thalassiothrix sp.	D25	Very sparse
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Very sparse
	Dinophysales	Dinophysaceae	*Dinophysis sp.*	DF2	Very sparse
	Gonyaulacales	Pyrophacaceae	*Pyrophacus sp.*	DF3	Very sparse
		Ceratiaceae	*Ceratium furca*	DF4	Very sparse
			Ceratium fusus	DF5	Very sparse
			Ceratium tripos	DF6	Very sparse

TABLE:-67 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPA HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKSDURING NEAP TIDE OF NOVEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnussp.*	T1	Very sparse
		Codonellidae	*Tintinnopsis dadayi*	T2	Very sparse
			Tintinnopsisfailakkaensis	T3	Very sparse
			Tintinnopsis gracilis	T4	Very sparse
			Tintinnopsis mortensenii	T5	Very sparse
			Tintinnopsis radix	T6	Very sparse
			Tintinnopsis tocantinensis	T7	Very sparse
		Tintinnidae	*Amphorellopsis sp.*	T8	Very sparse
			Eutintinnus sp.	T9	Very sparse
		Xystonellidae	*Favella sp.*	T10	Very sparse
Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Sparse
			Parvocalanus sp.	C2	Very sparse
		Acartiidae	*Acartia sp.*	C3	Very sparse
		Clausocalanidae	*Clausocalanus sp.*	C4	Very sparse
		Centropagidae	*Centropages sp.*	C5	Very sparse
		Temoridae	*Temora sp.*	C6	Very sparse
	Cyclopoida	Oithonidae	*Oithona sp.*	C7	Abundant
	Harpacticoida	Ectinosomatidae	*Microsetella*sp.	C8	Scattered
		Euterpinidae	*Euterpina sp.*	C9	Sparse
	Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C10	Very sparse
Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse
Malacostraca	Mysida, Decapoda	Penaeidae	*Metapenaeussp.*	M1	Very sparse
		Solenoceridae	*Solenocera sp.*	M2	Very sparse

Appendicularia		Fritillariidae	*Fritillaria sp.*	U1	Very sparse
		Oikopleuridae	*Oikopleura sp.*	U2	Very sparse
Oligohymenophorea	Sessilida	Zoothamniidae	*Zoothamnium sp.*	CI1	Very sparse
Copepoda			Nauplius larvae of copepods	L1	Dominant
Malacostraca Decapoda			Brachyuran zoea	L2	Very sparse
Maxillopoda Thecostraca			Cirripede larvae	L3	Very sparse
			Cyphonautes larvae	L4	Very sparse
			Ophiopluteus larvae	L5	Very sparse
Polychaeta			Trochophore larvae	L6	Very sparse

TABLE:-68 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING OF DPA HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKSDURING SPRING TIDE OF NOVEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnussp.*	T1	Scattered
		Codonellidae	*Tintinnopsis dadayi*	T2	Very sparse
			Tintinnopsisfailakkaensis	T3	Very sparse
			Tintinnopsis gracilis	T4	Very sparse
			Tintinnopsis mortensenii	T5	Very sparse
			Tintinnopsis radix	T6	Sparse
			Tintinnopsis tocantinensis	T7	Very sparse
		Metacylididae	*Metacylis*sp.	T8	Very sparse
		Tintinnidae	*Amphorellopsis sp.*	T9	Very sparse
			Eutintinnus sp.	T10	Very sparse
		Xystonellidae	*Favella sp.*	T11	Sparse
Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Scattered
			Parvocalanus sp.	C2	Very sparse
		Acartiidae	*Acartia sp.*	C3	Very sparse
		Clausocalanidae	*Clausocalanus sp.*	C4	Very sparse
		Centropagidae	*Centropages sp.*	C5	Very sparse
		Eucalanidae	*Subeucalanus sp.*	C6	Very sparse
	Cyclopoida	Oithonidae	*Oithona sp.*	C7	Abundant
	Harpacticoida	Ectinosomatidae	*Microsetella*sp.	C8	Sparse
		Euterpinidae	*Euterpina sp.*	C9	Sparse
Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse
Malacostraca	Mysida, Decapoda	Solenoceridae	*Solenocera sp.*	M1	Very sparse

Appendicularia		Fritillariidae	*Fritillaria sp.*	U1	Very sparse
		Oikopleuridae	*Oikopleura sp.*	U2	Very sparse
Oligohymenophorea	Sessilida	Zoothamniidae	*Zoothamnium sp.*	CI1	Very sparse
Copepoda			Nauplius larvae of copepods	L1	Dominant
Malacostraca Decapoda			Brachyuran zoea	L2	Sparse
Maxillopoda Thecostraca			Cirripede larvae	L3	Very sparse
			Cyphonautes larvae	L4	Very sparse
			Ophiopluteus larvae	L5	Very sparse
Gastropoda Streptoneura			Opisthobranchia larvae	L6	Very sparse
Polychaeta			Trochophore larvae	L7	Sparse
Pelecypoda			Veliger larvae of bivalves	L8	Very sparse

TABLE:-69 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPA OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINARDURING NEAP TIDE OF NOVEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnussp.*	T1	Sparse
		Codonellidae	*Tintinnopsisfailakkaensis*	T2	Very sparse
			Tintinnopsis gracilis	T3	Very sparse
			Tintinnopsis radix	T4	Very sparse
			Tintinnopsis tocantinensis	T5	Very sparse
		Tintinnidae	*Amphorellopsis sp.*	T6	Very sparse
		Xystonellidae	*Favella sp.*	T7	Very sparse
Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Scattered
			Parvocalanus sp.	C2	Very sparse
	Cyclopoida	Oithonidae	*Oithona sp.*	C3	Abundant
	Harpacticoida	Euterpinidae	*Euterpina sp.*	C4	Very sparse
		Ectinosomatidae	*Microsetella*sp.	C5	Very sparse
	Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C6	Very sparse
Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse
Appendicularia		Fritillariidae	*Fritillaria sp.*	U1	Very sparse
		Oikopleuridae	*Oikopleura sp.*	U2	Very sparse
Copepoda			Nauplius larvae of copepods	L1	Dominant
Maxillopoda Thecostraca			Cirripede larvae	L2	Very sparse
Gastropoda Streptoneura			Opisthobranchia larvae	L3	Very sparse
Polychaeta			Trochophore larvae	L4	Very sparse
Pelecypoda			Veliger larvae of bivalves	L5	Very sparse

TABLE:-70 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPA OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING SPRING TIDE OF NOVEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnussp.*	T1	Abundant
		Codonellidae	*Tintinnopsisgracilis*	T2	Very sparse
			Tintinnopsis mortensenii	T3	Very sparse
			Tintinnopsis radix	T4	Very sparse
		Xystonellidae	*Favella sp.*	T5	Scattered
Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Sparse
			Parvocalanus sp.	C2	Very sparse
		Centropagidae	*Centropages sp.*	C3	Very sparse
		Tortanidae	*Tortanus sp.*	C4	Very sparse
	Cyclopoida	Oithonidae	*Oithona sp.*	C5	Abundant
		Euterpinidae	*Euterpina sp.*	C6	Very sparse
	Harpacticoida	Ectinosomatidae	*Microsetella*sp.	C7	Scattered
	Poicilostomatatoida	Corycaeidae	*Corycaeus sp.*	C8	Very sparse
Appendicularia		Fritillariidae	*Fritillaria sp.*	U1	Very sparse
		Oikopleuridae	*Oikopleura sp.*	U2	Very sparse
Oligohymenophorea	Sessilida	Zoothamniidae	*Zoothamnium sp.*	CI1	Very sparse
Copepoda			Nauplius larvae of copepods	L1	Dominant
Malacostraca Decapoda			Brachyuran zoea	L2	Very sparse
Gastropoda Streptoneura			Opisthobranchia larvae	L3	Very sparse
Pelecypoda			Veliger larvae of bivalves	L4	Very sparse

BENTHIC ORGANISMS:

Few Benthic organisms were observed in the collected sediments by using the Van-Veen grabs during the sampling conducted during spring tide period and Neap tide period from DPA harbour region and nearby creek. The Meio-benthic organisms during spring tide were represented by Polychaetes *Tharyx sp*and *Nereis sp.*, during Neap tide *by Neries sp.* and few Amphipods. Population of benthic fauna was varying from 10-60- N/m^2 during spring tide and 0-80 N/m^2 during Neap tide. The benthic communities at path finder Creek were represented by Polychaetes *Glycera* sp. *Cirratulus* sp. *Nereis sp*. and few Amphipods. Their population was varying as 60 N/m^2 at OOT jetty premises and 80 N/m^2 near the SPM area during spring tide and 50 N/m^2 at OOT jetty premises and 50 N/m^2 near the SPM area during Neap tide period.

Table:-71 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPA HARBOUR AREA CREEKS DURING SPRING TIDE IN NOVEMBER 2022

ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS						
REPRESENTATION BY GROUP	DPA HARBOUR			CREEKS		
Benthic fauna						
POLYCHAETES	DPA-1	DPA-2	DPA-3	DPA-4	DPA-5	DPA-6
Family : CIRRATULIDAE *Tharyxsp.*	20	10	10	0	0	NS
Family :NEREIDAE *Nereis sp.*	0	0	0	20	40	NS
AMPHIPODA	0	0	0		20	NS
TOTAL Benthic Fauna NUMBER/ M^2	20	10	10	20	60	NS

NS: No sample

Table:-72 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPA HARBOUR AREA CREEKS DURING NEAP TIDE IN NOVEMBER 2022

ABUNDANCE IN NO/M^2 DIFFERENT SAMPLING STATIONS						
REPRESENTATION BY GROUP	DPA HARBOUR			CREEKS		
Benthic fauna						
POLYCHAETES	DPA-1	DPA-2	DPA-3	DPA-4	DPA-5	DPA-6
Family :NEREIDAE *Nereis sp.*	0	0	0	40	60	NS
Amphipoda	0	20	10	10	20	NS
TOTAL Benthic Fauna NUMBER/M^2	0	20	10	50	80	NS

Table:-73 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPA OOT JETTY AREA, VADINAR DURING SPRING TIDE IN NOVEMBER 2022

ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS		
REPRESENTATION BY GROUP	OOT Jetty Area	SPM area
POLYCHAETES		
Family : Glyceride *Glycera*sp.	20	40
Family : CIRRATULIDAE *Cirratulus*sp.	0	20
Family: *NEREIDAE* *Nereis sp.*	30	10
Amphipoda	10	20
TOTAL Benthic Fauna NUMBER/ M^2	60	80

Table:-74 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPA OOT JETTY AREA, VADINAR DURING NEAP TIDE IN NOVEMBER 2022

ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS		
REPRESENTATION BY GROUP	OOT Jetty Area	SPM area
POLYCHAETES		
Family : Glyceridase *Glycera* sp.	20	40
Family: *NEREIDAE* *Nereis sp.*	30	10
TOTAL Benthic Fauna NUMBER/ M^2	50	50

11.0 Conclusive Summary and Remedial measures Suggested

- The AAQ monitoring of six locations at Deendayal Port Authority indicates that the mean PM_{10} and $PM_{2.5}$ values for four locations viz. Marine Bhavan, Oil Jetty, Estate Office and Coal storage area were found higher than the permissible limit (standards100 µg/m^3, 60 µg/m^3). The higher concentration of Particulate matter at Marine Bhavan may be due to vehicles emissions during loading-unloading of food grains and timbers; at Estate office due to construction work, vehicles emission produced from trucks, heavy duty vehicles that pass through the road outside Kandla port and Oil jetty area; while at Coal Storage area lifting of coal from grab yard and other coal handling processes. Moreover, the transportation of coal produces pollution from heavy vehicles. At Tuna Port location, concentration of PM_{10} varied from 88-175 µg/m^3 and mean value was observed 145 µg/m^3 which was exceed the prescribed standard limit (100 µg/m^3), concentration of $PM_{2.5}$ was ranged from 47-87 µg/m^3 and mean was found 71 µg/m^3 which was exceed the standard limit (60 µg/m^3). At Gopalpuri PM_{10} concentration ranged from 67-168 µg/m3 and mean was 127 µg/m3 while $PM_{2.5}$ concentration ranged from 34-94 µg/m3 and mean was 66 µg/m3 were found exceed standard limit prescribed by NAAQS.
- At Vadinar, the average concentration of PM_{10} was 114 µg/m^3 and $PM_{2.5}$ was 74 µg/m^3 at Admin Colony which was slightly exceed the standard limit while at Signal building the mean concentration PM_{10} was 100 µg/m3 and $PM_{2.5}$ was 61 µg/m^3 which were very close to standard limit.
- During winter, the concentration of PM_{10} and $PM_{2.5}$ has been slowly augmented and reached a peak in the evening due to surface inversion of temperature after sunset. Thus, the pollutants are subsequently trapped in the lower layer of the atmosphere due to high atmospheric air pressure.
- Further, precautionary measures and management strategies to minimize the effect of particulate as well as gaseous pollutants have also been suggested for achieving its ambient levels in and around Kandla Port and Vadinar Port, Gujarat, India.

- Drinking water at all the twenty locations was found potable and it was found within in line of BIS standards (IS: 10500-2012).
- Transportation systems are the main source of noise pollution in project areas. Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading

containers and ships. All sampling location were within the permissible limit day time 75 dB (A) and night time 70 dB (A) for the industrial area.

- The treated sewage water of Kandla STP, Deendayal Port Colony (Gopalpuri) STP and Vadinar were in line with the standards set by the Central Pollution Control Board.
- It was suggested to monitor the STP performance on regular basis to avoid flow of contamination / Polluted water into the sea.
- Good species diversity suggests a relatively successful species in this habitat. A greater number of successful species and a more stable ecosystem. More ecological niches are available and the environment is less likely to be hostile complex food webs environmental change is less likely to be damaging to the ecosystem as a whole.
- The results obtained from the study for biological and ecological parameters in marine water for Arabian Sea at surrounding area of Deendayal Port Authority (DPA) Kandla and Vadinar were not affected by Port activities.
- The mean day time temperature at Deendayal Port was 27.92 °C. The day-time maximum temperature was 32.9°C and minimum was 21.1 °C. The mean night time temperature recorded was 25.47 °C. The night-time maximum temperature was 29.7°C and minimum was 20.0 °C. The mean Solar Radiation in November month was 167.27 w/m^2. The maximum solar radiation was recorded 759 w/m^2 in 4th November, 2022 and the minimum solar radiation was recorded 1.80 w/m^2 in 30th November, 2022. The mean Relative humidity was 69.00 % for the month of November. Maximum Relative humidity was recorded 99.0 % and minimum Relative humidity was recorded 34.0 %. The average wind velocity for the entire month of November was 1.21 m/s. Maximum wind velocity was recorded 10.19 m/s. The wind direction was mostly North-East.
- The results obtained from the study for the month of November 2022 for biological and ecological parameters in marine water for Arabian Sea at surrounding area of Deendayal Port Authority (DPA) Kandla and Vadinar were not affected by Port activities.

Reasons for higher Values of PM_{10}

- The unloading of coal directly in the truck, using grabs cause coal to spread in air as well as coal dust to fall on ground. This settled coal dust again mixes with the air while trucks travel through it.

- Also, the coal loaded trucks were not always covered with tarpaulin sheets and these results in spillage of coal from trucks/dumpers during its transit from vessel to yard or storage site. This also increased PM values around marine Bhavan & Coal storage area.

Remedial Measures

The values of PM_{10} & $PM_{2.5}$ during the month of November, 2022 were beyond the standard limit at all locations (Coal Storage, Marine Bhavan, Oil Jetty and Estate office, Tuna Port) except Gopalpuri the concentration of particulate matter was slightly exceed. Given below are the remedial measures suggest to minimize the Air pollution.

- During November, 2022 overall ambient air quality of the DPA was within CPCB permissible limits except TSPM, PM_{10}, $PM_{2.5}$ at Coal storage area, Marine Bhavan, Oil Jetty and Estate Office. To improve air quality the port was using number of precautionary measures, such as maintained a wide expanse of Green zone, initiated Inter-Terminal Transfer (ITT) of tractor-trailers, Centralized Parking Plaza, providing shore power supply to tugs and port crafts, the use of LED lights at DPA area helps in lower energy consumption and decreases the carbon foot prints in the environment, time to time cleaning of paved and un paved roads, use of tarpaulin sheets to cover dumpers at project sites etc. are helping to achieve the cleaner and green future at port.

Solution towards the Green port:

Today, it is increasingly recognized that air pollution hurts human health. Consequently, efficient mitigation strategies need to be implementation for substantial environmental and health co-benefits.

The guidelines can be considered a basis for governments for the implementation of a strategic plan focused on the reduction of multi pollutant emission, as well as of the overall air pollution related risk.

- The plantation should be all along the periphery of the port and inside and outside the port along with the road. Trees having high dust trapping efficiency (*Azadirachta indica, Cassia fistula, Delonix regia, Ficus religiosa, Pterocarpus marsupium*) are to be grown alongside the roads.
- The water sprinkling should be use at each and every stage of transporting coal up the loading of truck to avoid generation of coal dust.

- The vehicles should be covered during transportation and the vehicle carrying the coal should not be overloaded by raising the height of carriage.
- The water sprinklers should be use during transportation of loaded heavy vehicles on raw road.
- It should be ensure that regular sweeping of coal internal, main road and space a free circulation.
- Practice should be initiated for using mask as preventative measure, to avoid Inhalation of dust particle- Mask advised in sensitive areas.
- Department for use maintenance should have a routine checkup noise level by replacing bearings, tights of all loose parts that can vibrate.
- Speed control is also an effective way to mitigate noise pollution, the lowest sound emission arise from vehicles moving smoothly.
- Use of renewable energy like solar energy should be optimal and ensure to work continuously.
- Keep neat and clean public transport and all basic items at public interaction places as much as possible.
- Technology like Electric cart, Inter-Terminal Transfer (ITT) are worthy selection to reduce Port operation efficiency and fuel cost.
- Conventional RTGCs should be altered as E-RTGCs counting inside the port completely.
- Initiate Natural Gas (CNG) as fuel by all buses and trucks.

Green Ports Initiative

- Deendayal Port is committed to sustainable development and adequate measures are being taken to maintain the Environmental well-being of the Port and its surrounding environs. Weighing in the environmental perspective for sustained growth, the Ministry of Shipping had started “Project Green Ports” which will help in making the Major Ports across India cleaner and greener. “Project Green Ports” will have two verticals - one is “Green Ports Initiatives” related to environmental issues and second is “Swachh Bharat Abhiyaan”.

- The Green Port Initiatives include twelve initiatives such as preparation and monitoring plan, acquiring equipments required for monitoring environmental pollution, acquiring dust suppression system, setting up of waste water treatment plants/ garbage disposal plant, setting up Green Cover area, projects for energy generation from renewable

energy sources, completion of shortfalls of Oil Spill Response (OSR) facilities (Tier-I), prohibition of disposal of almost all kind of garbage at sea, improving the quality of harbour wastes etc.

- Deendayal port has also appointed GEMI as an Advisor for "Making Deendayal Port a Green Port - Intended Sustainable Development under the Green Port Initiatives.
- Deendayal Port has also signed MOU with Gujarat Forest Department in August 2019 for Green Belt Development in an area of 31.942 Ha of land owned by Deendayal Port Trust. The plantation is being carried out by the Social Forestry division of Kachchh.

ENVIRONMENTAL MONITORING REPORT FOR DEENDAYAL PORT AUTHORITY

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Revision	:	00
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Prepare	:	DETOX CORPORATION PVT. LTD., SURAT

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ENVIRONMENTAL MONITORING PLAN FOR DEENDAYAL PORT ENVIRONMENTALMONITORING REPORT- DECEMBER, 2022

1. EXECUTIVE SUMMARY

Monitoring of various environmental aspects of the Deendayal port by M/s Detox Corporation Pvt. Ltd. has been carried out through collection of samples, analysis of the same, comparing results with respect to the national standards and any other relevant standards by GBCB/CPCB/MoEF & CC to withinstand status of various parameters in the Environment of the Deendayal Port. The results shall address the identified impacts and suggest measures to minimize the environmental impact due to various operations at Deendayal Port.

A) Ambient Air

The monitoring of Ambient Air quality at 6-locations at Deendayal Port Authority Kandla and 2- location at Vadinar Port on 24 hourly basis for TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2, NH_3, CO_2, CO, C_6H_6 and NMHC in twice a week 24 hourly at uniform intervals (as per NAAQS) at Gopalpuri, Tuna Port, Marine Bhavan Building, Coal storage area, Estate building, Oil jetty and at Vadinar port, Vadinar Jetty and Vadinar colony area using respirable dust sampler, Fine particulate sampler and gaseous sampler.

The Maximum TSPM values in 1st December 2022 to 15th December 2022 were found 552.0µg/m^3 at Coal Storage area on 09.12.2022 and minimum 100.0 µg/m^3 at Tuna port on 06.12.2022. The Maximum PM_{10} values were 399.0 µg/m^3 at Coal Storage area on 09.12.2022 and minimum was 59.0 µg/m^3 at Tuna port on 06.12.2022. Maximum $PM_{2.5}$ values were 144.0 µg/m^3 at Coal Storage area on 09.12.2022 and minimum was 26.0 µg/m^3 at Tuna port on 06.12.2022. The average PM_{10} values were found for monitoring locations (Marine Bhavan Building, Coal Storage Area to exceed the Standard limit (NAAQS) while Gopalpuri and Tuna port to within the Standard limit (NAAQS). $PM_{2.5}$ values were found for monitoring locations (Marine Bhavan Building, Coal Storage Area) to exceed the Standard limit (NAAQS) while Oil Jetty, Estate Office, Gopalpuri, Tuna port to within the Standard limit (NAAQS).

The AAQ monitoring for Vadinar at Admin building the mean TSPM, PM_{10} and $PM_{2.5}$ were 153.0µg/m^3, 108.0 µg/m^3 and 40.0 µg/m^3 respectively. The $PM_{2.5}$ concentration was within the Standard limit (NAAQS), whereas PM_{10} slightly exceed the Standard limit (NAAQS). The Concentration at Signal Building the mean TSPM, PM_{10} and $PM_{2.5}$ were 149 µg/m^{3,} 99.0 µg/m^3 and 38 µg/m^3 respectively which was within the Standard limit (NAAQS). The overall values

of December for Gaseous SO_2, NO_2, NH_3, CO_2, CO, C_6H_6 concentration were within the permissible limit at all location and NMHC were found BQL (Below Quantification Limit).

B) Weather

The mean day time temperature at Deendayal Port was 25.20 °C. The day-time maximum temperature was 28.30°C and minimum was 21.70 °C. The mean night time temperature recorded was 24.33 °C. The night-time maximum temperature was 26.60°C and minimum was 22.15 °C. The mean Solar Radiation in December 1st December 2022 to 15th December 2022 was 89.76 w/m^2. The maximum solar radiation was recorded 606.1 w/m^2 in 4th December, 2022 and the minimum solar radiation was recorded 0.0 w/m^2. The mean Relative humidity was 60.25 % for the 1st December 2022 to 15th December 2022 of December. Maximum Relative humidity was recorded 79.0 % and minimum Relative humidity was recorded 38.0 %. The average wind velocity for the entire 1st December 2022 to 15th December 2022 of December was 3.07 m/s. Maximum wind velocity was recorded 9.0 m/s. The wind direction was mostly North-East.

C) Marine Ecology (Flora and Fauna) / Marine Water / Sediments:

The results obtained from the study for the 1st December 2022 to 15th December 2022 of December 2022 for biological and ecological parameters in marine water for Arabian Sea at surrounding area of Deendayal Port Authority (DPA) Kandla and Vadinar were not affected by Port activities.

D) Drinking Water Quality

The drinking water being supplied to Deendayal Port Authority was safe for drinking purpose. At all drinking water monitoring stations around port area were in line with the standard limit as per the drinking water specifications given in IS 10500:2012 as per tested parameters only.The average results for 20 locations were as: pH were found Min 7.41 and maximum 7.59, TDS were found min 461.39 mg/l and Max found 544.0 mg/l, Chloride were found Min 140.31 mg/l and Max 576.28 mg/l, Total Hardness were found Min 270.0 mg/l and Max 380.0 mg/l and Calcium were found Min 34.47 mg/l and Max 43.29 mg/l, color were colorless and odor were odorless. In all water samples BOD, Heavy metal like manganese, Hexavalent chromium, Copper, Cadmium, Arsenic, Mercury, Lead, zinc all are found BQL (Below Quantification Limit). The bacterial count (E-coli & Coliform) is absent in all drinking water samples.

E) Monitoring Performance of Sewage Treatment Plant

It was seen that the performance of STP at Deendayal Township Gopalpuri, DPA STP Plant Kandla and Vadinar STP plant was satisfactory by overall. The treatment plant was well maintained during [December 2022] with considerable removal efficiency achieving the standards prescribed for final disposal. At Gopalpuri STP, the pollutant removal efficiency for TSS, BOD and COD was ranged from 27.5- 79.17 %, 32.26-86.25 % and 27.52-81.25% respectively. At Kandla STP, removal efficiency for TSS, BOD and COD was ranged from 54.88-65.22%, 56.76-72.41% and 58.33-76.19% respectively & at Vadinar STP removal efficiency for TSS, BOD and COD was ranged from 38.57-51.85%, 50.0-55.56% and 33.33-50.0% respectively. At all STP location treated waste water the pH was ranged from 7.21-7.42, Total Suspended Solids were found 20.0- 58.0mg/l, Residual Chlorine were below Detection Limit (< 0.5), COD were found 30-79 mg/l and 3day BOD @ 27 °C were found 7.0-21.0 mg/l.

F) Noise

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. The Day Time Noise Level (SPL) in all 10 locations at Deendayal Port Authority ranged from 51.7 dB(A) to 69.8 dB(A) while at Vadinar port 3 location ranged from 53.4 dB(A) to 61.2 dB(A) which was within the permissible limits of 75 dB(A) for the industrial area for the daytime. The Night Time Average Noise Level (SPL) in all locations of Deendayal Port Authority ranged from 44.4 dB to 60.7 dB(A) while at Vadinar port ranged from 49.0 dB (A) to 55.9 dB(A) which was within the permissible limits of 70 dB(A) for the industrial area for the night time.

1.0 Introduction

About Deendayal Port

The Deendayal Port is situated in the Kandla Creek and is 90 Kms. From the mouth of Gulf of Kachchh. Latitude: 23° 01" N Longitude: 70° 13"E. Deendayal Port's journey began in 1931 with construction of RCC Jetty by Maharao Khengarji. After partition, Deendayal Port's success story has continued and it rise to the No. 1 Port in India in the year 2007-08 and since then retained the position for the 15-consecutive year. On 31.03.2016, Deendayal Port created history by handling 100 MMT cargoes in a year, the first Major Port to achieve the milestone. Kandla, also known as the Deendayal Port Authority is a seaport in Kutch District of Gujarat state in western India, near the city of Gandhidham. Located on the Gulf of Kutch, it is one of major ports on west coast. Kandla was constructed in the 1950s as the chief seaport serving western India, after the partition of India from Pakistan left the port of Karachi in Pakistan. The Port of Deendayal is located on the Gulf of Kutch on the northwestern coast of India some 256 nautical miles North West of the Port of Karachi in Pakistan and over 430 nautical miles north-northwest of the Port of Mumbai (Bombay). It is the largest port of India by volume of cargo handled. Kandla history Deendayal Port Authority, India's busiest major port in recent years, is gearing to add substantial cargo handling capacity with private sector participation. Deendayal port Authority creates a new record by handling 127.10 million metric tons of cargo during the FY 2021-22, as against 117.566 million metric tons in FY 2020-21. Showing a growth of 8.11 %. Incidentally, DPA is the only major Indian port of handle more than 127 MMT cargo throughout and it has also registered the highest cargo throughput in its history. While the port has flagged off several projects related to infrastructure creation, DPA has successfully awarded the work of augmentation of liquid cargo handling capacity by revamping the existing pipeline network at the oil jetty area in Sept. 2021. Even as much of this growth has come from handling of crude oil imports, mainly for Essar Oil's Vadinar refinery in Gujarat, the port is also taking measures to boost non-POL cargo. Last fiscal, POL traffic accounted for 63 per cent of the total cargo handled at Deendayal Port, as against 59% in 2007-08. The Deendayal Port Authority had commissioned the Off-shore Oil Terminal facilities at Vadinar in the year 1978, for which M/s. Indian Oil Corporation Limited (IOCL) provided Single Bouy Mooring (SBM) system, having a capacity of 54 MMTPA, which was first of its kind in India. Further, significant. Quantum of infrastructural up-gradation has been affected & excellent maritime infrastructure been created at Vadinar for the 32 MMTPA Essar Oil Refinery in Jamnagar District. Monitoring of various environmental aspects of the Deendayal port by M/s Detox Corporation Pvt. Ltd. has been carried out through collection of samples, analysis of the same, comparing results with respect to the prescribed standards by GPCB/CPCB/MoEF& CC. The results shall address the identified impacts and suggest measures to minimize the environmental

impact due to various operations at Deendayal Port. The environmental monitoring is carried out as per the Environment Management and Monitoring Plan submitted by Detox Corporation Pvt. Ltd.

2. Introduction

Air pollutants are added in the atmosphere from variety of sources that change the composition of atmosphere and affect the biotic environment. The concentration of air pollutants depends not only on the quantities that are emitted from air pollution sources but also on the ability of the atmosphere to either absorb or disperse these emissions. The air pollution concentration varies spatially and temporarily causing the air pollution pattern to change with different locations and time due to changes in meteorological and topographical condition. Air pollution occurs when harmful substances including particulates and biological molecules are introduced into earth's atmosphere. It may cause diseases, allergies or death of humans; it may also cause harm to other living organisms such as animals and food crops, and may damage the natural or built environment. Human activity and natural processes can both generate air pollution. A physical, biological or chemical alteration to the air in the atmosphere can be termed as pollution. It occurs when any harmful gases, dust, smoke enters into the atmosphere and makes it difficult for plants, animals and humans to survive as the air becomes dirty. The consequences of industrialization and the demand for improved quality of life has been increased exposure to air pollution (Vallero, 2014). An air pollutant is a substance in the air that can have adverse effects on humans and the ecosystem. The substance can be solid particles, liquid droplets, or gases. A pollutant can be of natural origin or man-made. Pollutants are classified as primary or secondary. Any gas could qualify as pollution if it reached a high enough concentration to do harm. Theoretically, that means there are dozens of different pollution gases. In practice, about ten different substances cause most concern. Heavy metals represent a class of omnipresent pollutants, with toxic potential, in some cases even at low exposure levels. They concentrate in each tropic level because of their weak mobility, so the concentration in plants is higher than in soil, in herbivore animals higher than in plants, in carnivores' tissues higher than in herbivore, the highest concentration being reached at the end of the tropic chain, at big predacious and human bodies. Globally, one of the main contributors to emissions of atmospheric pollutants and a significant user of energy is the industrial sector (Contiel,2015). The concentration of air pollutants depends not only on the quantities that are emitted from the polluting sources, but also on the ability of the atmosphere to either absorb or disperse such emissions (USEPA, 2008). Nowadays, the shipping sector provides low-cost and reliable delivery services in the economic field

(Arunachalam et al. 2015). Nevertheless, shipping-related activities have a considerable impact on air pollution, especially in coastal areas but also globally (Buccolieri et al. 2016).

The primary air pollutants are PM, VOCs, NOx, O_3, SO_2, and CO (Bailey and Solomon 2004). As a consequence, a wide range of options toward "greener" seaports is needed (Bailey and Solomon 2004). Some of these measures are easy to adopt such as the regulation of fuel quality (by using low-sulfur alternative fuels), the speed reduction (Lack et al. 2011), and the use of alternative transportation equipment (Lai et al. 2011). Clean air is the basic requirement of all living organisms. In recent times, due to population growth, urban sprawl, industrial development, and vehicular boom, the quality of air is deteriorating and being polluted. Pollutants of major public health concerns include particulate matter, carbon monoxide, ozone, nitrogen dioxide, and sulfur dioxide, which pose serious threats to human health and hygiene. In the present study, prime particulate pollutants (PM_{10}, $PM_{2.5}$), and gaseous pollutants (SO_2, and NO_2) were estimated at seven stations in and around Dahej Port, Gujarat, India (Soni and Jagruti Patel, 2017).Among particulate pollutants, particulate matter (PM) is a ubiquitous entity, and is especially a grave problem due to its higher suspension rate into the atmosphere, and adverse health effects on plants, animals, humans, and materials in the form of visibility reduction, soiling of buildings, etc. (Horaginamani and Ravichandran, 2010; Chaurasia *et al*., 2013). The sources of air pollutants include vehicles, industries, domestic sources and natural sources. Because of the presence of high amount of air pollutants in the ambient air, the health of the population and property is getting adversely affected. In order to arrest the deterioration in air quality, Govt. of India has enacted Air (Prevention and Control of Pollution) Act in 1981. The responsibility has been further emphasized within Environment (Protection) Act, 1986. It is necessary to assess the present and anticipated air pollution through continuous air quality survey/monitoring programs. Therefore, Central Pollution Control Board had started National Ambient Air Quality Monitoring (NAAQM) Network during 1984 - 85 at national level. The programme was later renamed as National Air Quality Monitoring Programme (NAMP).

2.1 Ambient Air Quality Monitoring

As per the Environmental Monitoring Plan of Deendayal Port Authority, Air monitoring was carried out at six identified locations at Deendayal Port and two locations at Vadinar Port.

Table: 1. Ambient Air Sampling Location

Sr. No.	Name of Location	Location Code	Latitude	Longitude	Remarks
1.	Marine Bhavan	AL-1	23° 0' 26.524"N	70° 13' 22.414"E	**DPA-Kandla**
2.	Oil Jetty	AL-2	23° 1' 45.613"N	70° 13' 11.052"E	
3.	Estate Office	AL-3	23° 1' 11.273"N	70° 12' 48.657"E	
4.	Gopalpuri Hospital	AL-4	23° 4' 53.551"N	70° 8' 7.047"E	
5.	Coal Storage Area	AL-5	22° 59' 31.812"N	70° 13' 9.979"E	
6.	Tuna Port	AL-6	22° 59' 15.291"N	70° 58' 57.018"E	
7.	Signal Building	AL-7	22° 26' 26.750"N	69° 40' 22.127"E	**DPA-Vadinar**
8.	Admin Building	AL-8	22° 26' 25.223"N	69° 40' 19.358"E	

- **Air Quality Monitoring Methodology**

Air quality is measured in all the stations, for 24 hours for Total Suspended Particulate Matter (TSPM), PM_{10}, $PM_{2.5}$, SO_2, NO_2, NH_3 & Benzene and Grab-sampling for CO & CO_2 measurements. The Air samplers are operated for a period of 24 hours and after a continuous operation of 8 hours for gaseous parameters. The absorbing reagents for SO_2: - Absorbing Reagent TCM (Potassium Tetrachloromercurate 0.04M): Mercuric Chloride, Potassium Chloride and EDTA used. For NO_2: - Absorbing Reagent Sodium Hydroxide (NAOH): Sodium Hydroxide and Sodium Arsenite used. For NH_3 need Conc. Sulphuric Acid and Distilled water was used. By replacing 3 times the reagents per day for each parameter namely, SO_2, NO_2, NH_3. The GFA filter paper and PTFE Membrane bound filter paper are used for a period of 24 hours to obtain one sample each of TSPM, PM_{10} & $PM_{2.5}$. The AAQ samples are collected two consecutive days a week as per CPCB guidelines, from all the eight locations as mentioned in the EMP.

2.2 Results

The ambient air quality monitoring data for six stations, viz. Marine Bhavan, Oil Jetty, Port Colony, Gopalpuri Hospital, Tuna Port and Nr. Coal Storage Area for the 1st December 2022 to 15th December 2022 of December 2022 are given in Tables 2 to 7. The ambient air quality monitoring data for two stations at Vadinar (Nr. Admin Building & Nr. Signal Building) are given in Tables 8 to 9. The Movement of heavy transport with uncovered coal transportation, raw road around ambient location may be causes fugitive dust emission from dry conditions. Particulate Matter then enters the atmosphere through the action of wind, vehicular movement, or other activities. The dust produces tends to float in air and spread all around the vicinity. Direction and speed of wind affect the dispersion of the dust particulate matter. Humidity of air also has strong effect on the spreading of particulate matter. With increasing humidity, moisture particles eventually grow in size to a point where 'dry deposition' occurs, reducing PM_{10} concentrations in the atmosphere.

Location 1: Marine Bhavan (AL1)

Table 2: Results of Air Pollutant Concentration at Marine Bhavan										
	Date	**TSPM [µg/ m^3]**	**PM$_{10}$ [µg/ m^3]**	**PM$_{2.5}$ [µg/ m^3]**	**SO$_2$ [µg/m^3]**		**NOx [µg/m^3]**		**NH$_3$ [µg/m^3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS Limit			**100 µg/m^3**	**60 µg/m^3**		**80 µg/m^3**		**80 µg/ m^3**		**400 µg/m^3**
AL1 – 1	02.12.2022	321	206	98	4.84 3.63 4.53	4.33	17.89 18.47 13.27	16.54	2.42 5.41 5.18	4.34
AL1 – 2	06.12.2022	377	241	106	5.74 4.23 5.44	5.14	14.43 15.58 18.47	16.16	5.87 4.26 6.56	5.56
AL1 – 3	09.12.2022	404	273	110	6.65 3.93 3.17	4.58	21.93 16.16 19.62	19.24	4.95 2.53 3.11	3.53
AL1 – 4	12.12.2022	372	233	96	3.02 5.74 4.23	4.33	17.89 18.47 21.93	19.43	6.22 7.83 5.06	6.37
AL1 – 5	15.12.2022	290	192	80	5.74 4.23 5.44	5.14	16.74 14.43 15.58	15.58	6.56 7.98 6.68	7.07
1st December 2022 to 15th December 2022 Average		353	229	98		4.7		17.4		5.4
Standard Deviation		46	32	12		0		2		1

Table 2 : Results of Air Pollutant Concentration at Marine Bhavan					
	Date	**C_6H_6 [µg/m^3]**	**HC**	**CO [mg/m^3]**	**CO_2 [ppm]**
Sampling Period		**8 hr**		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m^3**	**ppm**	**4.0 mg/m^3**	**-**
AL1 – 1	02.12.2022	1.1	BQL	1.67	1005
AL1 – 2	06.12.2022	1.21	BQL	1.46	1160
AL1 – 3	09.12.2022	1.16	BQL	1.71	938
AL1 – 4	12.12.2022	1.06	BQL	2.31	853
AL1 – 5	15.12.2022	1.12	BQL	1.96	598
1st December 2022 to 15th December 2022 Average		**1.13**	**-**	**1.82**	**910.80**
Standard Deviation		**0.06**	**-**	**0.33**	**207.91**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

At Marine Bhavan, the overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 is attributed mainly by motor vehicle emission produced from various types of automobiles (both diesel and petrol driven). Moreover, the loading and unloading of Food Grains and Timber at Jetty no. 1 and 2 also contributes to the high levels of TSPM and PM_{10}. The mean TSPM value at Marine Bhavan was 353.0 µg/m^3, the mean PM_{10} value was 229 µg/m^3 which was above the standard limit and $PM_{2.5}$ value was 98.0 µg/m^3 which is within the standard limit prescribed by NAAQS. The average values of SO_2, NO_2 and NH_3 were 4.7 µg/m^3, 17.4 µg/m^3 & 5.4 µg/m^3 respectively; these values were within the standard limit prescribed by NAAQS.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Marine Bhavan. The mean Benzene concentration was 1.13 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.82 mg/m^3, well below the permissible limit of 4.0 mg/m^3 prescribed by NAAQS.

Location 2: Oil Jetty (AL2)

Table 3 : Results of Air Pollutant Concentration at Oil Jetty										
	Date	TSPM [µg/ m^3]	PM_{10} [µg/ m^3]	$PM_{2.5}$ [µg/ m^3]	SO_2 [µg/m^3]		NO_X [µg/m3]		NH_3 [µg/m^3]	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS Limit			**100 µg/m^3**	**60 µg/m3**		**80 µg/ m^3**		**80 µg/m^3**		**400 µg/m^3**
AL2 – 1	02.12.2022	198	111	52	5.44	4.39	13.85	13.66	6.10	6.52
					5.14		11.54		7.83	
					2.59		15.58		5.64	
AL2 – 2	06.12.2022	211	132	62	3.63	3.73	10.97	11.16	3.34	4.91
					4.23		9.81		5.29	
					3.32		12.70		6.10	
AL2 – 3	09.12.2022	239	141	71	2.88	2.98	23.66	20.97	3.80	4.91
					3.46		17.31		3.11	
					2.59		21.93		7.83	
AL2 – 4	12.12.2022	224	137	68	3.32	3.93	16.16	14.24	3.22	4.72
					3.93		12.70		4.83	
					4.53		13.85		6.10	
AL2 – 5	15.12.2022	210	119	49	3.32	4.03	15.58	16.35	4.37	4.60
					4.23		14.43		7.98	
					5.44		15.58		6.68	
1st December 2022 to 15th December 2022 Average		216	128	60		4		15		5
Standard Deviation		16	13	10		1		4		1

Table 3 : Results of Air Pollutant Concentration at Oil Jetty					
	Date	**C_6H_6 [µg/m^3]**	***NMHC**	**CO [mg/m^3]**	**CO_2 [ppm]**
Sampling Period		**8 hr**		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL2-1	02.12.2022	1.07	BQL	1.16	768
AL2-2	06.12.2022	1.12	BQL	1.91	1208
AL2-3	09.12.2022	1.16	BQL	1.49	1056
AL2-4	12.12.2022	1.21	BQL	1.1	855
AL2 –5	15.12.2022	1.3	BQL	1.46	511
1st December 2022 to 15th December 2022 Average		**1.17**	**-**	**1.42**	**879.60**
Standard Deviation		**0.09**	**-**	**0.32**	**268.28**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

Oil Jetty Area, the overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 was mainly by motor vehicle emission produced from various types of vehicles at Oil Jetty Area. The mean TSPM value at Oil Jetty was 216.0 µg/m^3. The mean PM_{10} value was 128.0 µg/m^3 which was above the permissible limit mean, the mean $PM_{2.5}$ value was 60.0 µg/m^3 which was within the permissible limit. The average values of SO_2, NO_2 and NH_3 were within the permissible limit prescribed by NAAQS. The mean concentration of SO_2, NO_2 and NH_3 were 4.0 µg/m^3, 15.00 µg/m^3 and 5.0 µg/m^3 respectively.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Oil Jetty. The mean Benzene concentration was 1.17 µg/m^3 which was well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.42 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 3: Kandla Colony – Estate Office (AL-3)

Table 4 : Results of Air Pollutant Concentration at Estate Office										
	Date	**TSPM [µg/ m³]**	**PM_{10} [µg/ m³]**	**$PM_{2.5}$ [µg/ m³]**	**SO2 [µg/m³]**		**NOx [µg/m³]**		**NH_3 [µg/m³]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr**	**24hr**	**24hr**
NAAQMS Limit			**100 µg/m³**	**60 µg/m³**		**80 µg/m³**			**100 µg/m³**	**60 µg/m³**
AL3 – 1	02.12.2022	192	98	39	6.95	5.24	18.47	15.00	6.33	7.52
					5.74		16.74		7.83	
					3.02		9.81		8.40	
AL3 – 2	06.12.2022	201	110	42	4.84	4.64	11.54	11.93	6.45	4.18
					5.74		9.81		3.22	
					3.32		14.43		2.88	
AL3 – 3	09.12.2022	240	152	61	3.75	3.65	14.43	12.31	3.80	2.92
					4.32		11.54		3.22	
					2.88		10.97		1.73	
AL3 – 4	12.12.2022	222	126	59	3.93	4.63	19.04	16.74	5.76	4.34
					4.84		14.43		4.37	
					5.14		16.74		2.88	
AL3 – 5	15.12.2022	210	120	49	3.32	4.43	21.93	22.51	4.37	4.10
					3.02		31.16		4.72	
					6.95		14.43		3.22	
1st December 2022 to 15th December 2022 Average		213	121	50		4.5		15.7		4.6
Standard Deviation		19	20	10		1		4		2

Table 4 : Results of Air Pollutant Concentration at Estate Office					
Sampling Period	**Date**	**C_6H_6 [µg/m^3]**	***NMHC**	**CO [mg/m^3]**	**CO_2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL3 -1	02.12.2022	1.13	BQL	1.58	895
AL3 -2	06.12.2022	1.22	BQL	1.38	996
AL3 -3	09.12.2022	1.14	BQL	1.87	859
AL3 -4	12.12.2022	1.16	BQL	1.88	932
AL3 – 5	15.12.2022	1.05	BQL	1.34	523
1st December 2022 to 15th December 2022 Average		**1.14**	**-**	**1.61**	**841.00**
Standard Deviation		**0.06**	**-**	**0.26**	**184.84**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 at Kandla Port Colony (Estate Office) was attributed by vehicle emission produced from trucks and heavy-duty vehicles that pass through the road outside Kandla Port Colony. The mean TSPM values at Estate Office were 213.0 µg/m^3, the mean PM_{10} value was 121.0 µg/m^3 was above the permissible limit prescribed by NAAQS and $PM_{2.5}$ value was 50.0 µg/m^3 which was within the permissible limit prescribed by NAAQS. The average values of SO_2, NO_2 and NH_3 were 4.5 µg/m^3, 15.7 µg/m^3 and 4.6 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Kandla Port Colony. The mean Benzene concentration was 1.14 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide was 1.61 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 4: Gopalpuri Hospital (AL-4)

Table 5 : Results of Air Pollutant Concentration at Gopalpuri Hospital										
	Date	**TSPM [µg/ m^3]**	**PM$_{10}$ [µg/ m^3]**	**PM$_{2.5}$ [µg/ m^3]**	**SO2 [µg/m^3]**		**NOx [µg/m^3]**		**NH$_3$ [µg/m^3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr**	**24hr**	**24hr**
NAAQMS Limit			**100 µg/m^3**	**60 µg/m^3**		**80 µg/m^3**			**100 µg/m^3**	**60 µg/m^3**
AL4 -1	02.12.2022	140	92	35	5.14 3.02 5.44	4.53	10.39 7.50 6.93	8.27	4.37 3.45 2.88	3.57
AL4 -2	06.12.2022	162	109	40	4.84 3.02 4.23	4.03	5.77 10.39 11.54	9.23	2.42 3.68 4.49	3.53
AL4 -3	09.12.2022	173	100	56	4.61 2.88 2.59	3.36	6.93 10.97 7.50	8.46	1.96 2.42 2.19	2.19
AL4 -4	12.12.2022	155	93	49	1.21 2.12 1.81	1.71	9.23 11.54 6.35	9.04	3.22 1.84 2.53	2.53
AL4 – 5	15.12.2022	169	98	51	2.42 1.81 3.02	2.42	14.43 8.08 17.31	13.27	2.42 4.03 2.88	3.11
1st December 2022 to 15th December 2022 Average		160	98	46		3.21		9.66		2.99
Standard Deviation		13	7	9		1		2		1

Table 5 : Results of Air Pollutant Concentration at Gopalpuri Hospital					
Sampling Period	**Date**	**C_6H_6 [µg/m^3]**	***NMHC**	**CO [mg/m^3]**	**CO_2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL4 -1	02.12.2022	1.04	BQL	1.64	890
AL4 -2	06.12.2022	1.25	BQL	2.05	1314
AL4 -3	09.12.2022	1.13	BQL	1.21	924
AL4 -4	12.12.2022	1.22	BQL	1.55	1275
AL4 – 5	15.12.2022	1.1	BQL	1.35	405
1st December 2022 to 15th December 2022 Average		**1.15**	**-**	**1.56**	**961.60**
Standard Deviation		**0.09**	**-**	**0.32**	**367.00**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 at Gopalpuri Hospital was attributed by vehicle emission produced from light motor vehicles of the colony residents. The mean TSPM values at Gopalpuri Hospital were 160.0 µg/m^3, the mean PM_{10} value 98.0 µg/m^3 and $PM_{2.5}$ 46.0 µg/m^3 within the standard limit. The average values of SO_2, NO_2 and NH_3 were 3.21 µg/m^3, 9.66 µg/m^3 and 2.99 µg/m^3 respectively and were within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Gopalpuri Hospital. The mean Benzene concentration was 1.15 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon monoxide concentration was 1.56 mg/m^3 which is well below the permissible limit of 4.0 mg/m^3.

Location 5: Coal Storage Area (AL-5)

Table 6 : Results of Air Pollutant Concentration at Coal Storage Area										
	Date	**TSPM [µg/ m^3]**	**PM$_{10}$ [µg/ m^3]**	**PM$_{2.5}$ [µg/ m^3]**	**SO2 [µg/m^3]**		**NOx [µg/m^3]**		**NH$_3$ [µg/m^3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr**	**24hr**	**24hr**
NAAQMS Limit			**100 µg/m^3**	**60 µg/m^3**		**80 µg/m^3**			**100 µg/m^3**	**60 µg/m^3**
AL5 – 1	02.12.2022	392	310	129	7.25	6.04	13.85	18.85	4.95	6.56
					6.04		21.93		6.91	
					4.84		20.78		7.83	
AL5 – 2	06.12.2022	488	342	136	6.95	5.34	13.27	16.16	7.48	7.67
					5.14		22.51		8.06	
					3.93		12.70		7.48	
AL5 – 3	09.12.2022	552	399	144	5.77	4.52	21.93	23.85	3.80	3.49
					4.32		19.04		3.22	
					3.46		30.59		3.45	
AL5 – 4	12.12.2022	510	364	124	6.04	6.04	16.16	15.97	5.87	5.76
					7.55		12.70		4.03	
					4.53		19.04		7.37	
AL5 – 5	15.12.2022	472	290	110	6.35	4.94	19.62	20.01	7.71	6.56
					4.84		17.31		6.33	
					3.63		23.08		5.64	
1st December 2022 to 15th December 2022 Average		483	341	129		5.38		18.97		6.01
Standard Deviation		59	43	13		1		3		2

Table 6: Results of Air Pollutant Concentration at Coal Storage Area					
Sampling Period	**Date**	**C_6H_6 [µg/m^3]**	***NMHC**	**CO [mg/m^3]**	**CO_2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL5 – 1	02.12.2022	1.11	BQL	1.66	1289
AL5 – 2	06.12.2022	1.16	BQL	1.97	1427
AL5 – 3	09.12.2022	1.22	BQL	2.19	718
AL5 – 4	12.12.2022	1.13	BQL	1.48	1222
AL5 – 5	15.12.2022	1.19	BQL	1.43	481
1st December 2022 to 15th December 2022 Average		**1.16**	**-**	**1.75**	**1027.40**
Standard Deviation		**0.04**	**-**	**0.33**	**406.28**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 at Coal Storage Area was comparatively highest among all the locations of Air Quality monitoring in Kandla Port. High values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 at this location was due to lifting of coal with grab and other coal handling processes near Berth no. 6 & 7. Moreover, the traffic was also heavy around this place for transport of coal thus emissions produced from heavy vehicles. The mean TSPM values at Coal storage were 483.0µg/m^3, the mean PM_{10} value was 341.0 µg/m^3, and the $PM_{2.5}$ value was 129.0 µg/m^3 which was above the permissible limit prescribed by NAAQS. The average values of SO_2, NO_2 and NH_3 were 5.38 µg/m^3, 18.97 µg/m^3 and 6.01 µg/m^3 respectively and were within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Coal Storage Area. The mean Benzene concentration was1.16 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.75 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 6: Tuna Port (AL-6)

Table 7: Results of Air Pollutant Concentration at Tuna Port

	Date	TSPM [µg/ m^3]	PM_{10} [µg/ m^3]	$PM_{2.5}$ [µg/ m^3]	SO2 [µg/m^3]		NOx [µg/m^3]		NH_3 [µg/m^3]	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr**	**24hr**	**24hr**
NAAQMS Limit			**100 µg/m^3**	**60 µg/m^3**		**80 µg/m^3**			**100 µg/m^3**	**60 µg/m^3**
AL5 -1	02.12.2022	106	66	30	4.53	3.42	11.54	9.62	4.49	3.57
					3.02		9.81		3.91	
					2.72		7.50		2.30	
AL5 – 2	06.12.2022	100	59	26	2.42	1.91	7.50	8.27	2.65	3.61
					1.81		9.23		3.45	
					1.51		8.08		4.72	
AL5 – 3	09.12.2022	110	61	32	2.59	2.11	6.35	10.39	3.11	2.92
					1.73		11.54		2.07	
					2.02		13.27		3.57	
AL5 – 4	12.12.2022	126	78	40	1.21	1.31	8.66	10.97	2.42	2.95
					0.91		11.54		3.57	
					1.81		12.70		2.88	
AL5 – 5	15.12.2022	108	70	36	1.81	2.82	13.27	11.73	5.76	5.45
					3.63		11.54		5.53	
					3.02		10.39		5.06	
1st December 2022 to 15th December 2022 Average		110	67	33		2.32		10.2		3.70
Standard Deviation		10	8	5		1		1		1

Table 7: Results of Air Pollutant Concentration at Tuna Port					
	Date	C_6H_6 [µg/m^3]	*NMHC	CO [mg/m^3]	CO_2 [ppm]
Sampling Period		8 hr		Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m3		4.0 mg/m3	-
AL6 -1	02.12.2022	1.1	BQL	1.78	1459
AL6 – 2	06.12.2022	1.27	BQL	1.55	1067
AL6 – 3	09.12.2022	1.1	BQL	2.1	651
AL6 – 4	12.12.2022	1.23	BQL	1.81	391
AL6 – 5	15.12.2022	1.12	BQL	1.29	471
AL6 – 6	02.12.2022	1.1	BQL	1.78	1459
1st December 2022 to 15th December 2022 Average		1.16	-	1.71	807.80
Standard Deviation		0.08	-	0.30	448.05

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The mean TSPM values at Tuna Port was 110.0 µg/m^3, the mean PM_{10} value was 67.0 µg/m^3 and $PM_{2.5}$ value was 33.0 µg/m^3 which were within the standard limit prescribed by NAAQS. The average values of SO_2, NO_2 and NH_3 were 2.32 µg/m^3, 10.2 µg/m^3 and 3.70 µg/m^3 respectively and were all within the standard limit prescribed by NAAQS.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Tuna Port. The mean Benzene concentration was 1.16 µg/m3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.71 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 7: Admin Building (Vadinar) (AL-7)

Table 8: Results of Air Pollutant Concentration at Admin Building										
	Date	**TSPM [µg/ m^3]**	**PM$_{10}$ [µg/ m^3]**	**PM$_{2.5}$ [µg/ m^3]**	**SO2 [µg/m^3]**		**NOx [µg/m^3]**		**NH$_3$ [µg/m^3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr**	**24hr**	**24hr**
NAAQMS Limit			**100 µg/m^3**	**60 µg/m^3**		**80 µg/m^3**			**100 µg/m^3**	**60 µg/m^3**
AL7 -1	02.12.2022	160	106	44	3.93	3.93	11.54	12.12	8.17	8.52
					4.84		15.00		9.44	
					3.02		9.81		7.94	
AL7 -2	06.12.2022	163	114	48	3.52	5.13	10.39	12.12	7.25	8.40
					5.28		14.43		8.52	
					6.59		11.54		9.44	
AL7 -3	09.12.2022	155	109	39	3.32	3.93	10.97	9.62	7.02	6.10
					3.63		10.39		4.83	
					4.84		7.50		6.45	
AL7 -4	12.12.2022	159	112	41	5.14	5.24	13.27	13.08	7.94	7.60
					6.65		10.97		6.79	
					3.93		15.00		8.06	
AL7 -5	15.12.2022	130	99	29	3.02	3.73	16.16	15.97	6.79	7.52
					5.44		18.47		7.60	
					2.72		13.27		8.17	
1st December 2022 to 15th December 2022 Average		**153**	**108**	**40**		**4.39**		**12.58**		**7.63**
Standard Deviation		**13**	**6**	**7**		**0.73**		**2.29**		**0.97**

Table 8: Results of Air Pollutant Concentration at Admin Building Vadinar					
Sampling Period	**Date**	**C_6H_6 [µg/m^3]**	***NMHC**	**CO [mg/m^3]**	**CO_2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL7 -1	02.12.2022	1.08	BQL	1.65	566
AL7 -2	06.12.2022	1.13	BQL	1.6	523
AL7 -3	09.12.2022	1.17	1.81	1.39	406
AL7 -4	12.12.2022	1.14	BQL	1.46	414
AL7 -5	15.12.2022	1.03	BQL	1.2	400
1st December 2022 to 15th December 2022 Average		**1.11**	**-**	**1.46**	**462**
Standard Deviation		**0.06**	**-**	**0.18**	**77**

*NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

At Admin Building, Vadinar the mean TSPM value was 153.0 µg/m^3, the mean PM_{10} value was 108.0 µg/m^3 which was slightly exceed the standard limit, mean $PM_{2.5}$ value was 40.0 µg/m^3 within the standard limit The average values of SO_2, NO_2 and NH_3 concentrations were 4.39 µg/m^3, 12.58 µg/m^3 and 7.63 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Vadinar Port. The mean Benzene concentration was 1.11µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.46 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 8: Signal Building (Vadinar) (AL-8)

Table 9 : Results of Air Pollutant Concentration at Signal Building, Vadinar

	Date	TSPM [µg/ m³]	PM_{10} [µg/ m³]	$PM_{2.5}$ [µg/ m³]	SO2 [µg/m³]		NOx [µg/m³]		NH_3 [µg/m³]	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr**	**24hr**	**24hr**
NAAQMS Limit			**100 µg/m³**	**60 µg/m³**		**80 µg/m³**			**100 µg/m³**	**60 µg/m³**
AL8 -1	02.12.2022	130	96	35	5.44 3.93 5.14	4.84	9.23 11.54 12.12	10.97	5.29 6.56 8.98	6.94
AL8 -2	03.12.2022	146	106	42	4.84 5.44 3.93	4.73	15.00 12.70 10.39	12.70	7.14 8.06 6.79	7.33
AL8 -3	06.12.2022	152	90	37	5.44 3.32 2.72	3.83	13.27 16.16 11.54	13.66	5.76 4.95 6.45	5.72
AL8 -4	09.12.2022	149	94	30	4.23 5.14 6.35	5.24	10.97 15.00 13.27	13.08	6.33 5.64 5.06	5.68
AL8 -5	15.12.2022	150	108	48	5.44 6.04 4.84	5.44	12.12 15.58 17.31	15.00	5.29 7.14 4.49	5.64
1st December 2022 to 15th December 2022 Average		**145**	**99**	**38**		**4.82**		**13.08**		**6.26**
Standard Deviation		**8.88**	**7.82**	**6.88**		**0.62**		**1.47**		**0.81**

Table 9 : Results of Air Pollutant Concentration at Signal Building Vadinar					
		C_6H_6 [µg/m^3]		CO [mg/m^3]	CO_2 [ppm]
Sampling Period	**Date**	**8 hr**	***NMHC**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL8 -1	02.12.2022	1.19	BQL	0.98	576
AL8 -2	06.12.2022	1.2	BQL	1.38	510
AL8 -3	09.12.2022	1.14	BQL	1.97	378
AL8 -4	12.12.2022	1.1	BQL	1.94	403
AL8 -5	15.12.2022	1.19	BQL	1.41	393
1st December 2022 to 15th December 2022 Average		**1.16**	**-**	**1.54**	**452**
Standard Deviation		**0.04**	**-**	**0.42**	**87**

* NMHC- Non- Methane Hydrocarbon
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

At Signal Building, Vadinar the mean TSPM value was 145 µg/m^3, the mean PM_{10} value was 99 µg/m^3 and $PM_{2.5}$ value was 38 µg/m^3 which were within the permissible limit. The average values of SO_2, NO_2 and NH_3 concentrations were 4.82 µg/m^3, 13.08 µg/m^3 and 6.26 µg/m^3 respectively and were all within the standard limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Vadinar Port. The mean Benzene concentration was 1.16 µg/m^3, well below the standard limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.54 mg/m^3, well below the standard limit of 4.0 mg/m^3.

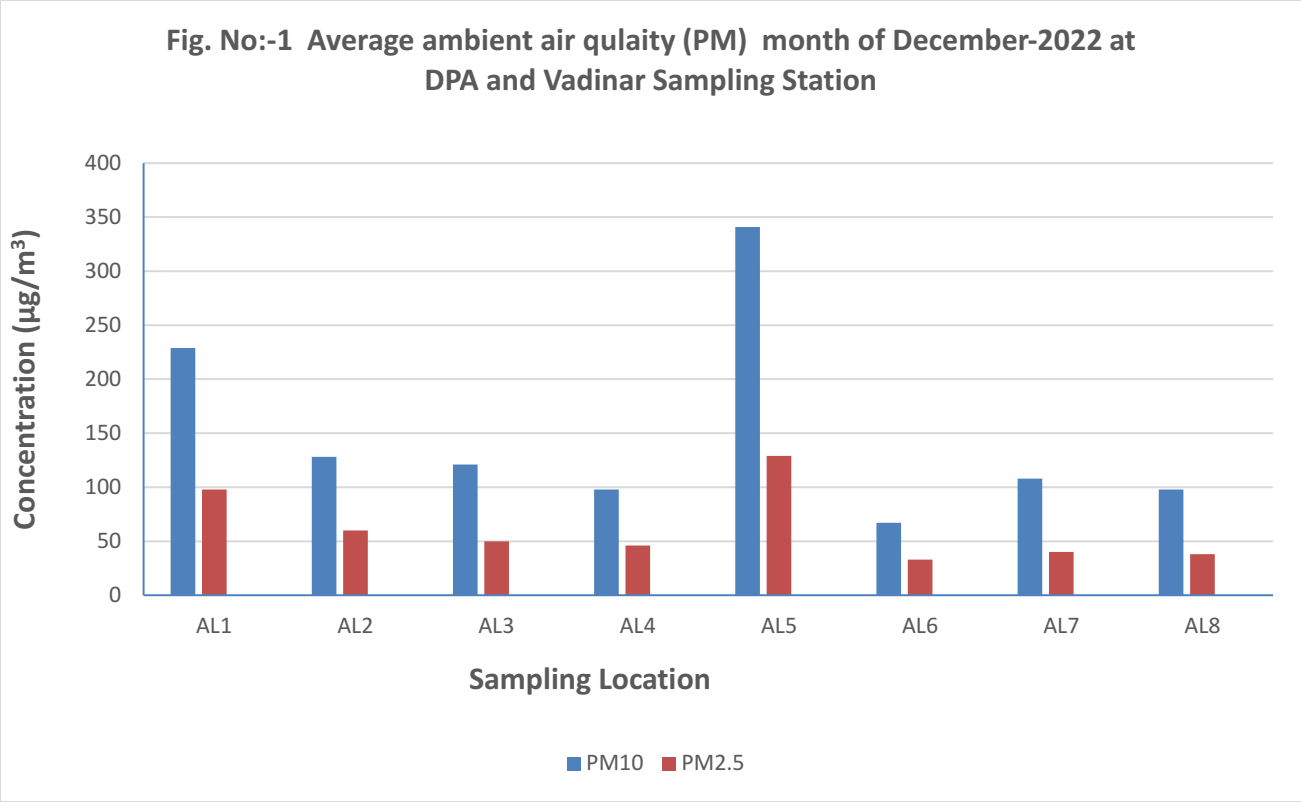


Fig. No:-1 Average ambient air qulaity (PM) month of December-2022 at DPA and Vadinar Sampling Station
Concentration (µg/m³)
400
350
300
250
200
150
100
50
0
AL1
AL2
AL3
AL4
AL5
AL6
AL7
AL8
Sampling Location
PM10
PM2.5

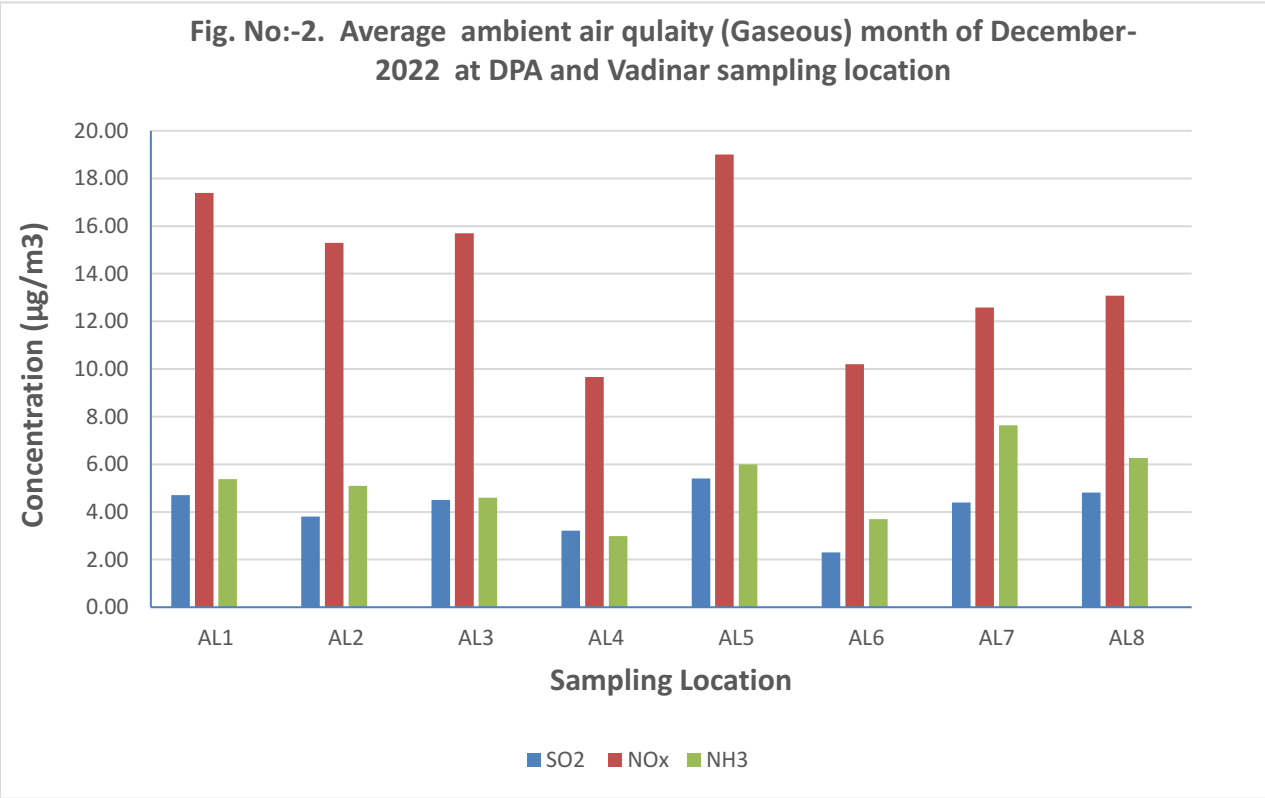


Fig. No:-2. Average ambient air qulaity (Gaseous) month of December-2022 at DPA and Vadinar sampling location
Concentration (µg/m3)
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
AL1
AL2
AL3
AL4
AL5
AL6
AL7
AL8
Sampling Location
SO2
NOx
NH3

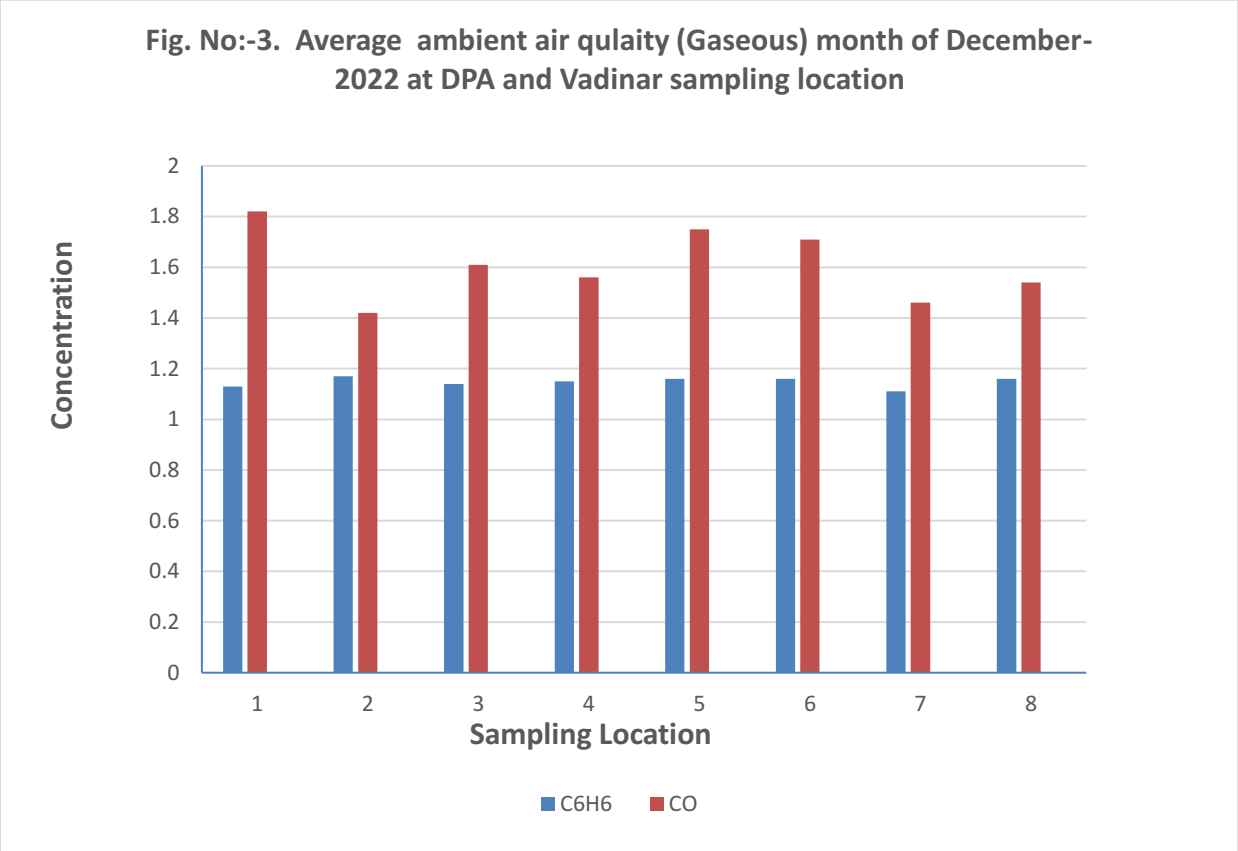


Fig. No:-3. Average ambient air qulaity (Gaseous) month of December-2022 at DPA and Vadinar sampling location
Concentration
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1
2
3
4
5
6
7
8
Sampling Location
C6H6
CO

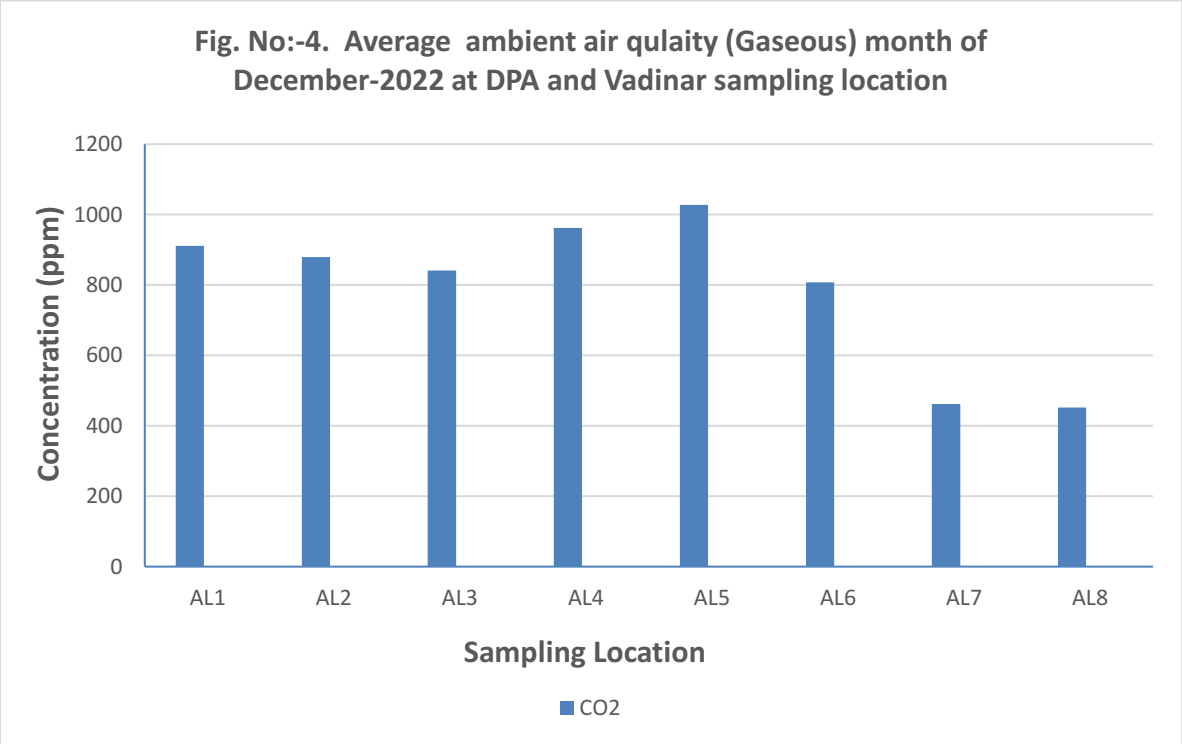


Fig. No:-4. Average ambient air qulaity (Gaseous) month of December-2022 at DPA and Vadinar sampling location
Concentration (ppm)
1200
1000
800
600
400
200
0
AL1
AL2
AL3
AL4
AL5
AL6
AL7
AL8
Sampling Location
CO2

2.3 Observations and Conclusion

During the monitoring period, the overall Ambient Air Quality of the port area was found within permissible levels for various gaseous pollutants. However, Particulate matter as PM_{10} and $PM_{2.5}$ was found to exceed the limits at Marine Bhavan, Oil Jetty, Estate Office and Coal Storage ambient air monitoring sampling locations.

The mean concentration of PM_{10} was slightly exceed the standard limit at admin building Vadinar while $PM_{2.5}$ was within standard limit and at Signal building Vadinar the concentration of PM_{10} & $PM_{2.5}$ within the standard limit.

The overall values of December for Gaseous SO_2, NO_2, NH_3, CO_2, CO, C_6H_6 concentration were within the permissible limit at all location and NMHC were found BQL (Below Quantification Limit).

4.1 Meteorological Data

Automatic Weather station (ID KAZPHOEN424) have been installed in Seva Sadan-3 at the Deendayal Port which records the data on Temperature (°C), Relative Humidity (%), Wind speed (m/s), Wind Direction (°), Solar radiation (w/m^2) and Rainfall mm.

Meteorological factors play an important role in environmental pollution studies particularly in pollutant transport irrespective of their entry into the environment. The wind speed and direction play a major role in dispersion of environment pollutants. Effects of pollution on receptors animate and inanimate depends on atmospheric condition.

Temperature

At Deendayal Port, the day time temperature was found range 21.70-28.30^{0}C. The average day time temperature was 25.20°C. The night time temperature was range from 22.15-26.60^{0}C. The mean night time temperature recorded was 24.33 °C.

Solar Radiation

The mean Solar Radiation in December 1st December 2022 to 15th December 2022 was 89.76 w/m^2. The maximum solar radiation was recorded 606.1 w/m^2 in 4th December, 2022 and the minimum solar radiation was recorded 0.00 w/m^2 in December, 2022.

Rainfall

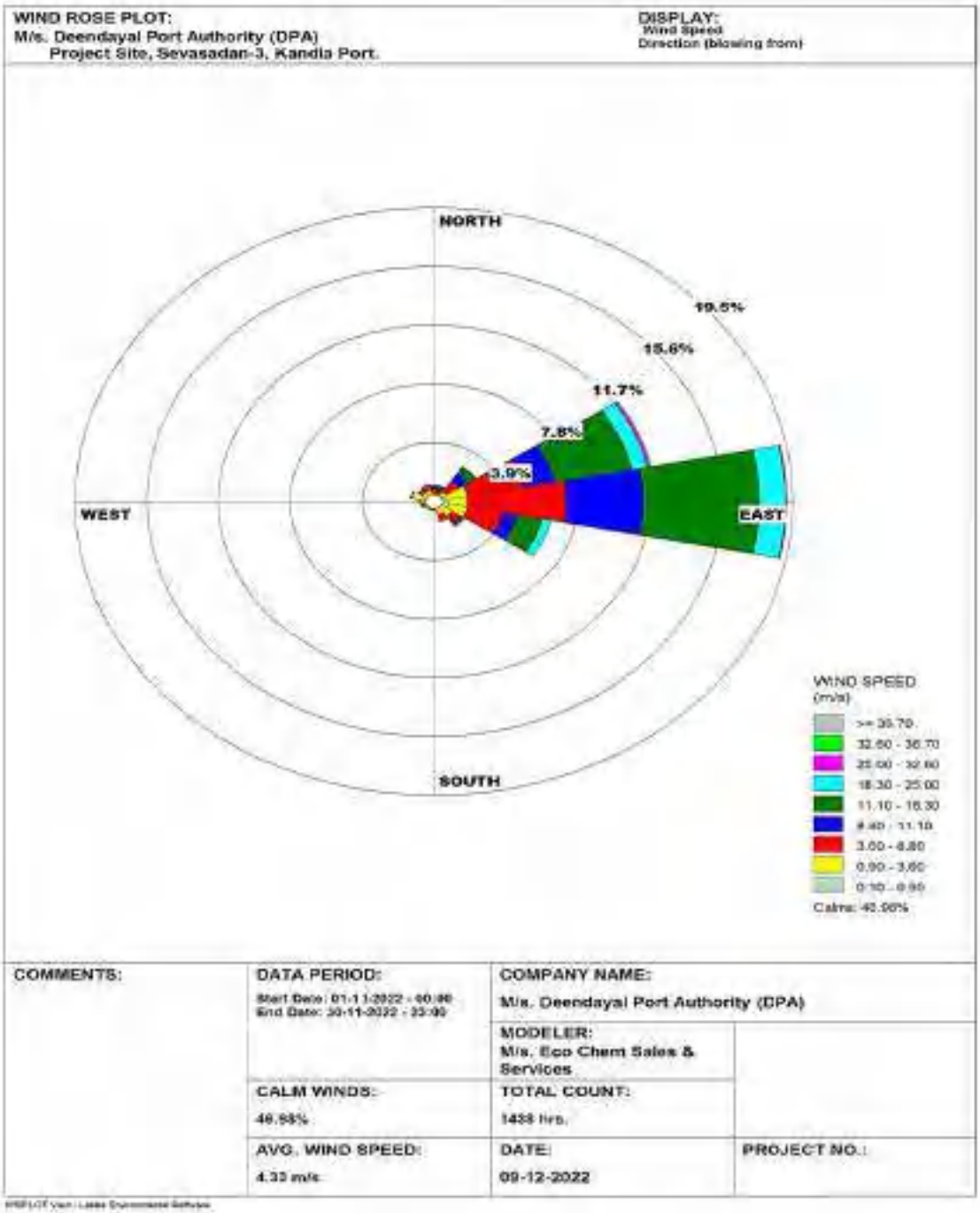
Rain fall of December 1st December 2022 to 15th December 2022 was recorded 0.00 mm.

Relative Humidity

The mean Relative humidity was 60.25 % for the 1st December 2022 to 15th December 2022 of December. Maximum Relative humidity was recorded 79.0 % and minimum Relative humidity was recorded 38.0 %.

Wind Velocity and Wind Direction

Velocity and direction of wind have a significant role in the dispersion of air borne materials and therefore determines the air quality of the area. The average wind velocity for the entire 1st December 2022 to 15th December 2022 of December was 4.33 m/s. Maximum wind velocity was recorded 9.0 m/s. The wind direction was mostly North-East.


WIND ROSE PLOT:
M/s. Deendayal Port Authority (DPA)
Project Site, Sevasadan-3, Kandla Port.
DISPLAY:
Wind Speed
Direction (blowing from)
NORTH
SOUTH
WEST
EAST
19.5%
15.6%
11.7%
7.8%
3.9%
WIND SPEED
(m/s)
>= 36.70
32.60 - 36.70
25.00 - 32.60
18.30 - 25.00
11.10 - 18.30
6.40 - 11.10
3.00 - 6.80
0.90 - 3.60
0.10 - 0.90
Calms: 40.98%
COMMENTS:
DATA PERIOD:
Start Date: 01-11-2022 - 00:00
End Date: 30-11-2022 - 23:00
COMPANY NAME:
M/s. Deendayal Port Authority (DPA)
MODELER:
M/s. Eco Chem Sales & Services
CALM WINDS:
40.98%
TOTAL COUNT:
1438 hrs.
AVG. WIND SPEED:
4.33 m/s
DATE:
09-12-2022
PROJECT NO.:

4.0 Drinking Water Quality Monitoring

Drinking Water Quality Monitoring was carried out at twenty stations at Kandla, Vadinar & Township Area of Deendayal Port.

Table No: -10. Drinking Water Sampling Location

Sr. No.	Name of Location	Location Code	Latitude	Longitude
1.	Nirman Building	DL-1	23° 0' 27"N	70° 13' 21"E
2.	P & C Building	DL-2	23° 0' 33"N	70° 13' 20"E
3.	North Gate	DL-3	23° 0' 26.97"N	70° 13' 21.87"E
4.	DPA-Canteen	DL-4	23° 2' 17.2674"N	70° 13'18.2814"E
5.	West Gate	DL-5	23° 59' 40.48"N	70° 12' 50.96"E
6.	Wharf Area	DL-6	22° 59' 52.2"N	70° 13' 22.95"E
7.	Sevasadan-3	DL-7	23° 0' 22.55"N	70° 13' 15.34"E
8.	Workshop	DL-8	23° 0' 33.74"N	70° 13' 20.05"E
9.	Custom Building	DL-9	23° 1' 8.70"N	70° 12' 52.0"E
10.	Kandla Colony	DL-10	23° 11' 14.9"N	70° 12' 48.4"E
11.	DPA Hospital	DL-11	23° 1' 5.02"N	70° 12' 44.38"E
12.	A.O. Building	DL-12	23° 3' 42.89"N	70° 8' 41.5"E
13.	Gopalpuri School	DL-13	23° 5' 1.03"N	70° 7' 55.42"E
14	Gopalpuri Guest House	DL-14	23° 4' 43.14"N	70° 7' 51.92"E
15.	E-Type Quarters	DL-15	23° 4' 59.90"N	70° 7' 56.72"E
16.	F-Type Quarters	DL-16	23° 4' 38.45"N	70° 8' 8.63"E
17.	Gopalpuri Hospital	DL-17	23° 4' 54.09"N	70° 8' 7.5"E
18.	Tuna Port	DL-18	23° 58' 23.06"N	70° 5' 35.6"E
19.	Vadinar Jetty	DL-19	22° 25' 51.73"N	69° 41' 36.62"E
20.	Vadinar Colony	DL-20	22° 30' 26.25"N	69° 39' 45.03"E

4.1 Drinking Water Monitoring Methodology

Samples for physico-chemical analysis were collected in 2 Carboys and samples for microbiological parameters were collected in sterilized bottles. These samples were then analyzed in laboratory for various drinking water parameters at Kandla Lab/Surat.

The Sampling was done as per IS: 3025 Part-1, analysis was done as per IS: 3025/APHA standard methods and, the analysis results compare with IS 10500:2012. The water samples were analyzed for various parameters, viz. Color, Odor, Turbidity, Conductivity, pH, Chlorides, TDS, Total Hardness, Iron, Sulphate, Salinity, DO, BOD, Na, K, Ca, Mg, F, NO_3, NO_2, Mn, Cr-6, Cu, Cd, As, Hg, Pb, Zn, Bacterial Count (CFU).

4.2 Results

The Drinking Water Quality monitoring data for 20 stations are given in below from table No. 11 to Table No. 17

Table 11: Drinking Water Quality Monitoring Parameters for Nirman Building, P & C Building and Main Gate (North) at Kandla.

Sr. No.	Parameter	Unit	Nirman Building 1	P & C Building	Main Gate North	Acceptable Limits as per IS 10500 :2012	Permissible Limits in the absence of Alternate Source as
1	pH	-	7.42	7.40	7.27	7.35	6.5 to 8.5
2	Total Dissolved Solids	mg/l	490	455	471	690	2000
3	Turbidity	NTU	1	0	0	0	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	980	910	942	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	170.38	155.35	130.29	250	1000
9	Ca as Ca	mg/l	47.29	33.67	39.28	75	200
10	Mg as Mg	mg/l	58.81	57.35	73.39	30	100
11	Total Hardness	mg/l	360	320	400	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.25	0.39	0.31	1	1.5
14	Sulphate as SO_4	mg/l	45.23	49.11	52.62	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	3.18	2.62	2.49	45	No Relaxation
17	Salinity	‰	0.31	0.28	0.24	NS*	NS*
18	Sodium as Na	mg/l	190.0	207.60	198.50	NS*	NS*
19	Potassium as K	mg/l	5.64	3.89	3.95	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/ 100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified BQL- Below Quantification Limit, (BOD-2.0 mg/l, Fe- 0.009 mg/l, Mn- 0.01 mg/l, Cr^{+6}- 0.03 mg/l, Cu- 0.004 mg/l, Cd- 0.003 mg/l, As- 0.003mg/l, Hg- 0.001 mg/l, Pb- 0.006mg/l, Zinc- 0.021 mg/l).

Table 12: Drinking Water Quality Monitoring Parameters for Canteen, West Gate – I & Wharf Area at Kandla

Sr. No.	Parameter	Unit	Canteen	West Gate – I	Wharf Area	Acceptable Limits as per IS 10500: 2012	Permissible Limits in the absence of Alternate Source as per IS 10500: 2012
1	pH	-	7.38	7.40	7.55	7.48	6.5 to 8.5
2	Total Dissolved Solids	mg/l	489	449	474	640	2000
3	Turbidity	NTU	1	0	1	0	5
4	Odor	-	Odorless	Odorless	Odorles	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorles	5	15
6	Conductivity	µs/cm	978	898	948	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	175.39	140.31	160.36	250	1000
9	Ca as Ca	mg/l	40.08	36.87	40.08	75	200
10	Mg as Mg	mg/l	43.74	55.40	34.02	30	100
11	Total Hardness	mg/l	280	320	240	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.33	0.24	0.35	1	1.5
14	Sulphate as SO4	mg/l	48.36	54.87	51.11	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	3.31	3.87	3.59	45	No Relaxation
17	Salinity	‰	0.32	0.25	0.29	NS*	NS*
18	Sodium as Na	mg/l	199.10	278.50	144.50	NS*	NS*
19	Potassium as K	mg/l	3.98	4.38	3.91	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100 ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified, BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l, BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6-0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

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Table 13: Drinking Water Quality Monitoring Parameters for Sewa sadan–3, Workshop I and Custom Building at Kandla

Sr. No.	Parameter	Unit	Sewa Sadan – 3	Workshop	Custom Building	Acceptable Limits as per IS 10500: 2012	Permissible Limits in the absence of Alternate Source as per IS 10500: 2012
1	pH	-	7.29	7.30	7.29	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	483	469	400	500	2000
3	Turbidity	NTU	1	1	0	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	966	937	800	NS*	NS*
7	Biochemical	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	155.35	180.40	165.37	250	1000
9	Ca as Ca	mg/l	41.68	39.28	40.88	75	200
10	Mg as Mg	mg/l	62.21	73.39	23.81	30	100
11	Total Hardness	mg/l	360	400	200	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.27	0.28	0.23	1	1.5
14	Sulphate as SO_4	mg/l	52.62	57.00	50.61	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	4.69	5.39	5.66	45	No Relaxation
17	Salinity	‰	0.28	0.33	0.30	NS*	NS*
18	Sodium as Na	mg/l	210.40	210.90	171.40	NS*	NS*
19	Potassium as K	mg/l	3.99	3.84	3.34	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified, BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l, BOD-2.0 mg/l, Fe-0.009 mg/l, Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 14: Drinking Water Quality Monitoring Parameters for Port Colony Kandla, Hospital Kandla and A.O. Building at Gandhidham.

Sr. No.	Parameter	Unit	Port Colony Kandla	Hospital Kandla	A.O. Building	Acceptable Limits as per IS 10500: 2012	Permissible Limits in the absence of Alternate Source as per IS 10500: 2012
1	pH	-	7.31	7.36	7.4	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	455	423	444	500	2000
3	Turbidity	NTU	1	0	1	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	910	846	888	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	180.40	145.32	155.35	250	1000
9	Ca as Ca	mg/l	44.89	42.48	37.68	75	200
10	Mg as Mg	mg/l	35.96	42.28	54.92	30	100
11	Total Hardness	mg/l	260	280	320	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.27	0.27	0.38	1	1.5
14	Sulphate as SO_4	mg/l	53.24	50.61	55.62	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	4.90	3.31	3.59	45	No Relaxation
17	Salinity	‰	0.33	0.26	0.28	NS*	NS*
18	Sodium as Na	mg/l	198.50	190.00	200.00	NS*	NS*
19	Potassium as K	mg/l	3.96	4.14	4.29	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l, BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

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Table 15: Drinking Water Quality Monitoring Parameters for School Gopalpuri, Guest House and E-Type Quarter at Gopalpuri, Gandhidham

Sr. No.	Parameter	Unit	Gopalpuri School	Guest House	E - Type Quarter	Acceptable Limits as per IS 10500: 2012	Permissible Limits in the absence of Alternate Source as per IS 10500: 2012
1	pH	-	7.5	7.59	7.42	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	448	450	455	500	2000
3	Turbidity	NTU	0	1	0	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	895	900	910	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	135.30	150.33	145.32	250	1000
9	Ca as Ca	mg/l	40.08	41.68	38.48	75	200
10	Mg as Mg	mg/l	63.18	71.93	44.71	30	100
11	Total Hardness	mg/l	360	400	280	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.25	0.25	0.11	1	1.5
14	Sulphate as SO_4	mg/l	35.08	48.23	51.62	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	5.59	3.04	3.73	45	No Relaxation
17	Salinity	‰	0.24	0.27	0.26	NS*	NS*
18	Sodium as Na	mg/l	201.00	200.00	192.00	NS*	NS*
19	Potassium as K	mg/l	3.80	3.70	3.65	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100 ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 16: Drinking Water Quality Monitoring Parameters for F-Type Quarter, Hospital Gopalpuri and Tuna Port.

Sr. No.	Parameter	Unit	F - Type Quarter	Hospital Gopalpuri	Tuna Port	Acceptable Limits as per IS 10500: 2012	Permissible Limits in the absence of Alternate Source as per IS 10500: 2012
1	pH	-	7.44	7.49	7.48	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	460	446	544	500	2000
3	Turbidity	NTU	1	0	1	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	920	892	1000	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	115.26	180.40	210.47	250	1000
9	Ca as Ca	mg/l	44.89	41.68	49.70	75	200
10	Mg as Mg	mg/l	60.26	33.05	67.07	30	100
11	Total Hardness	mg/l	360	240	400	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.27	0.30	0.40	1	1.5
14	Sulphate as SO_4	mg/l	52.62	53.12	62.64	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	4.28	5.39	4.28	45	No Relaxation
17	Salinity	‰	0.21	0.33	0.38	NS*	NS*
18	Sodium as Na	mg/l	200.00	204.00	122.30	NS*	NS*
19	Potassium as K	mg/l	3.58	3.83	BQL	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified, BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 17: Drinking Water Quality Monitoring Parameters for Vadinar Jetty and Port Colony at Vadinar.

Sr. No.	Parameter	Unit	Vadinar Jetty	Port Colony Vadinar	Acceptable Limits as per IS 10500: 2012	Permissible Limits in the absence of Alternate Source as per IS 10500: 2012
1	pH	-	7.42	7.38	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	249	250	500	2000
3	Turbidity	NTU	0.00	1.00	1	5
4	Odor	-	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	5	15
6	Conductivity	µs/cm	498	500	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	150.33	141.30	250	1000
9	Ca as Ca	mg/l	39.28	40.88	75	200
10	Mg as Mg	mg/l	44.23	62.69	30	100
11	Total Hardness	mg/l	280	360	200	600
12	Iron as Fe	mg/l	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.62	0.58	1	1.5
14	Sulphate as SO_4	mg/l	25.06	24.05	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	2.00	1.38	45	No Relaxation
17	Salinity	‰	0.27	0.25	NS*	NS*
18	Sodium as Na	mg/l	199.1	210.9	NS*	NS*
19	Potassium as K	mg/l	3.98	3.84	NS*	NS*
20	Manganese	mg/l	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

4.3 Results & Discussion

The colour of all drinking water samples was found Colourless and odour of the samples also agreeable. All parameters were found within the specified limit as per the Drinking water Standard.

pH

The pH is measure of the intensity of acidity or alkalinity and the concentration of hydrogen ion in water. At DPA Site the pH values for drinking water samples ranged from 7.27-7.59 and mean value was 7.41 while at Vadinar pH ranged from 7.38-7.42 and mean value was 7.40. All the sampling points showed pH values within the prescribed limit by Indian Standards.

Turbidity

The selected drinking water sample location turbidity range from 0-1NTU at all location of DPA and Vadinar in 1st December 2022 to 15th December 2022 of December. The Turbidity values were within the permissible limit at all sampling location prescribed limit by Indian standards.

Total Dissolved Solids (TDS)

Water has the ability to dissolve a wide range of inorganic and some organic minerals or salts such as potassium, calcium, sodium, bicarbonates, chlorides, magnesium, sulfates etc.

TDS values at DPA varied between 400-544 mg/l. The average TDS value was found 462.90 mg/l. The minimum value for TDS was 400 mg/l at Custom Building and maximum was 544.0 mg/l at Tuna Port while at Vadinar TDS ranged from 249-250 mg/l and mean was 249.5 mg/l. The TDS values were within the permissible limit at all sampling location prescribed limit by Indian standards.

Conductivity

Electrical Conductivity is the ability of a solution to transfer (conduct) electric current. Conductivity is used to measure the concentration of dissolved solids which have been ionized in a polar solution such as water. The conductivity in the samples collected during the 1st December 2022 to 15th December 2022 of December DPA ranged from 800.0 µs/cm at Custom Building to 1000.0 µs/cm at Tuna Port and mean value was 921.52 µs/cm while at Vadinar ranged from 498-500 µs/cm and mean was 499.0 µs/cm.

BOD

BOD value in the studied area of DPA and Vadinar was found Below Quantification Limit (<2.0 mg/l). IS 10500:2012 does not show any standard values for BOD in drinking water.

Chlorides

Excessive chloride concentration increase rates of corrosion of metals in the distribution system. This can lead to increased concentration of metals in the supply. The Chloride value in the studied area of DPA ranged from 115.26-210.47 mg/l. The mean value was 157.49 mg/l. The minimum chloride was 115.26 mg/l at F-Type colony and maximum was 210.47 mg/l at Tuna port while at Vadinar location chloride ranged from 115.26-210.47mg/l and mean was 157.49 mg/l. The Chloride was found within the Permissible limit of the Drinking Water Standard.

Calcium

Calcium is most abundant element on the earth crust and is very important for human cell physiology and bones. About 95% calcium in human body stored in bones and teeth. The high deficiency of calcium in humans may cause rickets, poor blood clotting, bones fracture etc. and the exceeding limit of calcium produced cardiovascular diseases.

The Calcium value in the studied area of DPA ranged from 33.67-49.7 mg/l. The mean value was 41.00 mg/l. The minimum calcium was 33.67 mg/l at P&C building and maximum was 49.7 mg/l at Tuna Port while at Vadinar location Calcium ranged from 33.67-49.7 and mean was 41.15 mg/l. All the locations had calcium within the prescribed limits of 75-200 mg/L.

Magnesium

The magnesium value in the studied area of DPA ranged from 23.81-73.39 mg/l. The mean value was 53.08 mg/l. The minimum magnesium was 23.81 mg/l at Custom Building and maximum was 73.39 mg/l at main gate north and workshop while at Vadinar location magnesium ranged from 44.23- 62.69 and mean was 53.46 mg/l. All the locations had magnesium within the prescribed limits of 30-100 mg/L.

Total Hardness

Total Hardness value in the studied area of DPA ranged from 200.0 mg/l at Port Colony to 400.0 mg/l at Main Gate, Guest House,Tuna Port & workshop and mean value was 326.67 mg/l while at Vadinar location total hardness ranged from 280.0-360.00 mg/l and mean was

320.0 mg/l. The values of total hardness were found within the Permissible limit of the Drinking Water Standard (200-600 mg/L). These results clear, that hardness of water is according to the IS standards and it is not harmful for local inhabitants.

Iron

Iron values in the studied area of DPA & Vadinar were Below Quantification Limit (0.009 mg/l) and hence well below the permissible limit as per Indian Standards are 0.3 mg/L.

Fluoride

Fluoride value in the studied area of DPA varied between 0.11-0.40 mg/l and mean was 0.29 mg/l. The minimum value was 0.11 mg/ at E-Type Quarter and maximum was 0.40 mg/l at Tuna port while at Vadinar location fluoride ranged from 0.58-0.62 mg/l and mean was 0.60 mg/l. The Fluoride values were well below the permissible limit as per Indian Standards is 1.0-1.5 mg/L. Moderate amounts lead to dental effects, but long-term ingestion of large amounts can lead to potentially severe skeletal problems.

Sulphate

Sulphate value in the studied area of DPA varied between 35.08- 62.64 mg/l and mean was 51.35 mg/l. The minimum value was 35.08 mg/ at School gopalpuri and maximum was 62.64 mg/l at Tuna port while at Vadinar location Sulphate ranged from 24.05- 25.06 mg/l and mean was 24.56 mg/l. All the sampling points showed Sulphate values within the prescribed limits by Indian Standards (200-400 mg/L). Sulphate content in drinking water exceeding the 400 mg/L imparts bitter taste.

Nitrites (NO_2) and Nitrates (NO_3)

The all values of Nitrite were found BQL (<0.05 mg/l) and Nitrate were well within the permissible limit of the Drinking water Standard.

Salinity

Salinity in drinking water in the present samples collected at DPA ranged from 0.21 ‰ F-type Quarter to 0.38 ‰ at Tuna port and average salinity was 0.29 ‰ while at Vadinar sampling location salinity ranged from 0.25-0.27 ‰. There are no prescribed Indian standards for salinity in Drinking water**.**

Sodium and Potassium Salts

Sodium values in the samples collected at DPA ranged from 122.3-278.5 mg/l and average was 196.04 mg/l while at Vadinar sodium ranged from 199.10- 210.9 mg/l and average was 205.0 mg/l . Potassium salts ranged at DPA ranged from 3.34-5.64 mg/l while average was 3.99 mg/l while at Vadinar sampling locations potassium were BQL (<2.0 mg/l). There are no prescribed limits of Sodium and Potassium in Indian standards for Drinking water**.**

Heavy Metals in Drinking Water

In the present study period drinking water samples were analyzed for Mn, Cr, Cu, Cd, As, Hg, Pb and Zn. All these heavy metals were well Below the Quantification limits prescribed by the Indian Standards.

Bacteriological Study

Analysis of the bacteriological parameter (E-coli and total coliform) at all location shows that Bacteria were not detectable. This shows that drinking water samples were safe for human consumption as per tested parameters.

4.4 Conclusions

These results were compared with permissible limits as prescribed in IS 10500:2012 – Drinking Water Specification. It was seen from the analysis data that during the study period at selected sampling location the water was safe for human consumption as per analyzed parameters at all drinking water monitoring stations.

5.0 Noise Level Monitoring

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. Noise Monitoring was done at 13 stations at Kandla, Vadinar and Township area.

5.1 Method of Monitoring

Sampling was done at all stations for 24-hour period. Data was recorded using automated sound level meter. The intensity of sound was measured in sound pressure level (SPL) and common unit of measurement is decibel (dB).

5.2 Results

Table 18: Noise Monitoring data for ten locations of Deendayal Port and three locations of Vadinar Port

Sr. No.	Location	Day Time Average Noise Level (SPL) in dB(A)	Night Time Average Noise Level (SPL) in dB(A)
	Sampling Time	**6:00 am to 10:00 PM pm**	**10:00PM to 6:00 AM**
1	Marine Bhavan	59.7	49.9
2	Nirman Building 1	68.5	50.0
3	Tuna Port	51.7	44.4
4	Main Gate North	61.4	48.8
5	West Gate I	68.1	54.2
6	Canteen Area	67.3	49.2
7	Main Road	68.6	51.4
8	ATM Building	65.8	47.1
9	Wharf Area /Jetty Area	69.8	60.7
10	Port & Custom Office	51.8	48.9
Vadinar Port			
11	Entrance Gate of Vadinar Port	54.0	49.5
12	Nr. Port Colony, Vadinar	61.2	55.9
13	Nr. Vadinar Jetty	53.4	49.0

5.3 Conclusions

Transportation systems are the main source of noise pollution in urban areas. Construction of buildings, highways, and roads cause a lot of noise, due to the usage of air compressors, bulldozers, loaders, dump trucks, and pavement breakers. Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships.

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. The Day Time Noise Level (SPL) in all 10 locations at Deendayal Port Authority ranged from 51.7 dB(A) to 69.8 dB(A) while at Vadinar port 3 location ranged from 53.4 dB(A) to 61.2 dB(A) which was within the permissible limits of 75 dB(A) for the industrial area for the daytime. The Night Time Average Noise Level (SPL) in all locations of Deendayal Port Authority ranged from 44.4 dB to 60.7 dB(A) while at Vadinar port ranged from 49.0 dB (A) to 55.9 dB(A) which was within the permissible limits of 70 dB(A) for the industrial area for the night time.

6.0 Soil Monitoring

Sampling and analysis of soil samples were withintaken at six locations within the study area (Deendayal Port and Vadinar Port) as a part of EMP. The soil sampling locations are initially decided based on the locations as provided in the tender document of the Deendayal Port.

Table No.:-19. Soil Sampling Location

Sr. No.	Name of Location	Location Code	Latitude	Longitude	Remarks
1.	Tuna Port	SL-1	22° 58' 10.18"N	70° 6' 3.7"E	Near main gate of Port
2.	IFFCO Plant	SL-2	23° 26' 8.37"N	70° 13' 4.4"E	10 m away from main gate
3.	Khori creek	SL-3	22° 58' 10.18"N	70° 6' 3.7"E	Sand from creek after tide
4.	Nakti Creek	SL-4	23° 2' 1.10"N	70° 9' 33.6"E	
5.	DPA admin site	SL-5	22° 26' 30.9"N	69° 40' 37.03"E	Vadinar
6.	DPA colony	SL-6	22° 23' 57.09"N	69° 42' 49.42"E	

6.1 Methodology

The soil samples were collected in the 1st December 2022 to 15th December 2022 of December 2022. The samples collected from the all locations are homogeneous representative of each location. At random locations were identified at each location and soil was dug from 30 cm below the surface. It was uniformly mixed before homogenizing the soil samples. The samples were filled in polythene bags, labeled in the field with number and site name and sent to laboratory for analysis.

6.2 Results

Table-20: Chemical Characteristics of Soil in the Study Area for Tuna port, IFFCO, Khori Creek, Nakti Creek, DPA admin site, DPA colony.

Sr. No.	Parameter	Unit	Station Name					
			SL1	SL2	SL3	SL4	SL5	SL6
			Tuna Port	IFFCO Plant	Khori Creek	Nakti Creek	DPA Admin Site	DPA Colony
			Near main gate of Port	10 m away from main	Sand from creek after tide		Vadinar	
1	Texture		Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	pH	-	7.40	7.10	7.90	6.80	6.96	7.10
3	Electrical Conductivity	µs/cm	22700.0	10260.0	33,900.00	10,080.0	307.0	389.0
4	Phosphorus	mg/kg	8	9.2	8.60	7.40	3.20	4.10
5	Moisture	%	2.2	2.9	1.40	2.50	3.20	4.32
6	Total Organic Carbon	%	3.8	1.6	2.80	4.20	1.80	2.00
7	Alkalinity	mg/kg	900.0	700.0	800.0	400.0	400.0	600.0
8	Total Nitrogen	%	BQL	BQL	BQL	BQL	BQL	BQL
9	Sulphate	mg/kg	790.00	888.00	972.00	752.00	46.0	59.0
10	Chloride	mg/kg	10582.0	4280.0	13,200.00	3,000.00	120.00	142.00
11	Calcium	mg/kg	1,042.00	1,709.00	6,813.00	3,206.00	1,444.00	1,468.00
12	Sodium	mg/kg	1711	1255.0	2,820.00	2,451.00	30.00	36.00
13	Potassium	mg/kg	591	634	707.00	416.00	4.60	5.60
14	Copper as Cu	mg/kg	28.8	39.2	21.60	12.40	63.80	74.10
15	Lead as Pb	mg/kg	25.1	7.8	10.90	BQL	BQL	BQL
16	Nickel as Ni	mg/kg	32.70	35.20	20.50	20.90	16.20	36.00
17	Zinc as Zn	mg/kg	81.3	78.40	150.90	35.10	20.60	81.30
18	Cadmium as Cd	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (TN: 0.001%, Cd: 1.0mg/kg)

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6.3 Discussion

- DPA Kandla soil sampling data shows that value of pH ranges from 6.8 at Natki Creek to 7.90 at Khari Creek while the average value of pH was 6.96 at DPA colony and 7.10 at DPA Admin Site in Vadinar sampling location
- The Electrical Conductivity of DPA Kandla soil sample ranged from 10080.0 µs/cm at Nakti Creek (Sand from creek after tide) to 33900.0 µs/cm at Khari creek and mean was 19235.0 µs/cm while Vadinar soil sampling location conductivity were 307.0 µs/cm at DPA Admin Site and 389.0 µs/cm at DPA Colony site.
- Total organic Carbon of DPA Kandla soil sample ranged from 1.6 % at IFFCO Plant to 4.20 % at Nakti Creek (Sand from creek after tide) and mean was 3.10 % while Vadinar soil sample were 2.0 % at DPA Colony and 1.80 % at DPA admin Site.
- The concentration of Phosphorus in the soil samples of DPA Kandla varies from 7.40 mg/kg at Nakti Creek (Sand from creek after tide) and 9.20 mg/kg at IIFCO Plant and mean was 8.30 mg/kg while the Vadinar soil sample for Phosphorus were 4.10 mg/kg at DPA Colony and 3.20 mg/kg at DPA Admin Site.
- Chloride in soil sample of DPA ranged from 3000.00 mg/kg at Nakti Creek (Sand from creek after tide) to 13200 mg/kg at Khari creek and mean was 7765.50 mg/kg while Vadinar soil sample were 140 mg/kg at DPA admin and 525 mg/kg at DPA Colony.
- The Concentration of Potassium in the soil samples of DPA Kandla ranged from 416 mg/kg at Nakti creek and 707 mg/kg at Khori Creek and mean was 587.0 mg/kg while the Vadinar soil sample for Potassium were 5.6 mg/kg at DPA Colony Site and 4.60 mg/kg at DPA Admin Site.
- The concentration of Sodium in the soil samples of DPA Kandla ranged from 1255.0 mg/kg at IFFCO plant and 2820.0 mg/kg at Khori Creek and mean was 2059.25 mg/kg while the Vadinar soil sample for Sodium were 36.00 mg/kg at DPA Admin Site and 30.0 mg/kg at DPA Colony.

These differences in NPK in soil at different locations are due to the dissimilar nature of soil at each of the locations. Samples SL# & SL4 (Khori Creek & Nakti Creek) where coastal soil; where as other locations are inland locations and have different chemical properties.

Heavy Metals in the Soil

Traces of Copper, Lead, Nickel and Zinc were observed in the soil samples collected from all the four locations of Deendayal Port Authority Kandla and two locations of Vadinar Port. Cadmium metal was below detection limit in the Soil.

6.4 Conclusion

The soils of Deendayal Port Authority Kandla and Vadinar Port appears to be neutral to basic with varying levels of Chloride, Sulphate, NPK and Calcium. As the nature of soil at different locations are different with respect to its proximity to the sea, the samples showed high degree of variations in their chemical properties.

7.0 Sewage Treatment Plant Monitoring

This involves safe collection of waste water (spent/used water) from wash areas, bathroom, industrial units, etc., waste from toilets of various buildings and its conveyance to the treatment plant and final disposal in conformity with the requirement and guidelines of State Pollution Control Board and other statutory bodies.

7.1 Methodology for STP Monitoring

To monitor the working efficiency of Sewage Treatment Plant (STP), STP Inlet and Outlet Samples were collected once a week. Locations selected are namely Gopalpuri Township, Deendayal Port and Vadinar. Samples were collected in 1 lit. Carboys and were analyzed in laboratory for various parameters.

A new STP with an improved capacity of 1 MLD is being constructed at Gopalpuri Colony.

Table No. 21. Sewage Treatment Plant

Sr. No.	Location of STP	Types of Treatment	STP Capacity	Treated water Utilization
1.	Gopalpuri Township	MBBR	450 KLD	Plantation and Gardening
2.	Deendayal Port, Kandla	MBBR	600 KLD	Discharge to marine through pipeline, Plantation, Gardening
3.	Vadinar Port Colony	MBBR	1.5 MLD	Plantation and Gardening

7.2 Results

Table 22: Sewage Water Monitoring at Kandla STP (1st Week)

Date of Sampling	03.12.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.46	7.62	6.5 - 8.5
2	Total Suspended Solids	mg/l	92	32	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	168	40.0	100
5	BOD @ 27 °C	mg/l	34.0	13.0	30
Aeration Tank					
6	MLSS	mg/l	88.0		
7	MLVSS	%	97.0		

Table 23: Sewage Water Monitoring at Kandla STP (2nd Week)

Date of Sampling	09.12.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.49	7.66	6.5 - 8.5
2	Total Suspended Solids	mg/l	82.0	37.0	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	120.0	50.0	100
5	BOD @ 27 °C	mg/l	37.0	16.0	30
Aeration Tank					
6	MLSS	mg/l	56.0		
7	MLVSS	%	85.0		

Table 24: Sewage Water Monitoring at Kandla STP (3rd Week)

Date of Sampling	15.12.2022

Sr. No.	Parameters	Unit	Results		CPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.14	7.09	6.5 - 8.5
2	Total Suspended Solids	mg/l	84.0	32.0	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	110.0	30	100
5	BOD @ 27 °C	mg/l	29.0	8.0	30
Aeration Tank					
6	MLSS	mg/l	14.0		
7	MLVSS	%	92.0		

Table 25: Sewage Water Monitoring at Gopalpuri STP (1st Week)

Date of Sampling	03.12.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.32	7.56	6.5 - 8.5
2	Total Suspended Solids	mg/l	80	58	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	109	79	100
5	BOD @ 27 °C	mg/l	31.0	21.0	30
Aeration Tank					
6	MLSS	mg/l	56.5		
7	MLVSS	%	85.0		

Table 26: Sewage Water Monitoring at Gopalpuri STP (2nd Week)

Date of Sampling	09.12.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.49	7.66	6.5 - 8.5
2	Total Suspended Solids	mg/l	96	20	100
3	Residual Chlorine	mg/l		<0.5	-
4	COD	mg/l	120	50.0	100
5	BOD @ 27 °C	mg/l	37.0	16.0	30
Aeration Tank					
6	MLSS	mg/l	30.0		
7	MLVSS	%	87.0		

Table 27: Sewage Water Monitoring at Gopalpuri STP (3rd Week)

Date of Sampling	15.12.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Gopalpuri STP I/L	Gopalpuri STP O/L	
1	pH	-	7.46	7.52	6.5 - 8.5
2	Total Suspended Solids	mg/l	96.0	42.0	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	109.0	50.0	100
5	BOD @ 27 °C	mg/l	33.0	16.0	30
Aeration Tank					
6	MLSS	mg/l	45.0		
7	MLVSS	%	87.0		

Table 28: Sewage Water Monitoring at Vadinar STP (1st Week)

Date of Sampling	03.12.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar STP O/L	
1	pH	-	7.49	7.30	6.5 - 8.5
2	Total Suspended Solids	mg/l	54.0	26.0	100
3	Residual Chlorine	mg/	-	<0.5	-
4	COD	mg/l	60.0	30.0	100
5	BOD @ 27 °C	mg/l	18.0	8.0	30

Table 29: Sewage Water Monitoring at Vadinar STP (2nd Week)

Date of Sampling	09.12.2022

Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar STP O/L	
1	pH	-	7.38	7.28	6.5 - 8.5
2	Total Suspended Solids	mg/l	39.6	20.3	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	50.0	30.0	100
5	BOD @ 27 °C	mg/l	12.0	6.0	30

Table 30: Sewage Water Monitoring at Vadinar STP (3rd Week)

Date of Sampling	15.12.2022

Sr. No.	**Parameters**	**Unit**	**Results**		**GPCB Prescribed Limit**
			Vadinar STP I/L	**Vadinar O/L**	
1	pH	-	7.31	7.29	6.5 - 8.5
2	Total Suspended Solids	mg/l	58.6	36.0	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	60.0	40.0	100
5	BOD @ 27 °C	mg/l	24.0	12.0	30

Table No. 31. General Standards for discharge of Environmental Pollutant Part-A

Sr. No.	**Parameter**	**Inland Surface Water**	**Land Irrigation**	**Marine Coastal Areas**
1.	pH	5.5-9.0	5.5-9.0	5.5-9.0
2.	Total Suspended Solids (mg/l)	100	200	100
3.	Residual Chlorine (mg/l)	1.0	-	1.0
4.	BOD (mg/l)	30	100	100
5.	COD (mg/l)	250	-	250

Source:CPCB

7.3 Results & Discussion

The STP Sample carried out to evaluate the efficiency and performance of the wastewater treatment plant at Gopalpuri, Kandla and Vadinar STP. The performance of these plants is an essential parameter to monitor because the treated sewage water is discharged for irrigation purposes and discharge into marine. Wastewater samples were collected from different unit operations of the plant i.e, the inlet, aeration tank and the final treated outlet. These samples were analyzed for various physico-chemical characteristics such as pH, TSS, Residual Chlorine, COD, BOD, MLSS and MLVS.

The final treated outlet observed pH values were within the allowed range at STP Gopalpuri, STP Kandla & STP Vadinar ranged from 7.32-7.63,7.39-7.66 & 7.28-7.49 respectively. The wastewater treatment makes it suitable for irrigation. These values are below the allowed limit of the GPCB. The final treated outlet observed Total suspended solid values at Gopalpuri, DPA Kandla & Vadinar ranged from 20.0-58.0 mg/l, 32.0-57.0 mg/l & 20.30-36.0 mg/l respectively. These values are below the allowed limit of the GPCB.The final treated outlet observed Residual Chlorine values were <0.5 at Gopalpuri, DPA Kandla & Vadinar. These values are below the allowed limit of the CPCB.The final treated outlet observed COD values were at Gopalpuri, DPA Kandla & Vadinar ranged from 30.0-79.0 mg/l, 30.0-50.0 mg/l & 30.0-40.0 mg/l respectively. These values are below the allowed limit of the CPCB. The main focus of wastewater treatment plants is supposed to reduce the BOD in the effluent discharged to natural waters. Wastewater treatment plants are designed to function as bacteria farms, where bacteria are fed oxygen and organic waste. The final treated outlet observed BOD values were at Gopalpuri, DPA Kandla & Vadinar ranged from 7.01-21.0 mg/l, 8.0-16.0 mg/l & 6.0-12.0 mg/l respectively. These values are below the allowed limit of the GPCB.

7.4 Conclusions: All parameters for STP outlet are within limit prescribed by CPCB. After the final treatment, it is found that the treated water is satisfactory.

8.0 Marine Water Monitoring

Marine Water Quality

The Forty Second Amendment to the Constitution in 1976 within scored the importance of 'green thinking'. Article 48A enjoins the state to protect and improve the environment and safeguard the forests and wildlife in the country. Further, Article 51A (g) states that the "fundamental duty of every citizen is to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures".

Policy Statement for Abatement of Pollution (1992) has suggested developing relevant legislation and regulation, fiscal incentives, voluntary agreements and educational programs and information campaigns. It emphasizes the need for integration by incorporating environmental considerations into decision making at all levels by adopting frameworks namely, pollution prevention at source, application of best practicable solution, ensure polluter pays for control of pollution, focus on heavily polluted areas and river stretches and involve public in decision-making. The National Conservation Strategy and Policy Statement on Environment and Development, (1992) aimed at "integrating environmental concerns with developmental imperatives to meet the challenges by redirecting the thrust of our developmental process so that the basic needs of our people could be fulfilled by making judicious and sustainable use of natural resources." The priorities mentioned in this policy document include the sustainable use of land and water resources, prevention and control of pollution and preservation of biodiversity.

The National Water Policy, (2002) contains provisions for developing, conserving, sustainable utilizing and managing this important water resources and need to be governed by national perspectives.

Sampling Stations

The monitoring of marine environment for the study of biological and ecological parameters was carried out on 05th & 06th October-2022 in harbor regions of DPA & Vadinar during Neap tide period of New moon phase of Lunar Cycle. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 12th & 16th October-2022 in harbor regions of DPA & Vadinar during Spring tide period first quarter of Lunar Cycle.

Plankton samples from sub surface layer was collected both during high tide period and low tide period from 3 water quality monitoring stations of DPA harbor area and two stations in Nakti creek and one station in Khori creek. The same sampling schedule was repeated during consecutive spring tide and neap tide in same 1st December 2022 to 15th December 2022. Plankton samples from sub surface layer was collected both during high tide period and low tide period from 1 water quality monitoring stations near Vadinar jetty area during spring tide and neap tide in this 1st December

2022 to 15th December 2022. Collected water samples were processed for estimation of Chlorophyll-a, Pheophytin- a, qualitative & quantitative evaluation of phytoplankton, qualitative & quantitative evaluation zooplanktons (density and their population).

Sampling Locations

Offshore monitoring requirement	Number of locations
Offshore Installations	3 in Kandla creek 2 in Nakti creek 1 in Khori creek 1 near Vadinar Jetty 1 near 1st SBM
Total Number of locations	**8**

8.1 Marine Water Quality and Results

Marine water quality of marine waters of Deendayal Port Harbor waters, Khori & Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each 1st December 2022 to 15th December 2022. The results of marine water quality from table no 32 to 39. *During low tide DPA-6 Nakti-II location monitoring was not possible due to non-availability of marine water.*

Table 32: Marine Water Quality Monitoring Parameters for Location Near DPA Colony

Sr. No.	Parameters	Unit	Kandla Creek Near DPA Colony (1)			
			23°0'58"N 70°13'22."E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.40	7.51	7.48	7.39
2	Color	-	agreeable	agreeable	agreeable	agreeable
3	Odor	-	agreeable	agreeable	agreeable	agreeable
4	Salinity	‰	32.1	31.7	30.7	29.8
5	Turbidity	NTU	46	39	42	46
6	Total Dissolved Solids	mg/l	52377.7	48868.0	42202.0	47413.0
7	Total Suspended Solids	mg/l	500	437	406.1	709.1
8	Total Solids	mg/l	52878	49304	42608	48122
9	DO	mg/l	5.3	5.2	5.5	5.4
10	COD	mg/l	86.0	84.0	82.0	86.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	2.53	2.01	0.99	0.91
13	Phosphate	mg/l	0.11	0.13	0.09	0.04
14	Sulphate	mg/l	3019.2	2893.9	3708.0	3658
15	Nitrate	mg/l	3.19	3.61	0.75	0.42
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	601.20	681.36	681.36	801.6
18	Magnesium	mg/l	1676.7	1555.2	1652.4	1628.1
19	Sodium	mg/l	9901.0	8291.0	8396.0	8699.0
20	Potassium	mg/l	316.2	310.2	391.0	395.0
21	Iron	mg/l	BQL	BQL	0.88	0.57
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 33: Marine Water Quality Monitoring Parameters for Location Near Passenger Jetty One at Kandla

Sr. No.	Parameters	Unit	Near passenger Jetty One (2)			
			23° 0'18 "N 70°13'31"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.42	7.39	7.52	7.33
2	Color	-	agreeable	agreeable	agreeable	agreeable
3	Odor	-	agreeable	agreeable	agreeable	agreeable
4	Salinity	‰	31.2	33.9	31.6	32.0
5	Turbidity	NTU	40	43	40	38
6	Total Dissolved Solids	mg/l	47345	53023	49279	47973
7	Total Suspended Solids	mg/l	351	663	860.9	976.8
8	Total Solids	mg/l	47696	53686	50140	48950
9	DO	mg/l	5	4.9	5.2	5
10	COD	mg/l	92.0	90.0	90.0	92.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	1.14	1.60	1.33	0.85
13	Phosphate	mg/l	0.34	0.16	0.33	0.19
14	Sulphate	mg/l	3006.7	4146.7	4072	3407
15	Nitrate	mg/l	12.18	3.52	1.17	4.36
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	641.28	601.20	641.28	601.2
18	Magnesium	mg/l	1749.6	1555.2	1725.3	1701
19	Sodium	mg/l	8871.0	7582.0	9247.0	9219.0
20	Potassium	mg/l	299.1	334.3	370.0	380.0
21	Iron	mg/l	0.47	BQL	1.76	0.30
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Nitrite: 0.05mg/lCu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 34: Marine Water Quality Monitoring Parameters for location Near Coal Berth

Sr. No.	Parameters	Unit	Near Coal Berth			
			22°59'12"N 70°13'40"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.52	7.32	7.58	7.66
2	Color	-	agreeable	agreeable	agreeable	agreeable
3	Odor	-	agreeable	agreeable	agreeable	agreeable
4	Salinity	‰	32.6	32.1	30.7	32.5
5	Turbidity	NTU	49	50	36	42
6	Total Dissolved Solids	mg/l	51431	49900	52201	47319
7	Total Suspended Solids	mg/l	469	550	624.8	821
8	Total Solids	mg/l	51900	50450	52826	48140
9	DO	mg/l	4.8	4.7	4.9	5.2
10	COD	mg/l	80.0	78.0	88.0	84.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	1.82	0.12	0.69	1.76
13	Phosphate	mg/l	0.31	0.64	0.12	0.61
14	Sulphate	mg/l	2731.1	1804	2981	3758
15	Nitrate	mg/l	7.64	4.70	2.68	4.70
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	721.44	561.12	761.52	561.12
18	Magnesium	mg/l	1530.9	1701	1701	1798.2
19	Sodium	mg/l	5451.0	7757.0	9245.0	9814.0
20	Potassium	mg/l	199.1	252.5	392.0	384.0
21	Iron	mg/l	BQL	BQL	BQL	1.34
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 35: Marine Water Quality Monitoring Parameters for location Khori creek at Kandla

Sr. No.	Parameters	Unit	Khori creek			
			Near 15/16 Berth			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.39	7.36	7.53	7.42
2	Color	-	agreeable	agreeable	agreeable	agreeable
3	Odor	-	agreeable	agreeable	agreeable	agreeable
4	Salinity	‰	33.5	31.7	30.3	30.7
5	Turbidity	NTU	42	44	40	46
6	Total Dissolved Solids	mg/l	52753	43459	46336	57920
7	Total Suspended Solids	mg/l	549	687	705.5	878
8	Total Solids	mg/l	53302	44146	47042	58798
9	DO	mg/l	4.6	5.1	5	4.8
10	COD	mg/l	90.0	94.0	92.0	96.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	1.72	2.61	1.39	1.18
13	Phosphate	mg/l	0.45	0.47	0.35	0.42
14	Sulphate	mg/l	2092.1	2555.7	3157	3170
15	Nitrate	mg/l	3.52	5.29	1.34	5.20
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	681.36	721.44	681.36	601.2
18	Magnesium	mg/l	1530.9	1628.1	1676.7	1701
19	Sodium	mg/l	6525.0	7297.0	7966.0	8696.0
20	Potassium	mg/l	308.1	296.8	382.0	377.0
21	Iron	mg/l	0.44	BQL	0.17	0.31
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	0.02
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 36: Marine Water Quality Monitoring Parameters for location Nakti Creek near Tuna Port

Sr. No.	Parameters	Unit	Nakti Creek Near Tuna Port			
			22°57'49."N 70° 7'0.67"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.48	7.44	7.53	7.41
2	Color	-	agreeable	agreeable	agreeable	agreeable
3	Odor	-	agreeable	agreeable	agreeable	agreeable
4	Salinity	‰	32.1	33.9	33.3	32.9
5	Turbidity	NTU	49	43	49	38
6	Total Dissolved Solids	mg/l	49694.3	56539	39315	41219
7	Total Suspended Solids	mg/l	424	421	406.8	768.7
8	Total Solids	mg/l	50118	56960	39722	41988
9	DO	mg/l	5.2	5	4.7	5.1
10	COD	mg/l	100.0	96.0	98.0	100.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	1.62	1.26	1.42	1.22
13	Phosphate	mg/l	0.41	0.11	0.46	0.12
14	Sulphate	mg/l	2718.5	3232.2	3445	3433
15	Nitrate	mg/l	2.85	2.68	5.12	1.69
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	521.04	480.96	801.6	641.28
18	Magnesium	mg/l	1798.2	1725.3	1628.1	1701
19	Sodium	mg/l	7075.0	8162.0	8655.0	7939.0
20	Potassium	mg/l	352.1	374.1	384.0	386.0
21	Iron	mg/l	BQL	0.33	0.34	0.18
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

Table 37: Marine Water Quality Monitoring Parameters for location Nakti Creek Near NH-8A at Kandla

Sr. No.	Parameters	Unit	Nakti Creek Near NH-8A			
			23° 02'01"N 70° 09'31"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.58	Sampling not possible during Low Tide	7.48	Sampling not possible during Low Tide
2	Color	-	agreeable		agreeable	
3	Odor	-	agreeable		agreeable	
4	Salinity	‰	33.0		32.5	
5	Turbidity	NTU	40		42	
6	Total Dissolved Solids	mg/l	46423		57638	
7	Total Suspended Solids	mg/l	787		495.9	
8	Total Solids	mg/l	47210		58134	
9	DO	mg/l	4.8		4.8	
10	COD	mg/l	100.0		110.0	
11	BOD	mg/l	BQL		BQL	
12	Silica	mg/l	1.56		0.16	
13	Phosphate	mg/l	0.35		0.46	
14	Sulphate	mg/l	3507.8		4961	
15	Nitrate	mg/l	5.71		3.52	
16	Nitrite	mg/l	BQL		BQL	
17	Calcium	mg/l	601.20		681.36	
18	Magnesium	mg/l	1579.5		1725.3	
19	Sodium	mg/l	9287.0		8528.0	
20	Potassium	mg/l	364.5		427.0	
21	Iron	mg/l	BQL		0.54	
22	Chromium	mg/l	BQL		BQL	
23	Copper	mg/l	BQL		BQL	
24	Arsenic	mg/l	BQL		BQL	
25	Cadmium	mg/l	BQL		0.01	
26	Mercury	mg/l	BQL		BQL	
27	Lead	mg/l	BQL		BQL	
28	Zinc	mg/l	BQL		BQL	

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l).

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Table 38: Marine Water Quality Monitoring Parameters for locations Nr. Vadinar Jetty

Sr. No.	Parameters	Unit	Nr.Vadinar Jetty			
			22°26'25.26"N 69°40'20.41"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.49	7.39	7.59	7.54
2	Color	-	agreeable	agreeable	agreeable	agreeable
3	Odor	-	agreeable	agreeable	agreeable	agreeable
4	Salinity	‰	32.6	33.5	31.2	31.6
5	Turbidity	NTU	37	45	40	39
6	Total Dissolved Solids	mg/l	53031	53126	46806	40112
7	Total Suspended Solids	mg/l	377	348	316.3	330.1
8	Total Solids	mg/l	53408	53474	47122	40442
9	DO	mg/l	4.6	4.5	4.9	5.1
10	COD	mg/l	98.0	96.0	96.0	92.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.38	0.55	0.36	0.28
13	Phosphate	mg/l	0.15	0.11	0.33	0.19
14	Sulphate	mg/l	2956.6	3232.2	3683	3645
15	Nitrate	mg/l	1.51	1.85	1.00	2.43
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	721.44	561.12	721.44	561.12
18	Magnesium	mg/l	1458	1506.6	1652.4	1798.2
19	Sodium	mg/l	7157.0	8212.0	7810.0	8912.0
20	Potassium	mg/l	318.3	317.4	452.0	456.0
21	Iron	mg/l	BQL	BQL	BQL	BQL
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	0.30	BQL	0.77	0.45

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l, Zinc-0.1 mg/l).

Table 39: Marine Water Quality Monitoring Parameters for locations Nr. Vadinar SPM

Sr. No.	Parameters	Unit	Nr. Vadinar SPM			
			22°30'56.15"N 69°42'12.07"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.30	7.22	7.56	7.44
2	Color	-	agreeable	agreeable	agreeable	agreeable
3	Odor	-	agreeable	agreeable	agreeable	agreeable
4	Salinity	‰	31.7	32.6	32.9	32.5
5	Turbidity	NTU	42	48	46	48
6	Total Dissolved Solids	mg/l	53437	51595	44012	54136
7	Total Suspended Solids	mg/l	283	281	348.1	364.1
8	Total Solids	mg/l	53720	51876	44360	54500
9	DO	mg/l	4.7	4.5	5.4	5.3
10	COD	mg/l	98.0	100.0	96.0	94.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.44	0.24	0.34	0.30
13	Phosphate	mg/l	0.10	0.12	0.46	0.28
14	Sulphate	mg/l	3094.4	3608	3745	4008
15	Nitrate	mg/l	4.70	2.77	4.95	2.10
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	801.60	681.36	641.28	721.44
18	Magnesium	mg/l	1433.7	1482.3	1676.7	1603.8
19	Sodium	mg/l	6329.0	6047.0	9131.0	8526.0
20	Potassium	mg/l	329.1	307.7	413.0	441.0
21	Iron	mg/l	BQL	BQL	BQL	BQL
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	0.25	BQL	0.50	BQL

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l,Cu-0.1 mg/l, As-0.1mg/l, Hg-0.01 mg/l,Zinc-0.1 mg/l)

8.2 Results & Discussion for Marine water samples

Marine water quality of Deendayal Port Harbor waters, Khori and Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each 1st December 2022 to 15th December 2022. The Heavy metal analyzed and mostly found below quantification limit.

pH

During spring tide, the pH values was ranged from 7.32-7.58 at DPA Kandla and 7.22-7.49 at Vadinar while during Neap Tide pH values was ranged from 7.33-7.66 at DPA Kandla and 7.44-7.59 at Vadinar.

Color and Odor

All marine samples for Odor and Color were found agreeable at all sampling locations.

Turbidity

During spring tide, the Turbidity values was ranged from 39-50 NTU at DPA Kandla and 37-48 NTU at Vadinar while during Neap Tide Turbidity values was ranged from 36-49 NTU at DPA Kandla and 39-48 NTU at Vadinar. Turbidity is the amount of particulate matter that is suspended in water. Turbidity measures the scattering effect that suspended solids have on light: the higher the intensity of scattered light, the higher the turbidity (Yap et al, 2011). Materials that cause water to be turbid include clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, plankton and microscopic organisms (Lawler, 2004). The turbidity affects the amount of light penetrating to the plants for photosynthesis.

Total Dissolved Solids (TDS)

TDS values in the studied area during Spring Tide varied between 43458.90–56539.50 mg/l at DPA Kandla and 51594.70–53436.70 mg/l at Vadinar while during Neap Tide TDS values was varied 39315.0-57920.0 mg/l at DPA Kandla and 40111.90–54135.90 mg/l at Near Vadinar.

Calcium

Calcium value in the studied area during Spring Tide varied between 480.96-721.44mg/l at DPA Kandla and 561.12-801.60 mg/l at Vadinar while during Neap Tide calcium values between 561.12-801.60 mg/l at DPA Kandla and 561.12-721.44mg/l at Vadinar.

Magnesium

Magnesium value in the studied area during Spring Tide varied between 1530.90-1798.20 mg/l at DPA Kandla and 1433.70-1506.60 mg/l at Vadinar while during Neap Tide magnesium values between 1628.10-1798.20 mg/l at DPA Kandla and 1603.80-1798.20 at Vadinar. Calcium and magnesium both play an important role in antagonizing the toxic effects of various ions and neutralizing the excess acid produced (Narayan R. et. al., 2007)

Nitrate

Nitrate value in the studied area during Spring Tide varied between 2.68-12.18 mg/l at DPA Kandla and 1.51-4.70 mg/l at Vadinar while during Neap Tide Nitrate values between 0.42-5.2 mg/l at DPA Kandla and 1.0-4.95 at Vadinar.

The variations were observed due to variation in phytoplankton excretion, oxidation of ammonia, reduction of nitrate and by recycling of nitrogen and bacterial decomposition of planktonic detritus (Asha and Diwakar, 2007).

Iron

Iron values in the studied area during Spring Tide ranged from 0.33-0.47 mg/l at DPA Kandla and at Vadinar were BQL (<0.10) while during Neap Tide Iron values ranged from 0.17-1.76 mg/l at DPA Kandla and 0.24-0.31 mg/l at Vadinar.

Sulphates

Sulphate values in the studied area during Spring Tide ranged from 1804-4146.70 mg/l at DPA Kandla and 2956-3608.0 mg/l at Vadinar while during Neap Tide the Sulphate values was varied 2981-4961 mg/l at DPA Kandla and 3645-4008mg/l at Vadinar.

Salinity

Salinity values in the studied area during Spring Tide varied ranged 31.23-33.95 ‰ at DPA Kandla and 31.69 to 33.50 ‰ at Vadinar while during Neap Tide the Salinity values was varied 29.84 to 33.35 ‰ at DPA Kandla and 31.15 to 32.91 ‰ at Vadinar.

Sodium and Potassium Salts

During Spring Tide the Sodium values ranged from 5451-9901.0 mg/l at DPA Kandla & 6047.0-8212.0 mg/l at Vadinar and Potassium salts ranged from 199-374.10mg/l at DPA Kandla & 307.70-329.10mg/l at Vadinar while during Neap Tide the Sodium values was

ranges from 7939-9814 mg/l at DPA Kandla & 7810-9131 mg/l at Vadinar and Potassium salts ranged from 370-427 mg/l at DPA Kandla & 413-456 mg/l at Vadinar.

DO

The DO refers to the amount of oxygen dissolved in the water and it is particularly important in limnology {(aquatic ecology) (Weiss 1970)}. The fate and behavior of DO is of critical importance to marine organisms in determining the severity of adverse impacts (Best et al. 2007). The major factor controlling dissolved oxygen concentration is biological activity: photosynthesis producing oxygen while respiration and nitrification consume oxygen (Best et al. 2007). From the studied samples, DO in marine water during Spring Tide was found in ranges from 4.6-5.30 mg/l at DPA Kandla and 4.50-4.70 mg/l at Vadinar while during Neap Tide 4.70-5.50 mg/l at DPA Kandla and 4.90-5.40 mg/l at Vadinar.

BOD

BOD in marine water at all sampling location in the studied samples were found BQL (<2.0 mg/l).

Heavy Metals in Marine Water

In the present study period marine water samples were analyzed for Cr, Cu, Cd, As, Hg, Pb and Zn. Maximum heavy metals parameters were well Below the Quantification limits.

9.3 Conclusion

In the present study period marine water samples were analyzed and found inline as per Primary Water Quality criteria for class-IV WATERS (For Harbour Waters).

9.0 Marine Sediments

The deep-sea ocean floor is made up of sediment. This sediment is composed of tiny particles such as fine sand, silt, clay, or animal skeletons that have settled on the ocean bottom. Over long periods of time, some of these particles become compressed and form stratified layers. Scientists that study these layers look at particle size, particle composition, and origin to help them create historical records of the deep ocean floor. This process is called weathering. Weathering can be either mechanical or chemical. Mechanical weathering can occur as ice, wind, or water wears away the rock's surface. Chemical weathering can occur as rocks are dissolved by a chemical such as acid rain. The particles created as a result of weathering are called terrigenous sediments. These particles are transported to the ocean by wind and by rivers and streams. Once the particles enter the ocean, they are dispersed by waves, currents, and tides. The heaviest and largest particles that reach the oceans, such as sand, settle very quickly to the bottom as a result of gravity. Sand is deposited near the coast whereas the smaller silt and clay particles are transported farther distances offshore before they settle to the bottom. Sediments are an important component of aquatic ecosystems because they provide nutrients and habitat for aquatic organisms (Benhamed et al. 2016). However, human activities result in accumulation of toxic substances such as heavy metals in marine sediments. Heavy metals are well-known environmental pollutants due to their toxicity, persistence in the environment, and bioaccumulation. Metals affect the ecosystem because they are not removed from water by self-purification, but accumulate in sediments and enter the food chain (Astakhov et al. 2015).

Sediment samples were collected with Van Veen Grab from the six locations in Kandla Port Waters and two locations in Vadinar Port. Benthic surface grab samplers look like giant metal jaws. They dig into the bottom and take a bite of the sediment. These samplers are good for collecting softer, sandy or silty sediments that do not contain rocks. A box corer is a cross between a surface sampler and a sediment corer. It is a special device that is used to collect an undisturbed sample of the very top surface layers and the sediment withineath. Samples were collected and preserved in silver foil in ice box to prevent the contamination/decaying of the samples.

10.1 Results

The Sediment Quality results are given in below from table no. 40 & 41.

Table 40: Results of Analysis of Sediment of Kandla & Vadinar Port (Neap Tide)

Sr. No.	Parameters	Unit	DPA – 1	DPA - 2	DPA - 3	DPA - 4	DPA - 5	Jetty	SPM
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	0.93	0.70	0.86	0.73	0.40	0.64	0.76
3	Organic Carbon	mg/kg	0.37	0.44	0.54	0.40	0.50	0.37	0.44
4	Inorganic Phosphate	mg/kg	98.00	101.00	80.00	86.00	100.00	90.00	94.00
5	Moisture	%	22.80	12.40	16.00	18.80	20.24	21.10	24.50
6	Aluminum	mg/kg	ND	ND	ND	ND	ND	ND	ND
7	Silica	mg/kg	6.80	7.20	6.40	7.10	6.20	7.00	8.20
8	Phosphate	mg/kg	11.23	14.49	18.16	10.07	10.45	100.00	197.00
9	Sulphate	mg/kg	740.00	823.00	590.00	463.00	496.00	800.00	390.00
10	Nitrite	mg/kg	0.12	0.10	0.11	0.12	0.11	0.11	0.11
11	Nitrate	mg/kg	1.11	3.8	19.01	26.6	36.1	BQL	BQL
12	Calcium	mg/kg	1442.00	2125.00	1844.00	1783.00	1623.00	1783.00	2204.00
13	Magnesium	mg/kg	1178.00	1968.00	1628.00	1603.00	874.00	1530.00	1931.00
14	Sodium	mg/kg	3434.00	4319.00	1656.00	2860.00	2525.00	3493.00	3231.00
15	Potassium	mg/kg	486.0	520.0	436.0	520.0	102.0	595.00	701.00
16	Chromium	mg/kg	56.30	44.30	42.60	52.00	41.40	64.00	43.10
17	Nickel	mg/kg	25.00	20.90	18.30	24.30	19.20	31.10	18.30
18	Copper	mg/kg	14.20	11.90	11.50	13.30	11.40	26.20	14.30
19	Zinc	mg/kg	40.30	38.40	29.10	37.50	36.40	44.10	30.10
20	Cadmium	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
21	Lead	mg/kg	4.70	4.20	3.80	5.80	3.90	4.60	4.80
22	Mercury	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
23	Arsenic	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL

*ND - Not Detected, BQL: Below Quantification Limit (NO3:10.0mg/kg, Cd: 1.0mg/kg, Hg: 1.0mg/kg, As: 1.0mg/kg).

Table 41 : Results of Analysis of Sediment of Kandla & Vadinar Port (Spring Tide)

Sr. No.	Parameters	Unit	DPA – 1	DPA - 2	DPA - 3	DPA - 4	DPA - 5	Jetty	SPM
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	1.13	0.66	0.76	0.76	1.13	1.33	1.04
3	Organic Carbon	mg/kg	0.65	0.38	0.44	0.4	0.65	0.77	0.60
4	Inorganic Phosphate	mg/kg	92.00	80.00	100.00	89.00	106.00	96.00	100.00
5	Moisture	%	4.20	6.00	3.20	1.80	2.60	3.30	4.20
6	Aluminum	mg/kg	ND	ND	ND	ND	ND	ND	ND
7	Silica	mg/kg	7.00	6.80	7.20	6.40	8.80	9.60	10.00
8	Phosphate	mg/kg	620.00	542.00	444.00	682.00	481.00	510.00	600.00
9	Sulphate	mg/kg	810.00	648.00	498.00	333.00	421.00	658.00	398.00
10	Nitrite	mg/kg	0.11	0.12	0.10	0.11	0.11	0.10	0.11
11	Nitrate	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
12	Calcium	mg/kg	2104.00	2184.00	2364.00	1783.00	2184.00	1783.00	1663.00
13	Magnesium	mg/kg	1798.00	2320.00	1652.00	2876.00	1931.00	1530.00	1615.00
14	Sodium	mg/kg	1711.00	1255.00	2820.00	2451.00	1430.00	309.00	258.00
15	Potassium	mg/kg	41.30	414.20	55.70	518.70	165.20	143.0	110.0
16	Chromium	mg/kg	52.30	34.20	75.50	60.00	42.30	62.90	54.50
17	Nickel	mg/kg	26.80	17.70	41.10	31.50	21.70	31.50	28.30
18	Copper	mg/kg	11.90	9.30	19.00	14.50	10.40	18.30	15.20
19	Zinc	mg/kg	36.90	32.90	58.50	49.00	29.10	45.40	56.20
20	Cadmium	mg/kg	BQL	BQL	BQL	BQL	BQL	0.30	BQL
21	Lead	mg/kg	4.80	3.70	9.60	7.00	5.50	6.40	6.10
22	Mercury	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
23	Arsenic	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL

*ND - Not Detected, BQL: Below Quantification Limit (NO3:10.0 mg/kg,Cd: 1.0 mg/kg, Hg: 1.0mg/kg, As: 1.0mg/kg)

9.2 Discussion of Marine Sediment samples

Marine Sediments of Deendayal Port Harbor waters, Khori and Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each 1st December 2022 to 15th December 2022. The Heavy metal analyzed and found below quantification limit.

9.3 Conclusion

The sediment types are majority Sandy loamy. Also, maximum heavy metals parameters found below Quantification limit wise, Pb, Cd, Hg, As, Nitrate and Al was not Detected.

10.0 INTRODUCTION:

10.1 Sampling Stations: The monitoring of marine environment for the study of biological and ecological Parameters was carried out on 01st December 2022 in harbour region of DPT at Kandla Creek, and on 02nd December 2022 in creeks near by the port during Neap tide. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 08th December, 2022 in harbour region of DPT at Kandla Creek and on 09th December, 2022 in creeks near by the port during spring tidal condition.

Plankton samples from sub surface layer was collected both during high tide period and low tide period from 3 water quality monitoring stations of DPA harbour area and two stations in Nakti creek and one station in Khori creek. Sampling at second sampling station of Nakti creek was possible only during high tide period.

Plankton samples from sub surface layer were collected during high tide period and low tide period from monitoring station near Vadinar jetty at Path Finder Creek during Neap tide on 01/12/2022 and Spring tide period on 08/12/2022. Collected water samples were processed for estimation of Chlorophyll- a, Pheophytin- a, qualitative and quantitative evaluation of phytoplankton, qualitative and quantitative evaluation of zooplankton density and their population.

TABLE 42. SAMPLING LOCATIONS

monitoring requirement	Number of locations
Kandla creek Nakti creek Khori Creek Vadinar jetty SPM	3 in Kandla creek 2 in Nakti creek 1 in Khori creek 1 near Vadinar Jetty 1 near I stSPM
Total Number of locations	**8**

Sampling methodology adopted:

A marine sampling is an estimation of the body of information in the population. The theory of the sampling design is depending upon the within lying frequency distribution of the population of interest. The requirement for useful water sampling is to collect a representative sample of suitable volume from the specified depth and retain it free from contamination during retrieval.

50 litres of the water sample were collected from Sub surface by using bucket. From the collected water sample 1 litres of water sample was taken in an opaque plastic bottle for chlorophyll estimation, thereafter plankton samples were collected by using filtration assembly with Nylobolt cloth of 20µm mesh size.

Samples Processing for chlorophyll estimation:

Samples for chlorophyll estimation were preserved in ice box on board in darkness to avoid degradation in opaque container covered with aluminum foil. Immediately after reaching the shore after sampling, 1 litre of collected water sample was filtered through GF/F filters (pore size 0.45 µm) by using vacuum filtration assembly. After vacuum filtration the glass micro fiber filter paper was grunted in tissue grinder, macerating of glass fiber filter paper along with the filtrate was done in 90% aqueous Acetone in the glass tissue grinder with glass grinding tube. Glass fiber filter paper will assist breaking the cell during grinding and chlorophyll content was extracted with 10 ml of 90% Acetone, within cold dark conditions along with saturated magnesium carbonate solution in glass screw cap tubes. After an extraction period of 24 hours, the samples were transferred to calibrated centrifuge tubes and adjusted the volume to original volume with 90% aqueous acetone solution to make up the evaporation loss. The extract was clarified by using centrifuge in closed tubes. The clarified extracts were then decanted in clean cuvette and optical density was observed at wavelength 664, 665 nm. By using corrected optical density, Chlorophyll-a value was calculated as given in (APHA, 1998).

PLANKTON:

The entire area open water in the sea is the pelagic realm. Pelagic organisms live in the open sea. In contrast to the pelagic realm, the benthic realm comprises organisms and zone of the bottom of the sea. Vertically the pelagic realm can be dividing into two zones based on light penetration; upper photic or euphotic zone and lower dark water mass, aphotic zone below the photic zone.

The term plankton is a general term for organisms which have such limited powers of locomotion that they are at the mercy of the prevailing water movement. Plankton is subdivided to phytoplankton and zooplankton. Phytoplankton are free floating organisms that are capable of photosynthesis and zooplankton are the various free-floating animals. Pelagic zone, represents the entire ocean water column from the surface to the deepest depths, is home to a diverse community of organisms. Differences in their locomotive ability categorize the organisms in the pelagic realm into two, ***plankton*** and ***nekton*** (Lalli and Parsons, 1997). ***Plankton*** consists of all organisms drifting in the water and is unable to swim against water currents, whereas ***Nekton*** includes organisms having strong locomotive power. Ecological studies on the plankton community, which form the base of the aquatic food chain, help in the better withinstanding of the dynamics and functioning of the marine ecosystem. The term 'Plankton' first coined by Victor Hensen (1887), Plankton, (Greek word: *planktos* meaning "passively drifting or wandering") is defined as drifting or free-floating organisms that inhabit the pelagic zone of water. Based on their mode of nutrition planktonic organisms are categorised into phytoplankton (organisms having an autotrophic mode of nutrition) and zooplankton (organisms having a heterotrophic mode of nutrition).

Phytoplankton in the marine environment:

Phytoplankton are free floating unicellular, filamentous and colonial eutrophic organisms that grow in aquatic environments whose movement is more or less dependent upon water currents. These micro flora acts as primary producers as well as the basis of food chain, source of protein, bio-purifier and bio-indicators of the aquatic ecosystems of which diverse array of the life depends. They are considered as an important component of aquatic flora, play a key role in maintaining equilibrium between abiotic and biotic components of aquatic ecosystem.

The phytoplankton includes a wide range of photosynthetic and phototrophic organisms. Marine phytoplankton is mostly microscopic and unicellular floating flora, which are the primary producers that support the pelagic food-chain. The two most prominent groups of phytoplankton are Diatoms (Bacillariophyceae) and Dinoflagellates (Dinophyceae). The phytoplankton those normally captured in the net from the Gulf of Kutch is normally dominated by these two major groups; Diatoms and Dinoflagellates. Phytoplankton also include numerous and diverse collection of extremely small, motile algae which are termed micro flagellates (naked flagellates) as well as and Cyanophytes (Blue-green algae).

Algae are an ecologically important group in most aquatic ecosystems and have been an important component of biological monitoring programs. Algae are ideally suited for water quality assessment because they have rapid reproduction rates and very short life cycles, making them valuable indicators of short-term impacts.

Aquatic populations are impacted by anthropogenic stress, resulting in a variety of alterations in the biological integrity of aquatic systems. Algae can serve as an indicator of the degree of deterioration of water quality, and many algal indicators have been used to assess environmental status.

Zooplankton in the marine environment:

Zooplankton includes a taxonomically and morphologically diverse community of heterotrophic organisms that drift in the waters of the world's oceans. Qualitative and quantitative studies on zooplankton community are a prerequisite to delineate the ecological processes active in the marine ecosystem. Zooplankton community plays a pivotal role in the pelagic food web as the primary consumers of phytoplankton and act as the food source for organisms in the higher trophic levels, particularly the economically essential groups such as fish larvae and fishes. They also function in the cycling of elements in the marine ecosystem. The dynamics of the zooplankton community, their reproduction, and growth and survival rate are all significant factors determining the recruitment and abundance of fish stocks as they form an essential food for larval, juvenile and adult fishes (Beaugrand et al., 2004). Zooplankton grazing in the marine environment controls the primary Production and helps in determining the pelagic ecosystem (Banse, 1995). Through grazing in surface waters and following the production of sinking faecal matters and also by the active transportation of dissolved and particulate matter to deeper waters via vertical migration, they help in the transport of

organic carbon to deep ocean layers and thus act as key drivers of 'biological pump' in the marine ecosystem. Zooplankton grazing and metabolism also, transform particulate organic matter into dissolved forms, promoting primary producer community, microbial demineralization, and particle export to the ocean's interior.

The categorization of zooplankton into various ecological groups is based on several factors such as duration of planktonic life, size, food preferences and habitat. As they vary significantly in size from microscopic to metazoic forms, the classification of zooplankton based on size has paramount importance in the field of quantitative plankton research.

Based on the duration of planktonic life, zooplankton are categorized into Holoplankton (organisms which complete their entire lifecycle as plankton) and Meroplankton (organisms which are planktonic during the early part of their lives such as the larval stages of benthic and nektonic organisms). Tychoplankton are organisms which live a brief planktonic life, such as the benthic crustaceans (Cumaceans, mysids, isopods) which ascend to the water column at night for feeding and certain ectoparasitic copepods, they leave the host and spend their life as plankton during their breeding cycle.

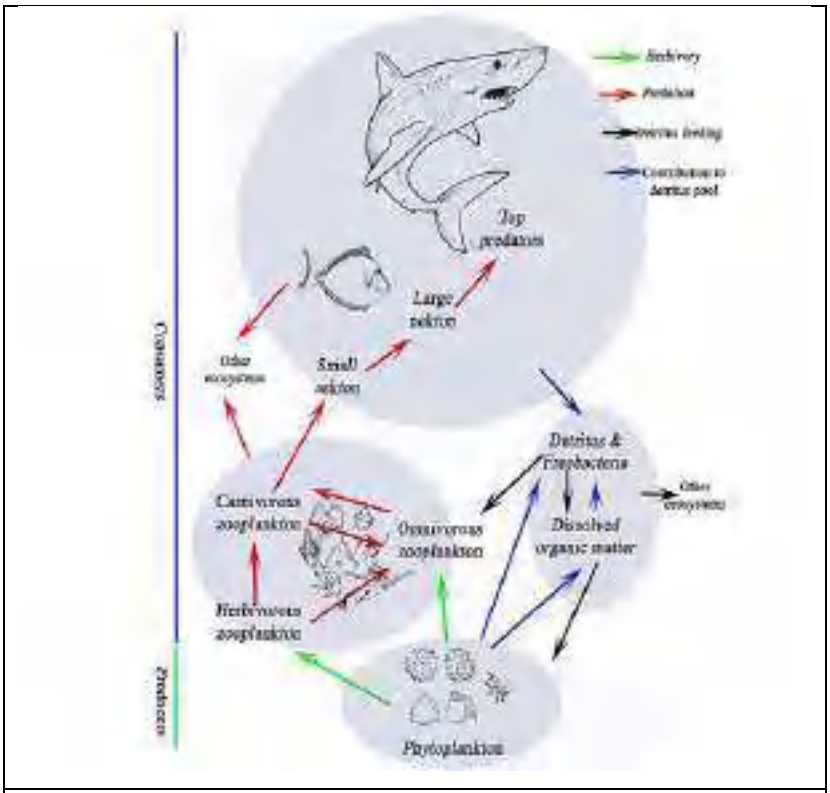
Zooplankton can be subdivided into holoplankton, i.e., permanent members of the plankton (e.g., Calanoid copepods), and meroplankton, i.e., temporary members in the plankton e.g., larvae of fish, shrimp, and crab). The meroplankton group consists of larval and young stages of animals that will adopt a different lifestyle once they mature. In contrast to phytoplankton which consist of a relatively smaller variety of organisms, Zooplankton are extremely divers, consist of a host of larval and adult forms representing many animal phylum.

Among the zooplankton one group always dominate than others; members of sub class copepods (Phylum Arthropoda) and Tintinnids (Phylum Protozoa) among the net planktons. These small animals are of vital importance in marine ecosystem as one of the primary herbivores animals in the sea, and it is they provide vital link between primary producer (autotrophs) and numerous small and large marine consumers.

As their community structure and function are highly susceptible to changes in the environmental conditions regular monitoring of their distribution as well as their interactions with various physicochemical parameters is inevitable for the sustainable management of the ecosystem (Kusum et al., 2014). Of all the marine zooplankton groups, copepods mainly Calanoid copepods are the dominant groups in marine subtropical and tropical waters and exhibit considerable diversity in morphology and habitats they occupy (Madhupratap, 1991 ;)

It has been well established that potential of pelagic fishes viz. finfishes, crustaceans, molluscs and marine mammals either directly or indirectly depend on zooplankton. The herbivorous zooplanktons are efficient grazers of the phytoplankton and are referred to as living machines transforming plant

material into animal tissue. Hence, they play an essential role as the intermediaries for nutrients/energy transfer between primary and tertiary trophic levels. Due to their large density, shorter lifespan, drifting nature, high group/species diversity and different tolerance to the stress, they used as the indicator organisms for the physical, chemical and biological processes in the aquatic ecosystem (Ghajbhiye, 2002).



Simplified marine food web

Spatial distribution of Plankton:

A characteristic of plankton population is that they tend to occur in patches, which are varying spatially on a scale of few meters to far as few kilometres in distance. They also vary in time scale, season as well as vertically in the water column. It is this patchiness and its constant changes in time and spot, that has made it so difficult for plankton biologist to learn about the ecology of plankton. The biological factors that causes this patchiness is due to the ability of zooplankton to migrate vertically and graze out the phytoplankton at a rapid rate that can create patchiness. Similarly, the active swimming ability by certain zooplankton organisms can cause to aggregate in dense group.

At its most extreme, because the water in which plankton is suspended is constantly moving, each sample taken by the plankton biologists remain a different volume of water, so each sample is unique and replicate does not exist. Physical factors contribute to this type of patchiness include light intensity, nutrients and density gradients in the water column.

Phytoplankton in particular tends to be unequally distributed vertically, which leads to the existence of different concentration of a chlorophyll value between photic zone and below the photic zone.

Methodology adopted for Plankton sampling:

Mixed plankton sample were obtained from the sub surface layer at each sampling locations by towing the net horizontally with the weight. After a tow of about 15-30 minutes, plankton net was pulled up and washed down to the tail and the plankton adhered to plankton net is collected in the collection bucket at the bottom by springing outer and inner surface of the net with sea water, while the net was hanging with the mouth upward. For quantitative evaluation 50 L water samples were collected from subsurface layer and filtered through 20 µm mesh size net by using bucket and filtration assembly.

Preservation and storage:

Both filtered plankton and those collected from the plankton net were preserved with 5% buffered formalin and stored in 1L plastic container for further processing in the laboratory.

Sample concentration:

The collected plankton samples were concentrated by using centrifuge and made up to 50 ml with 5% formalin -Glycerine mixture.

Taxonomic evaluation:

Before processing, the sample was mixed carefully and a subsample was taken with a calibrated Stempel-pipette. 1 ml of the concentrated plankton samples were transferred on a glass slide with automatic pipette. The plankton sample on the glass slides were stained by using Lugol's iodine and added glycerine to avoid drying while observation. The plankton samples were identified by using Labex triangular Research microscope with photographic attachment. Microphotographs of the plankton samples were taken for record as well as for confirming the identification. The bigger sized zooplankton was observed through dissecting stereomicroscope with magnification of 20-30 x. Plankton organisms in the whole slide were identified to the lowest taxon possible. A thorough literature search was conducted for the identification of the different groups of phytoplankton and zooplankton that were encountered.

Cell counts by drop count method:

The common glass slide mounted with a 1ml of concentrated phytoplankton/zooplankton sample in glycerol and covered with cover slip 22 mm x 60 mm was placed within the compound microscope provided with a mechanical stage. The plankton was then counted from the microscopic field of the left top corner of the slide. Then slide is moved horizontally along the right side and plankton in each microscopic field was thus counted. When first microscopic field row was finished the next consecutive row was adjusted using the mechanical device of the stage. In this way all the plankton present in entire microscopic field are counted. From this total number in 1ml of the concentrated

plankton, total amount of phytoplankton in the original volume of sample filtered was calculated as units/L and Zooplankton as N/m^3

BENTHIC ORGANISMS:

Benthos is those organisms that are associated with the sea bed or benthic habitats. Epi- benthic organisms live attached to a hard substratum or rooted to a shallow depth below the surface. In fauna organisms live below the sediment–water interface. Interstitial organisms live and move in pore water among sedimentary grains.

Because the benthic organisms are often collected and separated on sieves, a classification based on the overall size is used. Macro benthos include organisms whose shortest dimension is greater than or equal to 0.5 mm. Meio benthos are smaller than 0.5mm but larger than 42µ in size.

The terms such as macro fauna and Meio fauna generally have little relevance with taxonomic classification. The terms Meio fauna and macro fauna depend on the size. Meio fauna were considered as good bioassay of community health and rather sensitive indicators of environmental changes.

SAMPLING METHODOLOGY ADOPTED FOR SUB TIDAL REGION:

Van veen sampler ($0.09m^2$) was used for sampling bottom sediments. Two sets of sediments were sampled from each location, one for macro fauna and other for Meio fauna. The macro fauna in the sediments were sieved on board to separate out the organisms. The fixation of Meio fauna is normally done by bulk fixation of the sediment sample. The bulk fixation is done by using 10% formalin (Buffered with borate). The organisms were preserved with seawater as diluting agent.

Sample sieving:

Sediments samples were sieved to extract the organisms. Sieving was performed carefully as possible to avoid any damage to the animals. The large portion of the sediment was split in to smaller portions and mixed with sea water in a bucket. The cohesive lumps were broken down by continuous stirring. The disaggregated sediments were then passed through the sieves.

Sample staining:

Sorting of the Meio fauna from the sieve is difficult task especially in the preserved material, because organisms are not easily detectable. To facilitate the animal detection the entire sample retained on the sieve after sieving operation were stained by immersing the sieve in a flat bottom tub with 1% Rose Bengal stain; a protein stain. A staining period of 10-30 minutes is sufficient for sample detection.

DIVERSITY INDICES:

On the whole, diversity indices provide more information about community composition than simply species richness (number of species present); they also, take the relative abundances of different species into account. Based on this fact, diversity indices therefore depend not only on species

richness but on the evenness, or equitability, with which individuals are distributed among the different species (Magurram, A. E. (1988)

A diversity index is a measure of species diversity within a community that consists of co-occurring populations of several (two or more) different species. It includes two components: richness and evenness. Richness is the measure of the number of different species within a sample, more the types of species in a community, the higher is the diversity or greater is the richness. Evenness is the measure of relative abundance of the different species with in a community.

The basic idea of diversity index is to obtain a quantitative estimate of biological variability that can be used to compare biological entities composed of discrete components in space and time (Carol H.R. *etal*. 1998). Biodiversity is commonly expressed through indices based on species richness and species abundances (Whittaker 1972, Lande 1996, Purvis and Hector 2000). Biodiversity indices are a non-parametric tool used to describe the relationship between species number and abundance. The most widely used bio diversity indices are Shannon Weiner index and Simpson's index.

A diversity Index is a single statistic that incorporates information on richness and evenness. Any study intended to interpret causes and effect of adverse impact on Biodiversity of communities require suitable measures to evaluate specie richness and Diversity. The former is number of species in community, while latter is a function of relative frequency of different species. Species richness is the iconic measure of biological diversity (Magurran, 2004). Several indices have been created to measure the diversity of species; however, the most widely used in the last decades are the Shannon (1948) and Simpson (1949) (Buzas and Hayek 1996; Gorelick 2006), with the components of diversity: richness (*S)* and evenness (*J)*

Simpson's diversity index

Simpson's index (**D**) is a measure of diversity, which takes into account both species richness, and evenness of abundance among the species present. The Simpson index is one of the meaningful and robust biodiversity measures available. (Magurran ,2004).

The formula for calculating D is presented as:

$$D = \frac{\sum n_i(n_i - 1)}{N(N-1)}$$

Where n_i = the total number of organisms of each individual species

N = the total number of organisms of all species

The value of D ranges from 0 to 1. With this index, 0 represents infinite diversity and, 1, no diversity. When D increases diversity decreases. Simpson's index is therefore usually expressed as 1-D or 1/D. (Magurran, 2004)

Low species diversity suggests:relatively few successful species in the habitat the environment is quite stressful with relatively few ecological niches and only a few organisms are really well adapted

to that environment food webs which are relatively simple change in the environment would probably have quite serious effects High species diversity suggests: a greater number of successful species and a more stable ecosystem more ecological niches are available and the environment is less likely to be hostile complex food webs environmental change is less likely to be damaging to the ecosystem as a whole

Species richness indices

The species richness***(S)*** is simply the number of species present in an ecosystem. Species richness Indices of species richness are widely used to quantify or monitor the effects of anthropogenic disturbance. A decline in species richness in may be concomitant with severe or chronic human-induced perturbation (Fair weather 1990,) Species richness measures have traditionally been the mainstay in assessing the effects of environmental degradation on the biodiversity of natural assemblages of organisms (Clarke & Warwick, 2001). Species richness is the iconic measure of biological diversity (Magurran, 2004). The species richness ***(S)*** is simply the number of species present in an ecosystem. This index makes no use of relative abundances. The term species richness was coined by McIntosh (1967) and oldest and most intuitive measure of biological diversity (Magurran, 2004).

Margalef's diversity index is a species richness index. Margalef's Species richness index (d), or indices that describe the evenness of the distribution of the numbers of individuals among species, were derived.

The value of a diversity index increases both when the number of types increases and when evenness increases. For a given number of types, the value of diversity index is maximized when all types are equally abundant [Rosenzweig, M. L. (1995)]

Shannon-Wiener's index:

An index of diversity commonly used in plankton community analyses is the Shannon-Wiener's index **(H),** which emphasizes not only the number of species (richness or variety), but also the apportionment of the numbers of individuals among the species (Odum 1971 and Reish 1984). Shannon-Wiener's index **(H**) reproduces community parameters to a single number by using an equation.

$$H' = -\sum_{i=1}^{s} \frac{n_i}{N} \ln\left(\frac{n_i}{N}\right)$$

Shannon and Weiner index represents entropy. It is a diversity index taking into account the number of individuals as well as the number of taxa. It varies from 0 for communities with only single taxa to high values for community with many taxa each with few individuals. This index can also determine the pollution status of a water body. Normal values range from 0 to 4. This index is a combination of species present and the evenness of the species. Examining the diversity in the range of polluted and

unpolluted ecosystems, Wilham and Dorris (1968) concluded that the values of the index greater than 3 indicate clean water, values in the range of 1 to 3 are characterized by moderate pollution and values less than 1 are characterized as heavily polluted

RESULTS:

CHLOROPHYLL-a:

In the sub surface water chlorophyll-a was varying from 0.511-0.883 mg/m^3 with an average value 0.734 mg/m^3 in harbour region of DPT in Kandla Creek during sampling done in spring tide period of December 2022. In the nearby creeks chlorophyll-a was varying from 0.322- 0.679 mg/m3. with an average value 0.555 mg/m$^{3.}$ Pheophytin–a level was below detectable limit- the all the sampling stations during spring tide. Even though the plankton diversity and abundance were more during the spring tide sampling, the chlorophyll -content was detected lesser than expected because, the phytoplankton communities were mainly represented by diatoms *Thalassiothrix sp.* *Biddulphia* sp and *Chaetoceros* sp.

In the sub surface water chlorophyll-a was varying from 0.44- 0.764 mg/m^3 with an average value 0.622 mg/m^3 in harbour region of DPT in Kandla Creek during sampling done in Neap tide period of December 2022. In the nearby creeks chlorophyll-a was varying from 0.204- 0.646 mg/m^3 with an average value 0.507 mg/m^3. Pheophytin –a level was below detectable limit at all the sampling stations. During neap tide sampling phytoplankton communities were mainly represented *by Thalassiothrix sp. Coscinodiscus sp. and* *Biddulphia* *sp*

In the sub surface water chlorophyll-a was varying from 0.424- 0.866 mg/m^3 in harbour region of DPT OOT in path finder Creek during sampling done in spring tide period of December 2022. In the sub surface water chlorophyll-a was varying from 0.509- 0.661 mg/m^3 in harbour region of DPT OOT in path finder Creek during sampling done in Neap Tide period of December 2022

TABLE 43 VARIATIONS IN CHLOROPHYLL –a PHEOPHYTIN- a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPT HARBOUR AREA IN KANDLA CREEK, NEAR BY CREEKS AND DPT OOT JETTY IN PATH FINDER CREEK AND SPM NEAR VADINAR DURING SPRING TIDE IN DECEMBER 2022

Sr. No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPT HARBOUR AREA KANDLA CREEK					
1	DPA1	High tide	0.883	BDL	59.161
		Low tide	0.527	BDL	35.309
2	DPA 2	High tide	0.866	BDL	58.022
		Low tide	0.511	BDL	34.237
3	DPA 3	High tide	0.765	BDL	51.255
		Low tide	0.851	BDL	57.017
CREEKS					
4	DPA-4 Khori-I	High tide	0.631	BDL	42.277
		Low tide	0.629	BDL	42.143
5	DPA-5 Nakti-I	High tide	0.679	BDL	45.493
		Low tide	0.513	BDL	34.371
6	DPA-6 Nakti-II	High tide	0.322	BDL	21.574
PATHFINDER CREEK VADINAR					
7	VADINAR-I jetty	High tide	0.866	BDL	58.022
8		Low tide	0.747	BDL	50.049
9	SPM	High tide	0.424	BDL	28.408
10		Low tide	0.528	BDL	35.376

BDL: Below Detectable Limit., ND: Not detected

TABLE 44 VARIATIONS IN CHLOROPHYLL –a PHEOPHYTIN- a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPT HARBOUR AREA, NEAR BY CREEKS AND DPT OOT JETTY IN PATH FINDER CREEK AND SPM NEAR VADINAR DURING NEAP TIDE IN DECEMBER 2022

Sr. No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPT HARBOUR AREA KANDLA CREEK					
1	DPA1	High tide	0.764	BDL	51.188
		Low tide	0.748	BDL	50.116
2	DPA 2	High tide	0.440	BDL	29.480
		Low tide	0.630	BDL	42.210
3	DPA 3	High tide	0.527	BDL	35.309
		Low tide	-	-	-
CREEKS					
4	DPA-4 Khori-I	High tide	0.629	BDL	42.143
		Low tide	0.646	BDL	43.282
5	DPA-5 Nakti-I	High tide	0.543	BDL	36.381
		Low tide	0.511	BDL	34.237
6	DPA-6 Nakti-II	High tide	0.204	BDL	13.668
PATHFINDER CREEK VADINAR					
7	VADINAR-I jetty	High tide	0.614	BDL	41.138
8		Low tide	0.509	BDL	34.103
9	SPM	High tide	0.661	BDL	44.287
10		Low tide	0.517	BDL	34.639

BDL: Below Detectable Limit. ND: Not detected

PHYTOPLANKTON POPULATION:

For the evaluation of the Phytoplankton population in DPT harbour area and within the immediate surroundings of the port, sampling was conducted from 5 sampling locations (3 in harbour area and two in Nakti creek) during high tide period and low tide period of spring tide and neap tide.

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by Diatoms, Blue green algae and Dinoflagellates during spring tide period. Diatoms were represented by 25 genera, Blue green algae were represented by 2 genera and Dinoflagellates were

represented by 4 genera during the sampling conducted in spring tide in December, 2022. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 48-312 units/ L during high tide period and 158-229 units/ L during low tide of Spring Tide. During spring tide sampling phytoplankton communities were dominated by *Thalassiothrix sp.* almost forming a bloom in the Kandla creek and other nearby creek area and abundant population of *Biddulphia sp* and *Chaetoceros* sp were also observed during spring tide in December, 2022.

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by Diatoms, Blue green algae and Dinoflagellates during Neap tide period. Diatoms were represented by 26 genera, Blue green algae were represented single genera and Dinoflagellates with 4 genera during the sampling conducted in Neap tide in December, 2022. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 28-261 units/ L during high tide period and 113-161 units/ L during low tide of Neap Tide. During Neap tide sampling phytoplankton communities were dominated by, *Thalassiothrix sp., Coscinodiscus sp.* and *Biddulphia sp.*

For the evaluation of the Phytoplankton population in DPT OOT jetty area in Path Finder creek sampling was conducted from two sampling locations; Jetty area and SPM area during high tide period and low tide of spring tide and Neap tide period.

The phytoplankton community of the sub surface water in the path finder creeks was represented by Diatoms, Blue green algae and Dinoflagellates during spring tide period. Diatoms were represented by 30 genera, Blue Green algae by 5 genera and Dinoflagellates by 4 genera during the sampling conducted in spring tide in December, 2022. Phytoplankton of the sampling stations at sub surface path finder creek near OOT Jetty area was 343 units/ L during high tide period and 204 units/ L during low tide of Spring Tide. Phytoplankton of the sampling stations at sub surface layer in the SPM area was varying from 287 units/ L during high tide period and 180 units/ L during low tide of Spring Tide.

The phytoplankton community of the sub surface water in the path finder creeks was represented by Diatoms, Blue green algae, Green algae and Dinoflagellates during Neap tide period. Diatoms were represented by 28 genera and Blue green algae by 5 genera, Green algae by single genera and Dinoflagellates by 4 genera during the sampling conducted in Neap tide in December, 2022. Phytoplankton of the sampling stations at sub surface path finder creek near OOT Jetty was varying from 246 units/ L during high tide period and 198 units/ L during low tide of Neap Tide. Phytoplankton of the sampling stations at sub surface path finder creek near SPM area was varying from 273 units/ L during high tide period and 212 units/ L during low tide of Neap Tide.

Species Richness Indices and Diversity Indices:

Margalef's diversity index (Species Richness) S

At the organismal level, the most widely used biodiversity measures are those based on the number of species present, perhaps adjusted for the number of individuals sampled, Here Margalef's Species richness index (d), or indices that describe the evenness of the distribution of the numbers of individuals among species, are derived.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek and nearby creeks sampling stations was varying from 1.808- 4.325 with an average of 3.472 during the sampling conducted in High tide period of spring tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek region and nearby creeks was varying from 2.345- 3.313 with an average of 2.712 during the consecutive low tide period.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations in Kandla creek and nearby creeks was varying from 2.345- 3.651 with an average of 3.007 during the sampling conducted in High tide period of Neap tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek region and nearby creeks was varying from 2.327- 2.895 with an average of 2.680 during consecutive low tide.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the sampling station was 5.139 at OOT jetty area and 4.064 at SPM area during the sampling conducted in High tide period of spring tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the path finder creek near OOT jetty was 3.385 and 3.851 at SPM during the consecutive low tide period.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations was 4.359 at OOT jetty area and 3.922 at SPM area during the sampling conducted in High tide period of Neap tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the path finder creek near OOT jetty was 4.727 and SPM area was 3.36 during the consecutive low tide period.

Shannon-Wiener's index:

Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.808- 0.967 between selected sampling stations with an average value of 0.925 during high tide period of spring tide at Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.813-0.900 (H'(log10)) between selected sampling stations with an average value of 0.874 during consecutive low tide at Kandla creek and nearby creeks.

Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.782– 0.905 between selected sampling stations with an average value of 0.840 during high tide

period of neap tide at Kandla creek and nearby creeks. Shannon-Wiener's Index of phytoplankton communities in the sampling stations was in the range of 0.850- 0.888 between selected sampling stations with an average value of 0.864 during consecutive low tide at Kandla creek and nearby creeks.

Shannon-Wiener's Index (H) of phytoplankton communities in the stations was 1.018 at OOT jetty area and 0.987 at SPM area during the sampling conducted in High tide period of spring tide. While Shannon-Wiener's Index (H) of phytoplankton communities in the path finder creek near OOT jetty was 0.913 and 0.989 at SPM during the consecutive low tide period of spring tide.

Shannon-Wiener's Index (H) of phytoplankton communities in the stations was 1.033 at OOT jetty area and 0.977 at SPM area during the sampling conducted in High tide period of Neap tide. While Shannon-Wiener's Index (H) of phytoplankton communities in the path finder creek near OOT jetty was 1.044 and at SPM area was 0.926 during the consecutive low tide period.

Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon-Wiener's index increases as both the richness and the evenness of the community increase. This result indicates that diversity of phytoplankton of Kandla Harbour region and nearby creeks is less but with abundant population of few, with relatively few ecological niches and only very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson's diversity index:

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks, which was varying from 0.831- 0.855 between selected sampling stations with an average of 0.844 during high tide period of spring tide. Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks, which was varying from 0.782 - 0.834 between selected sampling stations with an average of 0.821 during consecutive low tide.

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations except few in Kandla Harbour region and nearby creeks, during high tide period and low tide period during Neap tide also, which was varying from 0.757- 0.857 with an average value of 0.803 between selected sampling stations during high tide period and 0.823- 0.834 varying from with an average value of 0.830 between selected sampling stations during consecutive low tide period. Low species diversity suggests a relatively few successful species in this habitat.

Simpson diversity index (1-D) of phytoplankton communities in the stations was 0.867 at OOT jetty area and 0.866 at SPM area during the sampling conducted in High tide period of spring tide at Path finder creek. While Simpson diversity index (1-D) of phytoplankton communities in the path finder

creek near OOT jetty was 0.829 and 0.872 at SPM during the consecutive low tide period in the path finder creek.

Simpson diversity index (1-D) of phytoplankton communities in the stations was 0.878 at OOT jetty area and 0.859 at SPM area during the sampling conducted in High tide period of Neap tide at Path finder Creek. While Simpson diversity index (1-D) of phytoplankton communities in the path finder creek near OOT jetty was 0.883 and at SPM area was 0.856 during the consecutive low tide period. Low species diversity suggests a relatively few successful species in this habitat. The environment is quite stressful with relatively few ecological niches and only a few organisms are really well adapted to that environment. Any change in the environment would probably have quite serious effects.

Table 45 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND, NEAR BY CREEKS DURING SPRING TIDE IN DECEMBER 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% Of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	216	23/31	74.19	4.093	0.9669	0.8483
	2	204	24/31	77.42	4.325	0.9416	0.8307
	3	212	19/31	61.29	3.36	0.9529	0.8553
	4	312	25/31	80.65	4.179	0.9653	0.8418
	5	255	18/31	58.06	3.068	0.9152	0.8431
	6	48	8/31	25.81	1.808	0.8082	0.844
LOW TIDE	1	167	13/31	41.94	2.345	0.813	0.7817
	2	158	14/31	45.16	2.568	0.8933	0.8313
	3	175	14/31	45.16	2.517	0.8848	0.8344
	4	229	19/31	61.29	3.313	0.9004	0.8303
	5	205	16/31	51.61	2.818	0.8807	0.8271

Table 46 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND NEAR BY CREEKS DURING NEAP TIDE IN DECEMBER 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	171	18/31	58.06	3.306	0.805	0.7573
	2	167	13/31	41.94	2.345	0.7823	0.7861
	3	182	20/31	64.52	3.651	0.8661	0.7956
	4	242	20/31	64.52	3.462	0.9051	0.822
	5	261	17/31	54.84	2.875	0.8418	0.7984
	6	28	9/31	29.03	2.401	0.8423	0.8571
LOW TIDE	1	126	15/31	48.39	2.895	0.8881	0.833
	2	113	12/31	38.71	2.327	0.8511	0.8298
	3	147	15/31	48.39	2.805	0.8733	0.8336
	4	145	15/31	48.39	2.813	0.8504	0.8229
	5	161	14/31	45.16	2.558	0.8569	0.83

Table 47 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND, NEAR BY CREEKS DURING SPRING TIDE IN DECEMBER 2022

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	BLUE GREEN ALGAE	0-2	2/31	6.45
			DIATOMS	48-307	25/31	80.65
			DINOFLAGELLATES	0-5	4/31	12.90
			TOTAL PHYTO PLANKTON	**48-312**	**31**	
LOW TIDE	Sub surface	5	BLUE GREEN ALGAE	0-1	2/31	6.45
			DIATOMS	157-226	25/31	80.65
			DINOFLAGELLATES	0-2	4/31	12.90
			TOTAL PHYTO PLANKTON	**158-229**	**31**	

TABLE 48 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND, NEAR BY CREEKS DURING NEAP TIDE IN DECEMBER 2022

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	BLUE GREEN ALGAE	0-2	1/31	3.23
			DIATOMS	26-261	26/31	83.87
			DINOFLAGELLATES	0-6	4/31	12.90
			TOTAL PHYTO PLANKTON	**28-261**	**31**	
LOW TIDE	Sub surface	5	BLUE GREEN ALGAE	0-1	1/31	3.23
			DIATOMS	112-161	26/31	83.87
			DINOFLAGELLATES	0-1	4/31	12.90
			TOTAL PHYTO PLANKTON	**113-161**	**31**	

TABLE 49 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING SPRING TIDE IN DECEMBER 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	343	31/39	79.49	5.139	1.018	0.867
	SPM	287	24/39	61.54	4.064	0.987	0.866
LOW TIDE	Jetty	204	19/39	48.72	3.385	0.913	0.829
	SPM	180	21/39	53.85	3.851	0.989	0.872

TABLE 50 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING NEAP TIDE IN DECEMBER 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	246	25/38	65.79	4.359	1.033	0.878
	SPM	273	23/38	60.53	3.922	0.977	0.859
LOW TIDE	Jetty	198	26/38	68.42	4.727	1.044	0.883
	SPM	212	19/38	50.00	3.36	0.926	0.856

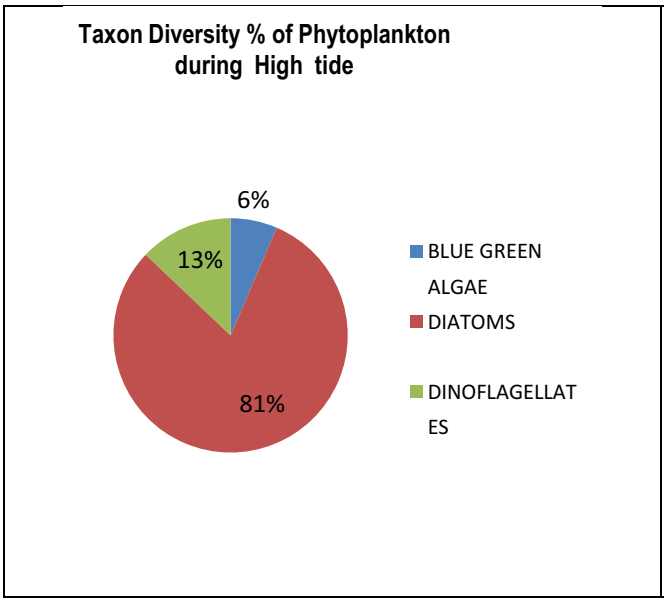
TABLE 51 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING SPRING TIDE IN DECEMBER 2022

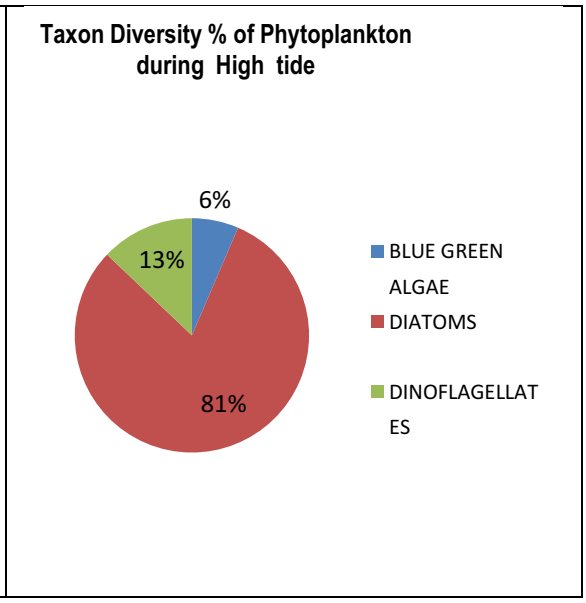
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	BLUE GREEN ALGAE	5-9	5/39	12.80
			DIATOMS	279-332	30/39	76.93
			DINOFLAGELLATES	2-3	4/39	10.27
			TOTAL PHYTO PLANKTON	**287-343**	**39**	
LOW TIDE	Sub surface	2	BLUE GREEN ALGAE	2-3	5/39	12.80
			DIATOMS	178-200	30/39	76.93
			DINOFLAGELLATES	0-1	4/39	10.27
			TOTAL PHYTO PLANKTON	**287-343**	**39**	

Table 52 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING NEAP TIDE IN DECEMBER 2022

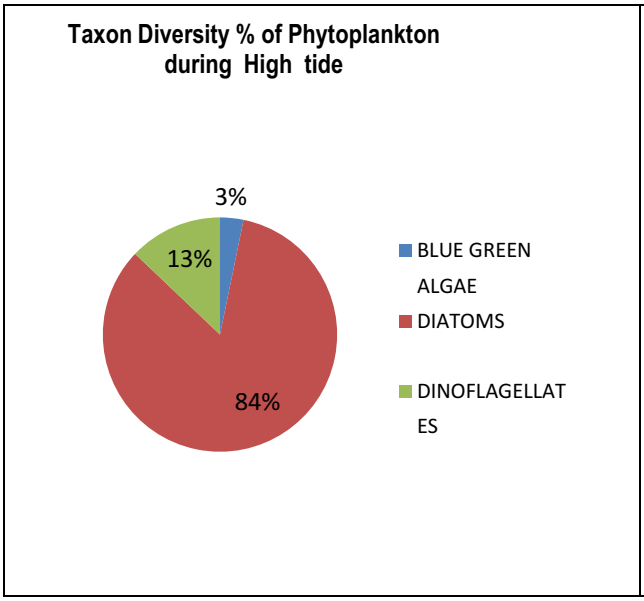
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	BLUE GREEN ALGAE	5-7	5/38	13.16
			GREEN ALGAE	0-1	1/38	2.63
			DIATOMS	235-266	28/38	73.68
			DINOFLAGELLATES	2-3	4/38	10.53
			TOTAL PHYTO PLANKTON	**246-273**	**38**	
LOW TIDE	Sub surface	2	BLUE GREEN ALGAE	2-3	5/38	13.16
			GREEN ALGAE	0	1/38	2.63
			DIATOMS	190-208	28/38	73.68
			DINOFLAGELLATES	2-5	4/38	10.53
			TOTAL PHYTO PLANKTON	**198-212**	**38**	

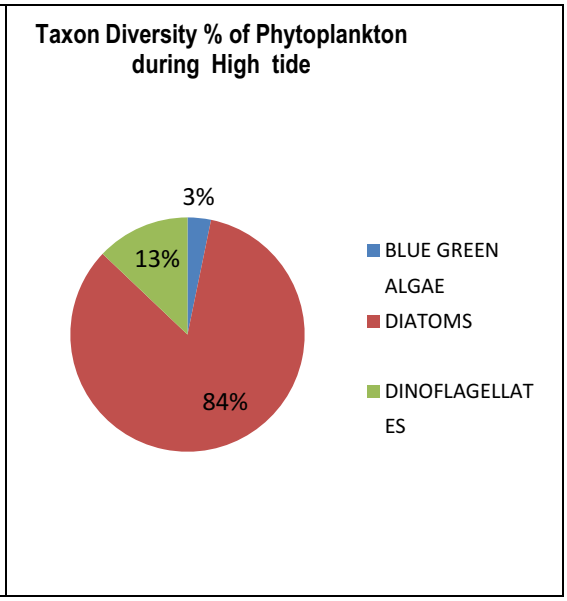
Taxon Diversity % of Phytoplankton during High tide and Low tide period during spring tide in Kandla creek and nearby creeks



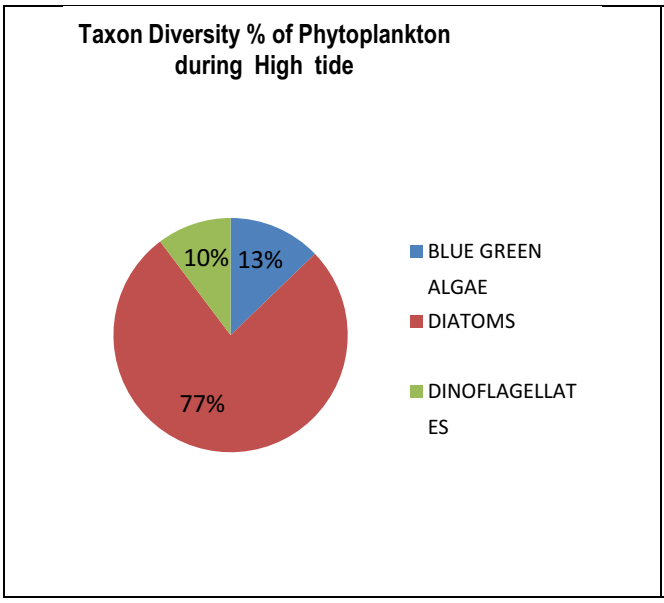


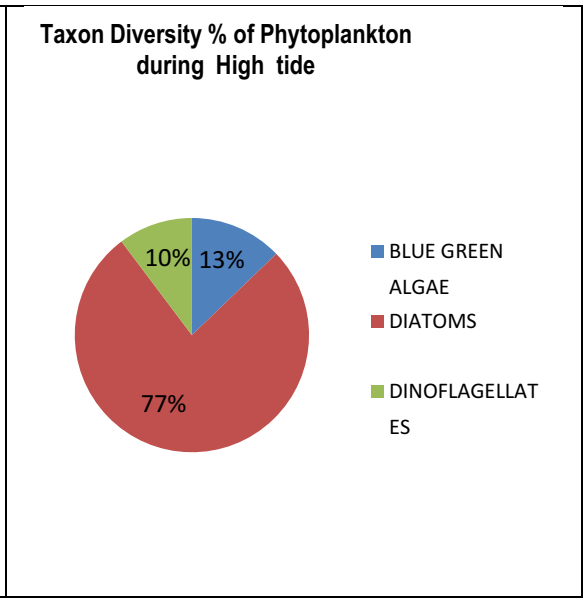
Taxon Diversity % of Phytoplankton during High tide and Low tide period during Neap tide in Kandla creek and nearby creeks



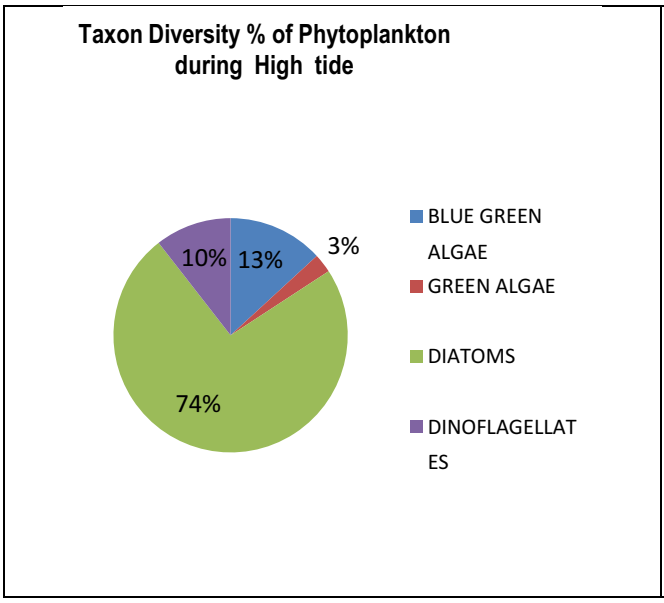


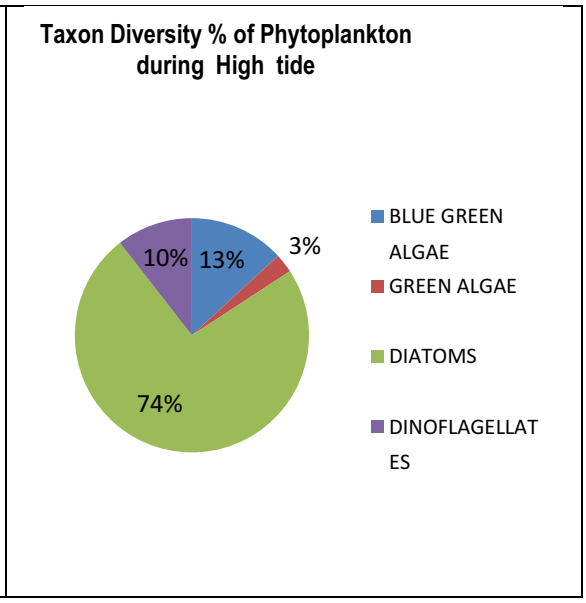
Taxon Diversity % of Phytoplankton during High tide and Low tide period during spring tide in Path Finder Creek, Vadinar





Taxon Diversity % of Phytoplankton during High tide and Low tide period during Neap tide in Path Finder Creek, Vadinar





ZOOPLANKTON POPULATION:

For the evaluation of the Zooplankton population in DPT harbour area and within the immediate surroundings of the port sampling was conducted from 6 sampling locations (3 in harbour area and two in Nakti creek and one in Khori creek) during high tide period and low tide period of spring tide and Neap tide in December, 2022. The Zooplankton community of the sub surface water in the harbour and nearby creeks during spring tide was represented by mainly five groups; Tintinids, Copepods, Mysids, Urochordata, Ciliates and 8 larval forms. The Zooplankton community of the sub surface water in the harbour and nearby creeks during neap tide was represented by mainly six groups; Tintinids, Copepods, Arrow worms, Mysids, Urochordata, Ciliates and 8 larval forms.

Zooplankton of the sampling stations at sub surface layer in the DPT harbour area and nearby creek was varying from 20-106 x10^3 N/ m^3 during high tide and 55-84 x10^3 N/ m^3 during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPT harbour area and nearby creek was varying from 27-100 x10^3 N/ m^3 during high tide and 60-82 x10^3 N/ m^3 during low tide of Neap Tide period.

For the evaluation of the Zooplankton population in DPT OOT jetty area in Path Finder creek and SPM in Vadinar selected 2 sampling locations (one in jetty area and one near SPM).

During spring tide sampling plankton sample were collected at Jetty area and near SPM during consecutive high tide period and low tide period. During Neap tide sampling Plankton samples were collected from jetty area and SPM during consecutive high tide period and low tide period.

The Zooplankton community of the sub surface water in the path finder creek during spring tide was represented by mainly four groups Tintinids, Copepods, Urochordata, Nematode and six larval forms. While the Zooplankton community of the sub surface water in the path Finder creeks at Jetty region and SPM during neap tide was represented by four groups, Tintinids, Copepods, Arrow worms, Urochordata and seven larval forms.

Zooplankton of the sampling stations at sub surface layer in the DPT OOT Jetty area of path finder creek was 119 x10^3 N/ m^3 during high tide and 55 x10^3 N/ m^3 during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPT SPM area of path finder creek was 92 x10^3 N/ m^3 during high tide and 73 x10^3 N/ m^3 during low tide of spring Tide period.

Zooplankton of the sampling stations at sub surface layer in the DPT OOT jetty area in path finder creek was recorded 80 x10^3 N/ m^3 during high tide and 61 x10^3 N/ m^3 during consecutive low tide period of Neap tide. Zooplankton of the sampling stations at sub surface layer in the DPT SPM area in path finder creek was recorded 90 x10^3 N/ m^3during high tide and 68 x10^3 N/ m^3 during consecutive low tide period of Neap Tide.

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Species Richness Indices and Diversity Indices:

Margalef's diversity index (Species Richness) S

Margalef's diversity index (Species Richness) S of Zooplankton communities in the stations Kandla creek region and nearby creeks were varying from 1.001- 4.539 with an average of 2.878 during the sampling conducted in High tide period. Margalef's diversity index (Species Richness) S of Zooplankton communities varying from 2.864 - 3.683 with an average of 3.281 during the sampling conducted in low tide period during Spring tide.

Margalef's diversity index (Species Richness) S of Zooplankton communities in the Kandla creek region and nearby creeks sampling stations were varying from 3.338- 5.688 with an average of 4.290 during the sampling conducted in high tide and varying from 3.404 - 4.152 with an average of 3.811 during the sampling conducted in low tide during Neap tide period.

Margalef's diversity index (Species Richness) S of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 3.976 and 3.244 respectively. Margalef's diversity index (Species Richness) S of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 3.538 and 3.496 respectively.

Margalef's diversity index (Species Richness) S of Zooplankton communities near Jetty at Path finder creek were varying from 3.195 and 2.919 respectively during the sampling conducted in consecutive High tide period and Low tide period of Neap tide. While Margalef's diversity index (Species Richness) S of Zooplankton communities near SPM at Path finder creek were varying from 2.667-2.607 respectively during the consecutive High tide and low tide period.

Shannon-Wiener's index:

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.473- 1.007 between selected sampling stations with an average value of 0.783 during high tide period of spring tide. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.860 - 0.928 between selected sampling stations with an average value of 0.894 during consecutive low tide period.

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.911-1.169 between selected sampling stations with an average value of 0.996 during high tide period of Neap tide. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range 0.886- 1.004 of between selected sampling stations with an average value of 0.939 during consecutive low tide period.

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.901-0.911 respectively. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.834 - 0.829 respectively.

Shannon-Wiener's Index (H) of Zooplankton communities near jetty at Path finder creek was varying from 0.803- 0.766 respectively during the sampling conducted consecutive High tide period and Low tide period of Neap tide. While Shannon-Wiener's Index (H) of Zooplankton communities near SPM at Path finder creek was varying from 0.737- 0.712 during the consecutive High tide and low tide period.

The Shannon-Wiener's index increases as both the richness and the evenness of the community increase. This result indicates that diversity of Zooplankton of Kandla Harbour region and nearby creeks stations is slightly high with very minimum diverse population but very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson's diversity index:

Simpson diversity index (1-D) of Zooplankton communities was below 0.9 most of sampling stations in the Kandla Harbour region and nearby creeks during high tide and low tide of spring tide period except few stations, which was varying from 0.611-0.847 between selected sampling stations with an average of 0.756 during high tide period and was varying from 0.805- 0.846 with an average value of 0.822 between selected sampling stations during low tide.

Simpson diversity index (1-D) of Zooplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks during high tide and low tide period of Neap tide except few, which was varying from 0.829- 0.899 between selected sampling stations with an average of 0.856 during high tide period and was varying from 0.784 -0.861 with an average value of 0.831 between selected sampling stations during consecutive low tide .This species diversity suggests a relatively few successful species in this habitat during December ,2022 sampling.

Simpson diversity index (1-D) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.777 and 0.833 respectively. Simpson diversity index (1-D) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.747 and 0.743 respectively.

Simpson diversity index (1-D) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of

Neap tide was recorded as 0.753- 0.776 respectively. Simpson diversity index (1-D) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.740 and 0.709 respectively.

TABLE 53 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND NEAR BY CREEKS DURING SPRING TIDE IN DECEMBER 2022

Tide	Sampling Station	Abundance In Nx10^3/ m^3	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	82	21/26	80.77	4.539	1.007	0.847
	2	71	16/26	61.54	3.519	0.8284	0.7702
	3	65	14/26	53.85	3.114	0.8058	0.7644
	4	106	12/26	46.15	2.359	0.7586	0.7456
	5	80	13/26	50.00	2.738	0.823	0.7981
	6	20	4/26	15.38	1.001	0.4729	0.6105
LOW TIDE	1	84	15/26	57.69	3.16	0.9102	0.823
	2	55	14/26	53.85	3.244	0.8598	0.8088
	3	77	16/26	61.54	3.453	0.9057	0.8052
	4	66	13/26	50.00	2.864	0.8662	0.8284
	5	77	17/26	65.38	3.683	0.9283	0.8459

TABLE 54 ZOOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND NEAR BY CREEKS DURING NEAP TIDE IN DECEMBER 2022

Tide	Sampling Station	Abundance In No x10^3/ m^3	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	68	25/28	89.29	5.688	1.169	0.899
	2	76	19/28	67.86	4.156	1.016	0.8684
	3	68	19/28	67.86	4.266	1.017	0.8529
	4	96	20/28	71.43	4.163	0.9455	0.8289
	5	100	20/28	71.43	4.126	0.9107	0.8091
	6	27	12/28	42.86	3.338	0.9188	0.8519
LOW TIDE	1	77	16/28	57.14	3.453	0.9303	0.8401
	2	60	18/28	64.29	4.152	0.9864	0.8605
	3	77	19/28	67.86	4.144	1.004	0.8606
	4	78	18/28	64.29	3.902	0.8859	0.7835
	5	82	16/28	57.14	3.404	0.8898	0.8127

Table 55 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND NEAR BY CREEKS DURING SPRING TIDE IN DECEMBER 2022

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^3/ m^3$ Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinids	4-22	6/26	23.08
			Copepods	4-32	8/26	30.77
			Mysids	0-2	1/26	3.85
			Urochordata	0-3	2/26	7.68
			Ciliates	0-1	1/26	3.85
			Larval forms	12-51	8/26	30.77
			TOTAL ZOOPLANKTON	**20-106**	**26**	
LOW TIDE	Sub surface	5	Tintinids	14-24	6/26	23.08
			Copepods	13-33	8/26	30.77
			Mysids	0-2	1/26	3.85
			Urochordata	0-2	2/26	7.68
			Ciliates	0-1	1/26	3.85
			Larval forms	23-41	8/26	30.77
			TOTAL ZOOPLANKTON	**55-84**	**26**	

TABLE 56 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA IN KANDLA CREEK AND, NEAR BY CREEKS DURING NEAP TIDE IN DECEMBER 2022

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^{3/}$ / m^3 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinids	6-25	7/28	25.00
			Copepods	5-30	8/28	28.57
			Arrow worms	0-2	1/28	3.57
			Mysids	0-2	1/28	3.57
			Urochordata	0-3	2/28	7.15
			Ciliates	0-2	1/28	3.57
			Larval forms	15-43	8/28	28.57
			TOTAL ZOOPLANKTON	**27-100**	**28**	
LOW TIDE	Sub surface	5	Tintinids	14-23	7/28	25.00
			Copepods	19-28	8/28	28.57
			Arrow worms	0-2	1/28	3.57
			Mysids	0-1	1/28	3.57
			Urochordata	0-2	2/28	7.15
			Ciliates	0-1	1/28	3.57
			Larval forms	22-39	8/28	28.57
			TOTAL ZOOPLANKTON	**60-82**	**28**	

Table 57 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING SPRING TIDE IN DECEMBER 2022

Tide	Sampling Station	Abundance In $x10^3$N / m^3	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	119	20/20	100	3.976	0.901	0.777
	SPM	92	17/20	85.00	3.538	0.834	0.747
LOW TIDE	Jetty	55	14/20	70.00	3.244	0.911	0.833
	SPM	73	16/20	80.00	3.496	0.829	0.743

TABLE 58 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING NEAP TIDE IN DECEMBER 2022

Tide	Sampling Station	Abundance In N$x10^3$/ m^3	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	80	15/22	68.18	3.195	0.803	0.753
	SPM	90	13/22	59.09	2.667	0.737	0.740
LOW TIDE	Jetty	61	13/22	59.09	2.919	0.766	0.776
	SPM	68	12/22	54.55	2.607	0.712	0.709

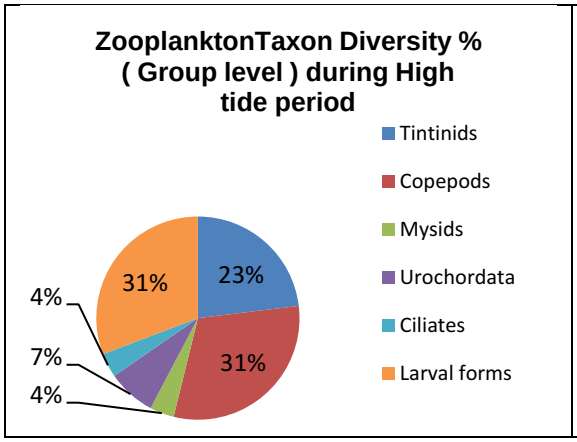
Table 59 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT OOT AREA AND PATH FINDER CREEK AND NEAR BY SPM DURING SPRING TIDE IN DECEMBER 2022

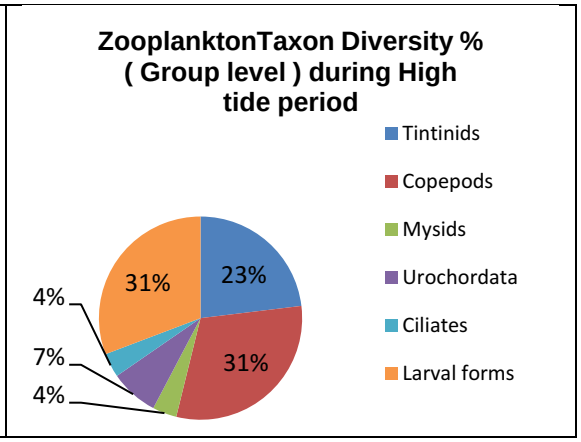
Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^3$/ m^3 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	Tintinids	14-22	4/20	20.00
			Copepods	22-25	7/20	35.00
			Urochordata	2-3	2/20	10.00
			Larval forms	54-67	6/20	30.00
			Nematode	0-2	1/20	5.00
			TOTAL ZOOPLANKTON	**92-119**	**20**	
LOW TIDE	Sub surface	2	Tintinids	12	4/20	20.00
			Copepods	15	7/20	35.00
			Urochordata	1-2	2/20	10.00
			Larval forms	27-44	6/20	30.00
			Nematode	0	1/20	5.00
			TOTAL ZOOPLANKTON	**55-73**	**20**	

TABLE 60 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING NEAP TIDE IN DECEMBER 2022

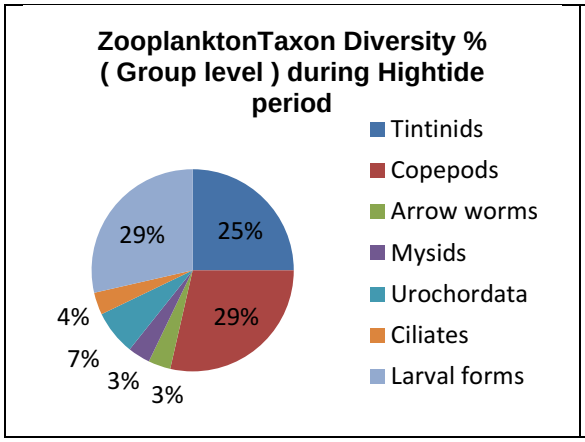
Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^3/ m^3$ Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	Tintinids	23-36	5/22	22.73
			Copepods	6-15	7/22	31.82
			Arrow worms	0-1	1/22	4.55
			Urochordata	1	2/22	9.08
			Larval forms	41-46	7/22	31.82
			TOTAL ZOOPLANKTON	**80-90**	**22**	
LOW TIDE	Sub surface	2	Tintinids	21-32	5/22	22.73
			Copepods	4-8	7/22	31.82
			Arrow worms	0	1/22	4.55
			Urochordata	0-2	2/22	9.08
			Larval forms	25-37	7/22	31.82
			TOTAL ZOOPLANKTON	**61-68**	**22**	

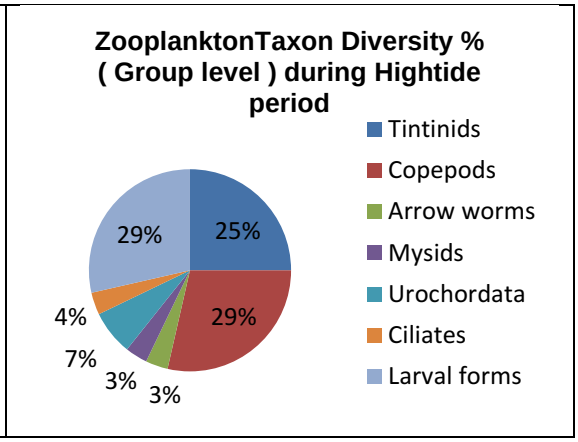
Taxon Diversity % of Zooplankton during High tide and Low tide period of Spring tide In Kandla Creek and nearby Creeks



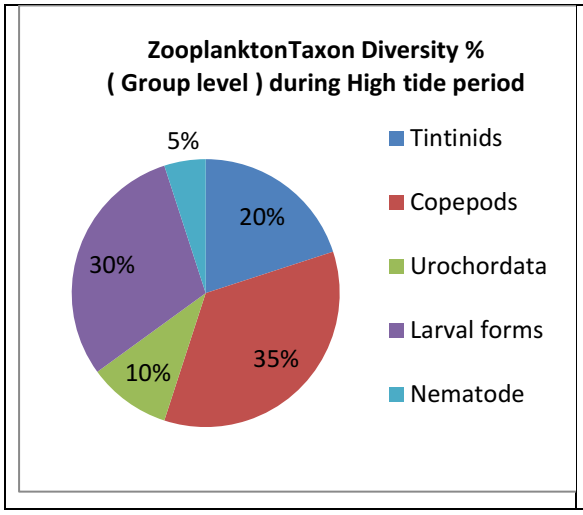


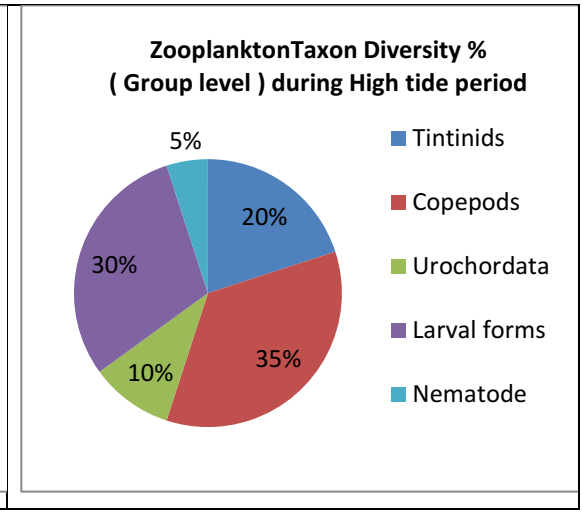
Taxon Diversity % of Zooplankton during High tide and Low tide period of Neap tide In Kandla Creek and nearby Creeks



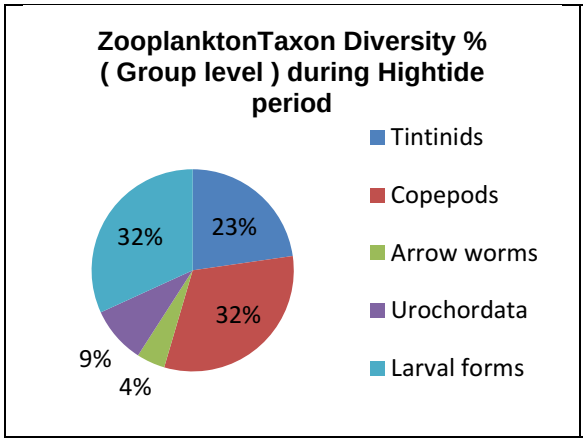


Taxon Diversity % of Zooplankton during High tide and Low tide period of Spring tide In Path Finder Creek and near Jetty





Taxon Diversity % of Zooplankton during High tide and Low tide period of Neap tide In Path Finder Creek near jetty and nearby SPM



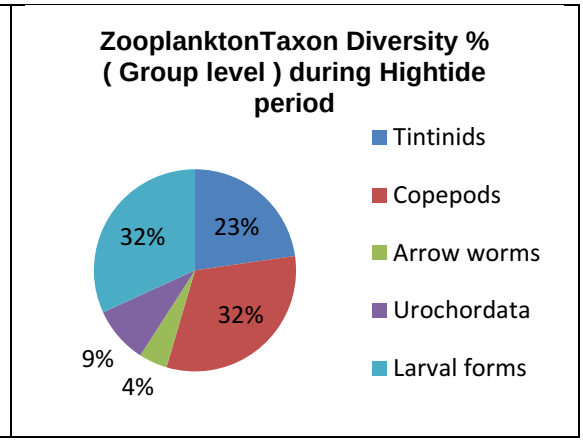


TABLE 61 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS OF DPT HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING NEAP TIDE OF DECEMBER 2022

GROUP	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAE	Nostocales	Oscillatoriaceae	*Oscillatoria sp.*	B1	Very sparse
DIATOMS	Biddulphiales	Biddulphiaceae	*Biddulphia* sp	D1	Abundant
	Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp.	D2	Scattered
	Corethrales	Corethraceae	*Corethron* sp	D3	Very sparse
	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D4	Abundant
	Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D5	Very sparse
		Hemiaulaceae	*Cerataulina sp.*	D6	Very sparse
	Melosirales	Melosiraceae	*Melosira sp*	D7	Very sparse
	Rhizosoleniales	Rhizosoleniaceae	*Guinardia sp.*	D8	Very sparse
			Rhizosolenia sp.	D9	Sparse
	Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D10	Sparse
	Thalassiosirales	Thalassiosiraceae	*Planktoniella* sp	D11	Sparse
		Lauderiaceae	*Lauderia* sp	D12	Very sparse
		Skeletonemataceae	*Skeletonema* sp	D13	Sparse
	Triceratiales	Triceratiaceae	*Odontella* sp.	D14	Sparse
			Triceratium sp.	D15	Very sparse
	Bacillariales	Bacillariaceae	*Bacillaria* sp.	D16	Very sparse
			Nitzschia sp	D17	Very sparse
			Pseudo-nitzschia sp.	D18	Very sparse
	Naviculales	Pleurosigmataceae	*Pleurosigma* sp.	D19	Very sparse
	Surirellales	Entomoneidaceae	*Entomoneis sp.*	D20	Very sparse
	Fragilariales	Fragilariaceae	*Asterionellopsis sp*	D21	Very sparse
			Fragilaria sp	D22	Sparse
			Synedra sp	D23	Very sparse
	Striatellales	Striatellaceae	*Grammatophora sp*	D24	Very sparse
	Thalassionematales	Thalassionemataceae	*Thalassionema sp.*	D25	Scattered
			Thalassiothrix sp.	D26	Dominant
DINO FLAGELLATES	Noctilucales	Noctilucaceae	*Noctiluca* sp.	DF1	Very sparse
	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF2	Very sparse
	Gonyaulacales	Ceratiaceae	*Ceratium furca*	DF3	Very sparse
			Ceratium tripos	DF4	Very sparse

TABLE 62 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPT HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING SPRING TIDE OF DECEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
Cyanophyceae	Nostocales	Oscillatoriaceae	*Oscillatoria sp.*	B1	Very sparse
	Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B2	Very sparse
Coscinodiscophyceae	Biddulphiales	Biddulphiaceae	*Biddulphia* sp	D1	Abundant
	Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp.	D2	Abundant
	Corethrales	Corethraceae	*Corethron* sp	D3	Very sparse
	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D4	Scattered
	Hemiaulales	Hemiaulaceae	*Cerataulina sp.*	D5	Very sparse
	Melosirales	Melosiraceae	*Melosira sp*	D6	Very sparse
	Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D7	Sparse
	Leptocylindrales	Leptocylindraceae	*Leptocylindrus sp*	D8	Very sparse
	Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D9	Scattered
	Thalassiosirales	Thalassiosiraceae	*Planktoniella* sp	D10	Very sparse
		Lauderiaceae	*Lauderia* sp	D11	Very sparse
		Skeletonemataceae	*Skeletonema* sp	D12	Very sparse
	Triceratiales	Triceratiaceae	*Odontella* sp.	D13	Very sparse
			Triceratium sp.	D14	Very sparse
Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria* sp.	D15	Very sparse
			Nitzschia sp	D16	Very sparse
			Pseudo-nitzschia sp.	D17	Very sparse
	Naviculales	Naviculaceae	*Navicula* sp.	D18	Very sparse
		Pleurosigmataceae	*Pleurosigma* sp.	D19	Sparse
	Surirellales	Entomoneidaceae	*Entomoneis sp.*	D20	Very sparse
Fragilariophyceae	Fragilariales	Fragilariaceae	*Asterionellopsis sp*	D21	Very sparse
			Fragilaria sp	D22	Scattered
			Synedra sp	D23	Very sparse
	Thalassionematales	Thalassionemataceae	*Thalassionema sp.*	D24	Scattered
			Thalassiothrix sp.	D25	Dominant
Noctilucea / Noctiluciphyceae (Dinokaryota)	Noctilucales	Noctilucaceae	*Noctiluca* sp.	DF1	Very sparse
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF2	Very sparse
	Gonyaulacales	Ceratiaceae	*Ceratium furca*	DF3	Very sparse
			Ceratium tripos	DF4	Very sparse

TABLE 63 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPT OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING NEAP TIDE OF DECEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
Cyanophyceae	Chroococcales	Chroococcaceae	*Merismopedia sp.*	B1	Very sparse
	Nostocales	Oscillatoriaceae	*Lyngbya sp.*	B2	Very sparse
			Oscillatoria sp.	B3	Very sparse
	Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B4	Very sparse
	Stigonematales	Stigonemataceae	*Stigonema sp.*	B5	Very sparse
Ulvophyceae	Cladophorales	Cladophoraceae	*Cladophora sp.*	G1	Very sparse
Coscinodiscophyceae	Biddulphiales	Biddulphiaceae	*Biddulphia* sp	D1	Abundant
	Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp	D2	Scattered
	Corethrales	Corethraceae	*Corethron* sp	D3	Very sparse
	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D4	Scattered
	Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D5	Very sparse
		Hemiaulaceae	*Cerataulina sp.*	D6	Very sparse
		Streptothecaceae	*Helicotheca sp*	D7	Very sparse
	Leptocylindrales	Leptocylindraceae	*Leptocylindrus sp*	D8	Very sparse
	Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D9	Abundant
	Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D10	Sparse
	Thalassiosirales	Lauderiaceae	*Lauderia sp*	D11	Very sparse
		Thalassiosiraceae	*Planktoniella* sp	D12	Very sparse
	Triceratiales	Triceratiaceae	*Odontella sp*	D13	Scattered
Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria* sp.	D14	Dominant
			Nitzschia sp	D15	Scattered
			Pseudo-nitzschia sp	D16	Very sparse
	Naviculales	Naviculaceae	*Navicula* sp	D17	Very sparse
		Plagiotropidaceae	*Plagiotropis sp*	D18	Very sparse
		Pinnulariaceae	*Pinnularia sp*	D19	Very sparse
		Pleurosigmataceae	*Pleurosigma* sp	D20	Very sparse
	Surirellales	Entomoneidaceae	*Entomoneis sp.*	D21	Sparse
		Surirellaceae	*Campylodiscus* sp	D22	Very sparse
			Surirella sp	D23	Very sparse
Fragilariophyceae	Fragilariales	Fragilariaceae	*Asterionellopsis sp.*	D24	Very sparse
			Synedra sp.	D25	Very sparse
	Licmophorales	Licmophoraceae	*Licmophora sp.*	D26	Very sparse
	Thalassionematales	Thalassionemataceae	*Thalassionema sp.*	D27	Very sparse
			Thalassiothrix sp.	D28	Sparse
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Very sparse
	Gonyaulacales	Pyrophacaceae	*Pyrophacus sp.*	DF2	Very sparse
		Ceratiaceae	*Ceratium furca*	DF3	Very sparse
			Ceratium tripos	DF4	Very sparse

TABLE 64 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPT OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING AND SPRING TIDE OF DECEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
Cyanophyceae	Chroococcales	Chroococcaceae	*Merismopedia sp.*	B1	Very sparse
	Nostocales	Oscillatoriaceae	*Lyngbya sp.*	B2	Very sparse
			Oscillatoria sp.	B3	Very sparse
	Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B4	Very sparse
	Stigonematales	Stigonemataceae	*Stigonema sp.*	B5	Very sparse
Coscinodiscophyceae	Biddulphiales	Biddulphiaceae	*Biddulphia* sp	D1	Scattered
	Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp.	D2	Abundant
	Corethrales	Corethraceae	*Corethron* sp	D3	Very sparse
	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D4	Dominant
	Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D5	Very sparse
		Hemiaulaceae	*Cerataulina sp.*	D6	Very sparse
		Streptothecaceae	*Helicotheca sp*	D7	Very sparse
	Rhizosoleniales	Rhizosoleniaceae	*Guinardia sp.*	D8	Very sparse
			Rhizosolenia sp.	D9	Abundant
	Leptocylindrales	Leptocylindraceae	*Leptocylindrus sp*	D10	Very sparse
	Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D11	Abundant
	Thalassiosirales	Thalassiosiraceae	*Planktoniella* sp	D12	Very sparse
			Thalassiosira sp	D13	Very sparse
		Lauderiaceae	*Lauderia* sp	D14	Very sparse
	Triceratiales	Triceratiaceae	*Odontella* sp.	D15	Sparse
			Triceratium sp.	D16	Very sparse
Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria* sp.	D17	Dominant
			Cylindrotheca sp.	D18	Very sparse
			Nitzschia sp	D19	Sparse
			Pseudo-nitzschia sp.	D20	Very sparse
	Naviculales	Pleurosigmataceae	*Pleurosigma* sp.	D21	Sparse
	Striatellales	Striatellaceae	*Striatella* sp	D22	Very sparse
	Surirellales	Entomoneidaceae	*Entomoneis sp.*	D23	Very sparse
		Surirellaceae	*Surirella sp.*	D24	Very sparse
Fragilariophyceae	Climacospheniales	Climacospheniaceae	*Climacosphenia sp.*	D25	Very sparse
	Fragilariales	Fragilariaceae	*Asterionellopsis sp*	D26	Very sparse
			Synedra sp	D27	Very sparse
	Licmophorales	Licmophoraceae	*Licmophora sp.*	D28	Very sparse
	Thalassionematales	Thalassionemataceae	*Thalassionema sp.*	D29	Sparse
			Thalassiothrix sp.	D30	Scattered
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Very sparse
	Dinophysales	Dinophysaceae	*Dinophysis sp.*	DF2	Very sparse
	Gonyaulacales	Ceratiaceae	*Ceratium furca*	DF3	Very sparse
			Ceratium tripos	DF4	Very sparse

TABLE 65 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPT HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING NEAP TIDE OF DECEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnus sp.*	T1	Abundant
		Codonellidae	*Tintinnopsis failakkaensis*	T2	Very sparse
			Tintinnopsis gracilis	T3	Very sparse
			Tintinnopsis radix	T4	Very sparse
		Tintinnidae	*Amphorellopsis sp.*	T5	Very sparse
			Eutintinnus sp.	T6	Very sparse
		Xystonellidae	*Favella sp.*	T7	Very sparse
Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Sparse
			Parvocalanus sp.	C2	Very sparse
		Acartiidae	*Acartia sp.*	C3	Very sparse
		Clausocalanidae	*Clausocalanus sp.*	C4	Very sparse
	Cyclopoida	Oithonidae	*Oithona sp.*	C5	Scattered
	Harpacticoida	Ectinosomatidae	*Microsetella* sp.	C6	Very sparse
		Euterpinidae	*Euterpina sp.*	C7	Very sparse
	Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C8	Very sparse
Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse
Malacostraca	Mysida, Decapoda	Penaeidae	*Metapenaeus sp.*	M1	Very sparse
Appendicularia		Fritillariidae	*Fritillaria sp.*	U1	Very sparse
		Oikopleuridae	*Oikopleura sp.*	U2	Very sparse
Oligohymenophorea	Sessilida	Zoothamniidae	*Zoothamnium sp.*	CI1	Very sparse
Copepoda			Nauplius larvae of copepods	L1	Dominant
Malacostraca Decapoda			Brachyuran zoea	L2	Very sparse
Maxillopoda Thecostraca			Cirripede larvae	L3	Very sparse
			Cyphonautes larvae	L4	Very sparse
			Ophiopluteus larvae	L5	Very sparse
Gastropoda Streptoneura			Opisthobranchia larvae	L6	Very sparse
Polychaeta			Trochophore larvae	L7	Very sparse
Pelecypoda			Veliger larvae of bivalves	L8	Very sparse

TABLE 66 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING OF DPT HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING SPRING TIDE OF DECEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnus sp.*	T1	Scattered
		Codonellidae	*Tintinnopsis failakkaensis*	T2	Very sparse
			Tintinnopsis mortensenii	T3	Very sparse
			Tintinnopsis radix	T4	Sparse
		Tintinnidae	*Eutintinnus* sp.	T5	Very sparse
		Xystonellidae	*Favella sp.*	T6	Very sparse
Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Sparse
			Parvocalanus sp.	C2	Very sparse
		Acartiidae	*Acartia sp.*	C3	Very sparse
		Clausocalanidae	*Clausocalanus sp.*	C4	Very sparse
		Centropagidae	*Centropages sp.*	C5	Very sparse
	Cyclopoida	Oithonidae	*Oithona sp.*	C6	Abundant
	Harpacticoida	Ectinosomatidae	*Microsetella* sp.	C7	Very sparse
		Euterpinidae	*Euterpina sp.*	C8	Very sparse
Malacostraca	Mysida, Decapoda	Penaeidae	*Metapenaeus sp.*	M1	Very sparse
Appendicularia		Fritillariidae	*Fritillaria sp.*	U1	Very sparse
		Oikopleuridae	*Oikopleura sp.*	U2	Very sparse
Oligohymenophorea	Sessilida	Zoothamniidae	*Zoothamnium sp.*	CI1	Very sparse
Copepoda			Nauplius larvae of copepods	L1	Dominant
Malacostraca Decapoda			Brachyuran zoea	L2	Very sparse
Maxillopoda Thecostraca			Cirripede larvae	L3	Very sparse
			Cyphonautes larvae	L4	Very sparse
			Ophiopluteus larvae	L5	Very sparse
Gastropoda Streptoneura			Opisthobranchia larvae	L6	Very sparse
Polychaeta			Trochophore larvae	L7	Sparse
Pelecypoda			Veliger larvae of bivalves	L8	Very sparse

TABLE 67 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPT OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING NEAP TIDE OF DECEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnus sp.*	T1	Abundant
		Codonellidae	*Tintinnopsis failakkaensis*	T2	Very sparse
			Tintinnopsis gracilis	T3	Very sparse
			Tintinnopsis radix	T4	Scattered
		Xystonellidae	*Favella sp.*	T5	Very sparse
Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Very sparse
			Parvocalanus sp.	C2	Very sparse
		Centropagidae	*Centropages sp.*	C3	Very sparse
	Cyclopoida	Oithonidae	*Oithona sp.*	C4	Sparse
	Harpacticoida	Euterpinidae	*Euterpina sp.*	C5	Very sparse
		Ectinosomatidae	*Microsetella* sp.	C6	Very sparse
	Poicilostomatatoida	Corycaeidae	*Corycaeus sp.*	C7	Very sparse
Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse
Appendicularia		Fritillariidae	*Fritillaria sp.*	U1	Very sparse
		Oikopleuridae	*Oikopleura sp.*	U2	Very sparse
Copepoda			Nauplius larvae of copepods	L1	Dominant
Ascidiacea			Ascidian tadpole larvae	L2	Very sparse
Malacostraca Decapoda			Brachyuran zoea	L3	Very sparse
Maxillopoda Thecostraca			Cirripede larvae	L4	Very sparse
Gastropoda Streptoneura			Opisthobranchia larvae	L5	Very sparse
Polychaeta			Trochophore larvae	L6	Very sparse
Pelecypoda			Veliger larvae of bivalves	L7	Very sparse

TABLE 68 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPT OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING SPRING TIDE OF DECEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnus sp.*	T1	Scattered
		Codonellidae	*Tintinnopsis failakkaensis*	T2	Very sparse
			Tintinnopsis radix	T3	Sparse
		Xystonellidae	*Favella sp.*	T4	Very sparse
Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Very sparse
			Parvocalanus sp.	C2	Very sparse
		Centropagidae	*Centropages sp.*	C3	Very sparse
	Cyclopoida	Oithonidae	*Oithona sp.*	C4	Abundant
	Harpacticoida	Euterpinidae	*Euterpina sp.*	C5	Very sparse
		Ectinosomatidae	*Microsetella* sp.	C6	Very sparse
	Poicilostomatatoida	Corycaeidae	*Corycaeus sp.*	C7	Very sparse
Appendicularia		Fritillariidae	*Fritillaria sp.*	U1	Very sparse
		Oikopleuridae	*Oikopleura sp.*	U2	Very sparse
Copepoda			Nauplius larvae of copepods	L1	Dominant
Malacostraca Decapoda			Brachyuran zoea	L2	Very sparse
Maxillopoda Thecostraca			Cirripede larvae	L3	Very sparse
Gastropoda Streptoneura			Opisthobranchia larvae	L4	Very sparse
Polychaeta			Trochophore larvae	L5	Sparse
Pelecypoda			Veliger larvae of bivalves	L6	Very sparse
			Unidentified nematodes	N1	Very sparse

BENTHIC ORGANISMS:

Few Benthic organisms were observed in the collected sediments by using the Van-veen grabs during the sampling conducted during spring tide period and Neap tide period from DPT harbour region and nearby creek. The meio-benthic organisms during spring tide were represented by Polychaetes *Nereis sp.*, during Neap tide by *Neries sp.*, *Cossura sp.*, *Heteromastus sp.* Population of benthic fauna was varying from 0-30- N/m^2 during spring tide and 10-40 N/m^2 during Neap tide. The benthic communities at path finder Creek were represented by Polychaetes *Heteromastus sp.* and Notomastus sp. Their population was varying as 20 N/m^2 at OOT jetty premises and 40 N/m^2 near the SPM area during spring tide and 50 N/m^2 at OOT jetty premises and 70 N/m^2 near the SPM area during Neap tide period.

Table 69 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPT HARBOUR AREA CREEKS DURING SPRING TIDE IN DECEMBER 2022

ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS						
REPRESENTATION BY GROUP	DPT HARBOUR			CREEKS		
Benthic fauna						
POLYCHAETES	DPA-1	DPA-2	DPA-3	DPA-4	DPA-5	DPA-6
Family: NEREIDAE *Nereis sp.*	10	0	0	20	30	NS
TOTAL Benthic Fauna NUMBER/ M^2	10	0	0	20	30	NS

NS : No sample

Table 70 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPT HARBOUR AREA CREEKS DURING NEAP TIDE IN DECEMBER 2022

ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS						
REPRESENTATION BY GROUP	DPT HARBOUR			CREEKS		
Benthic fauna						
POLYCHAETES	DPA-1	DPA-2	DPA-3	DPA-4	DPA-5	DPA-6
Family : NEREIDAE *Nereis sp.*	20	30	10	10	20	NS
Family; Cossuride *Cossura sp.*	10	0	10	0	10	
Family; Capitellidae *Heteromastus sp.*	0	0	0	0	10	NS
TOTAL Benthic Fauna NUMBER/ M^2	30	30	20	10	40	

Table 71 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPT OOT JETTY AREA, VADINAR DURING SPRING TIDE IN DECEMBER 2022

ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS		
REPRESENTATION BY GROUP	OOT Jetty Area	SPM area
POLYCHAETES		
Family; Capitellidae *Heteromastus sp.*	20	40
TOTAL Benthic Fauna NUMBER/ M^2	20	40

Table 72 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPT OOT JETTY AREA, VADINAR DURING NEAP TIDE IN DECEMBER 2022

ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS		
REPRESENTATION BY GROUP	OOT Jetty Area	SPM area
POLYCHAETES		
Family; Capitellidae *Heteromastus sp.*	40	50
Family : Capitellidae *Notomastus* sp.	10	20
TOTAL Benthic Fauna NUMBER/ M^2	50	70

11.0 Conclusive Summary and Remedial measures Suggested

- The AAQ monitoring of six locations at Deendayal Port Authority indicates that the mean PM_{10} values for four locations viz. Marine Bhavan, Oil Jetty, Estate Office and Coal storage area were found higher than the permissible limit (standards100 µg/m^3) while $PM_{2.5}$ were higher at Marine Bhavan and Coal storage (60 µg/m^3). The higher concentration of Particulate matter at Marine Bhavan may be due to vehicles emissions during loading-unloading of food grains and timbers; at Estate office due to construction work, vehicles emission produced from trucks, heavy duty vehicles that pass through the road outside Kandla port and Oil jetty area; while at Coal Storage area lifting of coal from grab yard and other coal handling processes. Moreover, the transportation of coal produces pollution from heavy vehicles. At Tuna port location and Gopalpuri Location, the concentration all parameter was within the standard limit. The concentration of PM_{10} at Gopalpuri was varied from 92-109 µg/m^3 while mean value was 98 µg/m^3 and $PM_{2.5}$ concentration ranged from 35-56 µg/m^3 while mean value was observed 46.0 µg/m^3 which were within the prescribed standard limit (100 µg/m^3 and 60µg/m^3), At Tuna port the concentration of PM_{10} was ranged from 78-59 µg/m^3 while mean was 67 µg/m and the concentration of $PM_{2.5}$ ranged was 26-40 µg/m^3 and mean was 33 µg/m^3 which were within the standard limit (100 µg/m^3 and 60µg/m^3) prescribed by NAAQS.
- At Vadinar, the average concentration of PM_{10} was 108 µg/m^3 and $PM_{2.5}$ was 40 µg/m^3 at Admin Colony, the average PM_{10} concentration 99 µg/m^3 and $PM_{2.5}$ 38 µg/m^3 was at Signal building which was within the standard limit.
- During winter, the concentration of PM_{10} and $PM_{2.5}$ has been slowly augmented and reached a peak in the evening due to surface inversion of temperature after sunset. Thus, the pollutants are subsequently trapped in the lower layer of the atmosphere due to high atmospheric air pressure.
- Further, precautionary measures and management strategies to minimize the effect of particulate as well as gaseous pollutants have also been suggested for achieving its ambient levels in and around Kandla Port and Vadinar Port, Gujarat, India.
- Drinking water at all the twenty locations was found potable and it was found within in line of BIS standards (IS: 10500-2012).

- Transportation systems are the main source of noise pollution in project areas. Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. All sampling location were within the permissible limit day time 75 dB (A) and night time 70 dB (A) for the industrial area.

- The treated sewage water of Kandla STP, Deendayal Port Colony (Gopalpuri) STP and Vadinar were in line with the standards set by the Central Pollution Control Board.
- It was suggested to monitor the STP performance on regular basis to avoid flow of contamination / Polluted water into the sea.
- Good species diversity suggests a relatively successful species in this habitat. A greater number of successful species and a more stable ecosystem. More ecological niches are available and the environment is less likely to be hostile complex food webs environmental change is less likely to be damaging to the ecosystem as a whole.
- The results obtained from the study for biological and ecological parameters in marine water for Arabian Sea at surrounding area of Deendayal Port Authority (DPA) Kandla and Vadinar were not affected by Port activities.
- The mean day time temperature at Deendayal Port was 25.20 °C. The day-time maximum temperature was 28.30°C and minimum was 21.7 °C. The mean night time temperature recorded was 24.33 °C. The night-time maximum temperature was 26.60°C and minimum was 22.15 °C. The mean Solar Radiation in December 1st December 2022 to 15th December 2022 was 89.76 w/m^2. The maximum solar radiation was recorded 606.1 w/m^2 in 4th December, 2022 and the minimum solar radiation was recorded 0.0 w/m^2 in December, 2022. The mean Relative humidity was 60.25 % for the 1st December 2022 to 15th December 2022 of December. Maximum Relative humidity was recorded 79.0 % and minimum Relative humidity was recorded 38.0 %. The average wind velocity for the entire 1st December 2022 to 15th December 2022 of December was 3.07 m/s. Maximum wind velocity was recorded 9.0 m/s. The wind direction was mostly North-East.
- The results obtained from the study for the 1st December 2022 to 15th December 2022 of December 2022 for biological and ecological parameters in marine water for Arabian Sea at surrounding area of Deendayal Port Authority (DPA) Kandla and Vadinar were not affected by Port activities.

Reasons for higher Values of PM_{10}

- The unloading of coal directly in the truck, using grabs cause coal to spread in air as well as coal dust to fall on ground. This settled coal dust again mixes with the air while trucks travel through it.
- Also, the coal loaded trucks were not always covered with tarpaulin sheets and these results in spillage of coal from trucks/dumpers during its transit from vessel to yard or storage site. This also increased PM values around marine Bhavan & Coal storage area.

Remedial Measures

The values of PM_{10} & $PM_{2.5}$ during the 1st December 2022 to 15th December 2022 of December, 2022 were beyond the standard limit at 4 locations (Marine Bhavan, Estate office Oil Jetty and Coal storage) at Gopalpuri and Tuna Port concentration of particulate matter was within the standard limit. Given below are the remedial measures suggest to minimize the Air pollution.

- During 1st December 2022 to 15th December 2022 overall ambient air quality of the DPA was within CPCB permissible limits except TSPM, PM_{10}, $PM_{2.5}$ at Coal storage area, Marine Bhavan, Oil Jetty. To improve air quality the port was using number of precautionary measures, such as maintained a wide expanse of Green zone, initiated Inter-Terminal Transfer (ITT) of tractor-trailers, Centralized Parking Plaza, providing shore power supply to tugs and port crafts, the use of LED lights at DPA area helps in lower energy consumption and decreases the carbon foot prints in the environment, time to time cleaning of paved and un paved roads, use of tarpaulin sheets to cover dumpers at project sites etc. are helping to achieve the cleaner and green future at port.

Solution towards the Green port:

Today, it is increasingly recognized that air pollution hurts human health. Consequently, efficient mitigation strategies need to be implementation for substantial environmental and health co-benefits.

The guidelines can be considered a basis for governments for the implementation of a strategic plan focused on the reduction of multi pollutant emission, as well as of the overall air pollution related risk.

- The plantation should be all along the periphery of the port and inside and outside the port along with the road. Trees having high dust trapping efficiency (*Azadirachta indica, Cassia fistula, Delonix regia, Ficus religiosa, Pterocarpus marsupium*) are to be grown alongside the roads.
- The water sprinkling should be use at each and every stage of transporting coal up the loading of truck to avoid generation of coal dust.
- The vehicles should be covered during transportation and the vehicle carrying the coal should not be overloaded by raising the height of carriage.
- The water sprinklers should be use during transportation of loaded heavy vehicles on raw road.
- It should be ensuring that regular sweeping of coal internal, main road and space a free circulation.
- Practice should be initiated for using mask as preventative measure, to avoid Inhalation of dust particle- Mask advised in sensitive areas.
- Department for use maintenance should have a routine checkup noise level by replacing bearings, tights of all loose parts that can vibrate.
- Speed control is also an effective way to mitigate noise pollution, the lowest sound emission arises from vehicles moving smoothly.
- Use of renewable energy like solar energy should be optimal and ensure to work continuously.
- Keep neat and clean public transport and all basic items at public interaction places as much as possible.
- Technology like Electric cart, Inter-Terminal Transfer (ITT) are worthy selection to reduce Port operation efficiency and fuel cost.
- Conventional RTGCs should be altered as E-RTGCs counting inside the port completely.
- Initiate Natural Gas (CNG) as fuel by all buses and trucks.

Green Ports Initiative

- Deendayal Port is committed to sustainable development and adequate measures are being taken to maintain the Environmental well-being of the Port and its surrounding environs. Weighing in the environmental perspective for sustained growth, the Ministry of Shipping had started "Project Green Ports" which will help in making the Major Ports across India cleaner and greener. "Project Green Ports" will have two verticals - one is "Green Ports Initiatives" related to environmental issues and second is "Swachh Bharat Abhiyaan".

- The Green Port Initiatives include twelve initiatives such as preparation and monitoring plan, acquiring equipments required for monitoring environmental pollution, acquiring dust suppression system, setting up of waste water treatment plants/ garbage disposal plant, setting up Green Cover area, projects for energy generation from renewable energy sources, completion of shortfalls of Oil Spill Response (OSR) facilities (Tier-I), prohibition of disposal of almost all kind of garbage at sea, improving the quality of harbour wastes etc.

- Deendayal port has also appointed GEMI as an Advisor for "Making Deendayal Port a Green Port - Intended Sustainable Development within the Green Port Initiatives.

- Deendayal Port has also signed MOU with Gujarat Forest Department in August 2019 for Green Belt Development in an area of 31.942 Ha of land owned by Deendayal Port Trust. The plantation is being carried out by the Social Forestry division of Kachchh.

ANNEXURE – G

Statement of 1600 Ha mangrove Plantation

DEENDAYAL PORT TRUST

DETAILS OF MANGROVE PLANTATION ALREDY CARRIED OUT & Proposed To be Carried Out:

Sr. No.	Name of the Organization	Total Mangrove Plantation carried out in Hectares till date and place of plantation and agency	Cost incurred
	(A)MANGROVE PLANTATION ALREDY CARRIED OUT		
1	DEENDAYAL PORT TRUST (CRZ Recommendation 13th to 16th CB issued by the GCZMA) (Total 1000 ha.)	20 Hectares – 2005-06 Satsida Bet,Kandla, by GUIDE,Bhuj 50 Hectares – 2008-09 Nakti Creek,Kandla by Patel Construction 100 Hectares – 2010-11 Nakti Creek ,Kandla by GEC. (Board 29/1/2010) 200 Hectares – 2011-12 by Forest Department, GoG at Satsaida Bet	Rs. 8.8 lakhs Rs. 27.4 lakhs Rs.24.5 lakhs Rs. 66.5 lakh Rs. 157.5 lakhs (total 630 hectares)
2	Creation of Berthing & allied Facilities off- tekra near Tuna (Outside Kandla Creek) – EC & CRZ Clearance. (Total 500 ha. – 250Ha. by DPT & 250 ha by Adani (concessionaire) MOU signed with GEC during Vibrant Gujarat	300 Hectares – 2015-17 by GEC at Kantiyajal, Bharuch District	Rs. 90.0 lakhs
3.	EC & CRZ Clearance dated 19/12/2016 for Developing 7 integrated facilities (Condition 100 Ha)	100 Ha. –2018- 20 by GEC	Rs. 45 lakhs
4.	EC and CRZ Clearance dated 18/02/2020 (Dev of 3 remaining facility) and EC and CRZ Clearance dated 19/02/2020(Development of Integrated facilities 5 projects (Stage II) Ref : CRZ recommendation GCZMA 100 ha (50+50 Ha)	100 ha by GEC 2021-22 (Kantiyajal, Bharuch)	Rs 45 Lakhs
TOTAL MANGROVE Plantation till date by DPT 1500 Ha. – Total 464.7 lakhs			

(A) Proposed Mangrove Plantation			
1.	**CRZ recommendation outfitting jetty & floating dry Dock at Vadinar by DPA**	**100 Ha by GEC (work in progress)work order dated 02/06/2022**	**Rs 50 Lakhs**

ANNEXURE – H

Mangrove Conservation and Management Plan
Jan – April 2015

Study on present status, Conservation and Management Plan for mangroves of Kandla Port Region

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R.V. Asari, IFS (Rtd.,)
Director

Gujarat Institute of Desert Ecology

17.08.2015

Certificate

Kandla Port Trust has extensive mangrove formations within its port limits. In order to study different ecological characters of these mangroves and to draw a scientific conservation and management plan, Kandla Port Trust approached Gujarat Institute of Desert Ecology, Bhuj for undertaking an environmental assessment of the mangrove formations with regard to its ecological status, which included baseline documentation, forest structure and a detailed conservation and management plan. Thus, GUIDE undertook this study and carried out field surveys, and sampling in representative mangrove stands in order to prepare this report.

This report presents various ecological status of mangrove formations within Kandla Port area and suggest a detailed conservation and management plan to be considered by the port authorities for execution. This project report forms a baseline document indicating the baseline status and conservation plan for the mangroves which could be used to ensure long term conservation and management of Kandla Port mangroves.

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1. INTRODUCTION:

Kandla Port is located in the Gulf of Kachchh on the northwest coast of India about 430 nautical miles northwest of the Port of Mumbai (Bombay) at the Latitude of 23° 01' N and Longitude of 70° 13' E on the shoreline of the Kandla Creek. The Kandla creek runs into the Gulf of Kachchh, approximately at a distance of 90 nautical miles from the Arabian Sea. The width of the channel varied between 200 meters to 1,000 meters. It is a leading port of India by capacity of cargo handled. Kandla Port as one of India's busiest major port, is gearing to add substantial cargo handling capacity with private sector participation. It handled 72.225 million tonnes of cargo in 2008-09, over 11% more than 64.9 million tonnes handled in 2007-08.At present, Kandla Port handled 87.005 MMTPA Cargo during 2013-2014 and 92.5 MMTPA during the financial year of 2014-2015. Against this capacity, a total of 87.005 MMTPA was handled at Kandla Port resulting in berth occupancy exceeding 80% at general cargo berths in 2013-14. Consecutively, to reduce the pressure on the existing berths and increase the capacity of dry and liquid cargo handling, Kandla Port Trust has developed new Barge Jetty at Tuna, Khori Creek and a new Oil Jetty at old Kandla. Other project for strengthening and upgrading existing facilities at Kandla Port is on the anvil.

Mangroves are a conspicuous ecological entity within Kandla Port area. Similar to other forest ecosystem they discharge multiple ecological services such as production of woody trees; provision of habitat, food, and nursery/spawning grounds for fin-fish and shellfish; provision of habitat for birds and other valuable fauna; protection of coastlines and accretion of sediment to form new land. There are also many economic benefits from mangrove resources; like as a source of firewood, self-replenishing area of fishery resources, for collecting honey and for tourism.

1.1 Origin of the Study:

Due to the major port activities and accompanying development, mangroves within the premises of KPT have possible for its vegetation structure modification over the years. Consequently, conservation and management of this mangrove formation has become imperative and an environmental responsibility of the Kandla

port authority. In view of the continued port expansion and development, Department of Forest and Environment, Government of Gujarat (GOG), Gandhinagar has mandated KPT to investigate the current ecological status of mangroves in the KPT premises through proper scientific assessment and formulate long term conservation and management plan. Kandla Port authorities assigned the task of investigating the mangrove ecology within the port jurisdiction to Gujarat Institute of Desert Ecology (GUIDE), Bhuj. The present study aims to come out with a sound conservation and management plan for mangroves of Kandla Port based on intensive field visits, analyzing the existing management practices of the port *vis-à-vis* mangroves and plantation and other conservation activities carried out by port authorities under different projects of the port.

1.2 Objective of the Present Study:

Suggesting management different management options with a view to conserve mangrove ecosystem within Kandla Port premises on a long term basis is the major objective of the present study. The present investigation is instituted with the following objectives.

1. This study aims to investigate thoroughly the present status of mangroves in terms of vegetation structure such as density, diversity, height, canopy dimensions and younger classes along with governing physical and chemical features of mangroves formations falling within the legal boundary of Kandla Port at Kandla, Gandhidham taluka of Kachchh.

2. Suggest a detailed plan for a holistic and long term management and conservation in order to ensure the long term wellbeing of mangroves of Kandla Port.

3. Review the mangrove plantation carried out so far by the port authorities, future mangrove plantation/rehabilitation plan, monitoring actions to be initiated in order to conserve/preserve the mangrove stands which will ward-off stand degradation in future.

4. Quantify the mangrove extent in terms of dense, sparse and other allied land cover such as mudflats, salt works, water etc by the application of GIS and RS technique.

2. STUDY AREA DESCRIPTION:

2.1 Location:

Kandla port is located in the northern coast of gulf of Kachchh (GoK) almost at its tail end (Map 2.1). Being in the arid zone, annual rainfall within the geographical range of Kandla Port is poor ranging from 250-350 mm which is often irregular. Mean rainfall (1932 to 2001) was 387 and 378 mm in the Gandhidham taluka where Kandla is located. Rain during monsoon is confined to only 15-20 days and occurs as an instant downpour. The weak monsoonal rainfall and high rate of evaporation not only make the area arid but also causes elevation in seawater salinity. Freshwater input into the near coastal waters is quite meagre and appears to have least influence on the ambient coastal water quality except during monsoon months, during which flash floods are discharged in the near coastal waters. Throughout the year, the winds are light to moderate in the Gulf except during late summer and southwest monsoon periods. Stronger winds are also encountered with the disturbances such as depressions and cyclones. Winter and summer temperatures range from 7- 48°C with a yearly average humidity of 60% which increases to 80% during south-west monsoon and decreases to 50% during November-December. Average wind speed is 4.65 m/s with a maximum wind speed of 10.61 m/s during June. Tides in the port environment are mixed, predominantly semidiurnal type with Mean High Water Spring (MHWS) of 6.66 m and Mean High Water Neap (MHWN) of 5.17 m. Mangroves within the port limits are predominantly composed of *Avicennia marina,* a species known for its high tolerance of water salinity and other environmental stresses with sporadic distribution of *Ceriops tagal*.

Kandla is a seaport in Kachchh district of Gujarat state in western India which runs into the Gulf of Kachchh at a point about 90 nautical miles from the Arabian Sea. One the major ports on west coast, Kandla was constructed in the 1950 as the chief seaport serving western India. The total length of the Kandla Port approach channel is

about 23 Km High tidal influences with low turnover time characterize Kandla creek. Kandla creek (22^0 55'- 23^0 5' N and 70^0 05'- 70^0 02' E) is one of the major creeks along the NW coast of India supplying water to the inner GoK which is an east- west oriented indentation. GoK is 75km wide at the mouth and after running about 170km away from the Arabian sea towards east, narrows down into a constriction at 70^0 20' E at Sathsaida Bet and then bifurcates into a creek system called the Little Rann.The Little Rann has a network of so many small and large creeks, intermingled with marshy tidal flats rich in fine clays. Kandla creek is one of the major tributaries of this creek system, which empties into the inner GoK. Two large creeks , Sara and Phang creeks join the Kandla creek and act as its tributaries. Nakti creek also joins the confluence of Sara and Phang creeks. All these creeks bring water from the Little Rann into Kandla creek, which has a fairly good depth and stable banks. The width of the creek channel varies from 200 m in the upstream to 1000m at the mouth and the depth varies from 8 to 12 m, while the tidal height ranges from 0.83 to 7.2m, with tidal currents varying from 0.08 to 2 m/s (Sinha *et al*. 2006)

Kandla port is located along the western bank of Kandla creek. The protruding Indus River brings heavy sediment load into the creek lowering its primary productivity. Sampling site at Kandla is located around 100 m away from the oil jetty of the port. Ongoing expansive drive of the port and establishment of many SEZs in and around the nearby Gandhidham Township has provided renewed impetus for this coastal town to proliferate further. Various industrial- chemical manufacturing units, fertilizer- manufacturing industry (IFFCO), salt manufacturing units with salt pans rich in brines occur around the Kandla creek. There are a total of six jetties in the creek used by the KPT, Indian Oil and IFFCO for handling liquid bulks, POL, fertilizers, raw materials, industrial chemicals, iron and steel, food grains, metal and its products, mineral ore and other dry cargo, etc. The port facilitates extensive traffic of oil tankers, freighters, passenger cargo vessels, ore carriers, fishing boats and container vessels in Kandla creek.Presence of a major port with heavy vessel traffic activities are temporarly distrub the creak water quality. These activities generate different types of waste , which act as potential sources of contamination. Irrespective

of their source of contribution, these contaminants from natural as well as human activities are ultimately distrub the creek water quality.

Figure 2.1: Shows the location map of the study area

2.2 Study Period:

The present field study for KPT mangrove monitoring was carried out in January 2015to April 2015.

3. VEGETATION STRUCTURE OF MANGROVES:

Mangroves are the most important salt tolerant trees of the intertidal areas (Kathiresan and Bingham, 2001). It is one of the most productive and bio-diverse wetlands on earth. Inhabiting the inter-tidal areas and estuary mouths between land and sea, mangroves provide critical habitat for a diverse marine and terrestrial flora and fauna. They normally grow poorly in stagnant waters and have luxuriant growth in the alluvial soil substrates with fine textured loose mud or silt. The diversity variability features of mangroves that occur within the inundated areas such as creeks, mudflats, salt-flats, or partially forested areas with dwarfed or sparsely distributed trees.

Vegetation structure is determined by the species diversity, relative densities of constituent species, overall density of the stand, basal area that represents the size of the plant girth and height. The vegetation structure of mangroves provides an indication of its functional capacity which has a bearing on fisheries, forestry and global climate due to its high carbon sequestration potential (Ong et al., 1993).

3.1 Methodology:

The vegetation structure of the present investigation was carried out at diverse representative sites of mangrove formations within the legal boundary of Kandla Port. Generally, KPT mangrove formations can be classified dense and sparse mangroves. Vegetation structure assessment was carried out during low tides by quadrate method by laying plots of 10 × 10m (Figure 3.1). For assessing the mangrove formations along the creeks systems, a fishing boat was used. In total, twenty one random sampling was carried out in the mangrove formations of the port premises representing different landscapes like dense mangroves and sparse mangroves in order to render the sampling truly representative. In each plot, the total numbers of mature trees along with the corresponding height (Figure 3.2), canopy dimension and tree girth-GBH (Figure 3.3) were recorded. At few places, Point Centre Quarter method was also used for the density assessment (Cottam et al. 1953).

Figure 3.1: Analysis of density by using 10 x 10 m quadrate

Figure 3.2: Measurement of tree height

Figure 3.3: Measurement of tree girth

To enumerate younger classes such as regeneration and recruitment classes, subplots of 1×1 m and 2×2 m were laid randomly in all the bigger plots of 10 × 10m. Younger plants less than 50 cm are considered as regeneration class and recruitment class represents the well established saplings which are more than 50cm but less than 1m tall. Density of mature trees, regeneration and recruitment class for each station was expressed as number per hectare (No/ha) extrapolating the data obtained for lesser units. Frequency class was analyzed in order to distinguish the location wise distribution, diversity, structure and composition of different age classes like tree height, GBH, canopy length and canopy width.

3.2 Result:

Overall vegetative structural characteristics of mangroves such as density, height, GBH and regeneration class, recruitment class and frequency classes (in order to distinguish the location wise common vegetation structure, composition of different age and growth classes) recorded in the Kandla Port premises are presented in table 3.1 and 3.2, respectively.

3.2.1 Mangrove Diversity:

During the entire study period (January to April 2015) *Avicenna marina* was the most predominant species with the sporadic occurrence of *Cereops tagal* and *Rhizophora mucronata*. In only one study site *Aegiceros corniculatum* was observed out of the study quadrate. Mangrove diversity of KPT region is comparatively higher than any other mangroves patches of Kachchh coast.

3.2.2 Mangrove Density:

The cumulative average mature tree density of 4124/ha was recorded from 21 sampling locations (Table 3.1). The occurrence of highest density of 7800tree/ha was recorded at 23°10'41.6″N; 70°35'35.4″E. as, the site is located near the water front receiving good tidal waters. Least mature tree density of 1500 trees/ha was estimated at 23° 08' 13.2″ N; 70° 18' 19.8″ E. Generally, recorded mature tree density is comparable with other healthy mangrove formations of Gulf of Kachchh (Thivakaran *et al.,* 2003).

3.2.3 Tree Height:

Mangrove stands of Kandla port showed significant variation in tree height. The overall average height of the mangroves at 21 sampled locations was 254 cm with the highest plant height of 391 cm recorded at the location 23° 02’ 24.9 N; 70° 13’ 45.4 E (Table 3.1). The overall height frequency of the mangrove stands from 21 sampling locations, revealed that the majority of the mangrove stands fall in the height class of 51-150 cm (Figure 3.4).

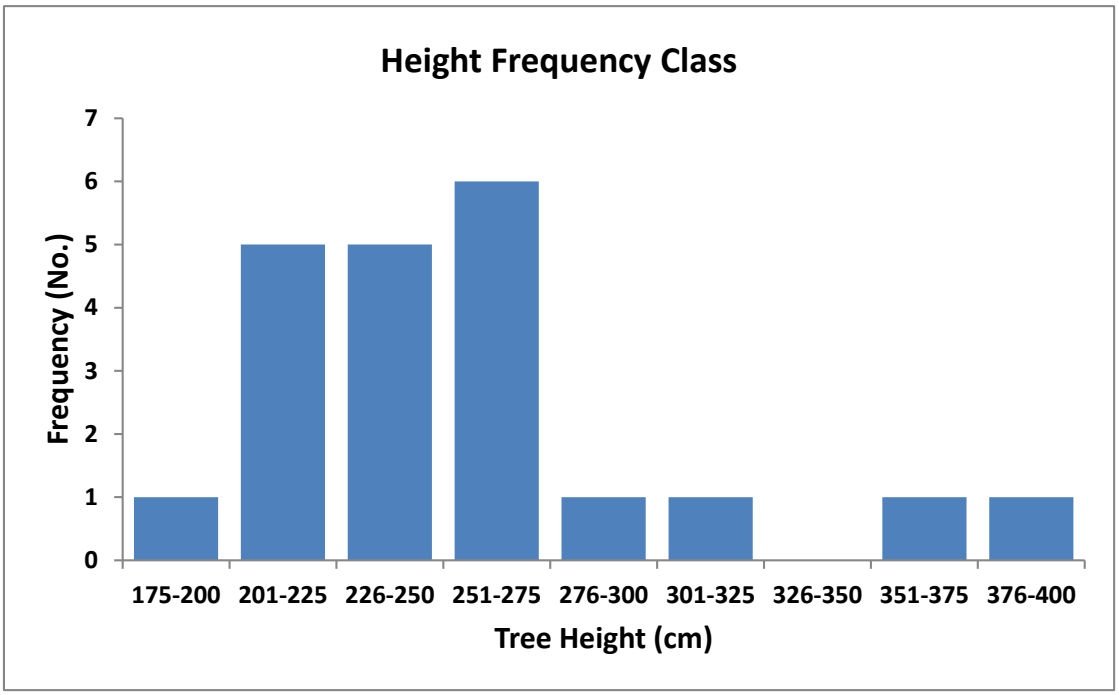

Figure 3.4: Height frequency class of sampled mangrove stands at KPT

3.2.4 Tree Girth (Girth at Breast Height-GBH):

Average tree girth (circumference) of mature trees at 21 sites ranged from 33.5 cm to 53 cm. The overall average girth based on the mean of all the 21 plots was 40.4cm (Table 3.1). During the present study very few transect showed the girth ranges of 34and 39 cm at 23° 03' 41.1″ N; 70°15'27.5″E; 23°02'48.3″N; 70°13'34.0″E, respectively. Majority of the mangrove girth were in the frequency class of 5.1 to 10cm (Figure 3.5).

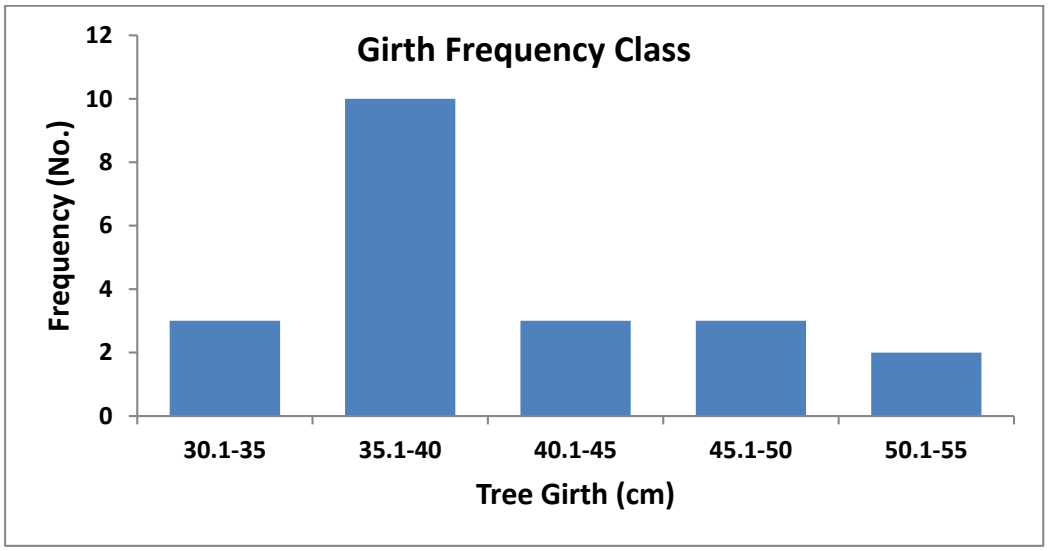

Figure 3.5: GBH freqency class ofsampled mangrove stands at KPT

3.2.5 Canopy Length (cm):

Average canopy length of mangrove was assessed at 21 sampled plots which varied from 159.5 cm to 325 cm. Cumulative average value canopy length based on the mean value of all the plots was 222.9 cm (Table 3.1). The coordinates of KPT at 23° 05'07.1N;70° 16' 25.2 E showed few trees with highest canopy length. The overall canopy length frequency class of all the mangrove formations exhibited that majority of the mangrove stands fall in the ranges of 51-100 cm (Figure 3.6).

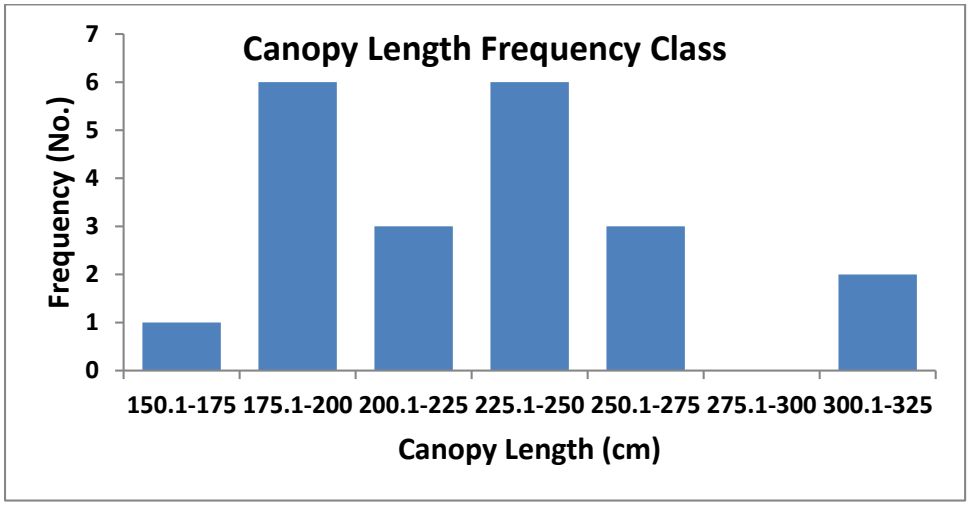

Figure 3.6: Canopy length freqency class of sampled mangrove stands at KPT

3.2.6 Canopy Width (cm):

Average canopy width of the mangrove studied at various plots ranged from 154 cm to 289.5 cm. The overall average canopy width of all the studied sampling plots was 208.4cm (Table 3.1). Mangroves at the coordinates 23° 05' 10.4 N; 70° 16' 25.2 E showed highest canopy width. The cumulative canopy width frequency of all the plots fall in the range of 51 to 100 cm (Figure 3.7).

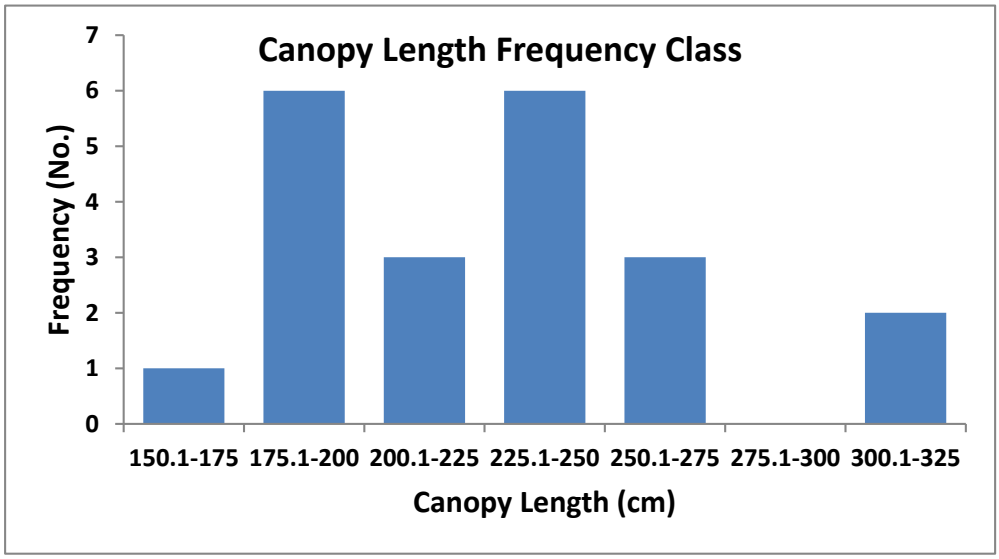

Figure 3.7: Canopy width freqency class of sampled mangrove stands at KPT

Table 3.1: Mangrove vegetation structure and classification carried out during the study

S. NO	GPS Coordinates	Density/ha	Height (cm)			Girth (cm)			Canopy Length (cm)			Canopy Width (cm)		
			Min	Max	Ave.	Min	Max	Ave.	Min	Max	Ave.	Min	Max	Ave.
1	23° 03' 41.1″ N;70° 15' 27.5″ E	3300	193	537	365	40	66	53	168	443	305.5	146	417	281.5
2	23° 02' 48.3″ N ;70° 13' 34.0″ E	2200	167	328	247.5	38	53	45.5	147	327	237	125	319	222
3	23° 02' 24.9″ N; 70° 13' 45.4″ E	3800	208	574	391	41	61	51	193	457	325	168	411	289.5
4	23° 01' 58.8″ N ;70° 15' 27.5″ E	3400	196	326	261	31.8	41.3	36.55	185	345	265	157	328	242.5
5	23° 01' 52.5″ N; 70° 15' 29.1″ E	2400	210	293	251.5	29	44	36.5	132	223	177.5	127	211	169
6	23° 02' 5.9″ N ; 70° 16' 00.7″ E	6800	157	274	215.5	30	47	38.5	98	263	180.5	89	243	166
7	23° 03' 45.3″ N; 70° 13'37.21″ E	3200	197	335	266	40	51	45.5	165	290	227.5	149	273	211
8	23° 06' 55.6″ N ;70° 16' 36.7″ E	7500	157	375	266	29	50	39.5	132	187	159.5	127	181	154
9	23° 06' 55.0″ N; 70° 16'25.5″ E	3500	154	261	207.5	28	53	40.5	130	233	181.5	119	239	179
10	23° 06' 52.5″ N; 70° 16' 25.5″ E	2100	159	335	247	28	49	38.5	138	307	222.5	126	293	209.5
11	23° 08'13.2″ N ;70° 18'19.8″ E	1500	183	302	206	31	44	37.5	156	295	225.5	143	282	212.5
12	23° 08' 20.9″ N; 70° 18' 16.6″ E	2100	165	247	213.5	28	39	33.5	139	218	178.5	127	203	165
13	23° 08' 29.7″ N ;70° 18' 17.8″ E	3500	157	270	192.5	29	40	34.5	134	242	188	122	219	170.5
14	23° 05' 03.5″ N; 70° 16' 18.0″ E	2800	155	230	272	28	40	34	136	215	175.5	124	209	166.5
15	23° 05'07.1″ N ;70° 16'23.8″ E	3400	154	390	280.5	28	48	38	128	375	251.5	111	347	229
16	23° 05' 10.4″ N; 70° 16' 25.2″ E	6800	166	395	243	28.5	65	46.75	132	383	257.5	124	369	246.5
17	23° 10' 35.9″ N ;70° 35' 28.2″ E	5900	159	330	238.5	29	50	39.5	142	327	234.5	131	314	222.5
18	23° 10' 38.6″ N; 70° 35' 31.3″ E	5700	162	324	269.5	30	48	39	145	294	219.5	128	281	204.5
19	23° 10' 30.6″ N; 70° 35' 28.3″ E	6200	163	314	254.5	30	50	40	142	311	226.5	135	303	219
20	23° 10' 36.5″ N ;70° 35' 39.0″ E	2700	165	374	229.5	33	55	44	151	257	204	139	244	191.5
21	23° 10' 41.6″ N; 70° 35' 35.4″ E	7800	160	349	214.5	28	46	37	148	332	240	129	324	226.5
Overall mean		**4124**	**171**	**341**	**254**	**31**	**49.5**	**40.4**	**144.8**	**301.1**	**222.9**	**130.7**	**286.1**	**208.4**

3.2.7 Regeneration Class:

The cumulative average density of regenerating mangroves from 21 sampled locations exhibited 24286 plants/ha (Table 3.2), which ranged from 3300 plants/ha to 100000 plants/ha. The present investigation showed that regeneration potential of mangroves in the KPT premises is good. This regeneration result indicated that the study site is healthy environment for potential mangrove growth and further succession. The co-ordinates are closure to the water front (23° 06' 55.6″ N; 70° 16' 36.7) shows maximum number of regenerating mangroves.

3.2.8. Recruitment Class:

The overall average of recruitment class in the study area was 8888 plants/ha which varied from 1000 to 56600 plants/ha (Table 3.2). The recruitment class of present study was lower than mature tree density at KPT premises due to canopy covering and the resulting low exposure to sunlight. The mature tree density and younger classes (recruitment and regeneration) at Kandla port surroundings show higher regeneration potential of the mangroves. Density Investigation of younger classes like regeneration and recruitment classes are generally indicate that future vegetation structure of the mangrove will be extended. At the coordinate 23° 06' 55.6″ N; 70° 16' 36.7 mature tree to regeneration and recruitment classes ratio is high which indicating the healthiness of the stand and its ability to perpetuate the stand characteristics in future.

In general, majority of the sampled plots shows less floral associates. Only at few plots the floral associates like *Sueda*, *Salicornea* sp. and *Salvadora* sp. are present.

Table 3.2: Regeneration and Recruitment details of the sampling points.

S. No.	GPS	Species	Regeneration/ha	Recruitment Class/ha
1	23° 03' 41.1″ N; 70° 15' 27.5″ E	*A. marina*	17000	9000
2	23° 02' 48.3″ N 70° 13' 34.0″ E	*A. marina*	11000	7500
3	23° 02' 24.9″ N 70° 13' 45.4″ E	*A. marina*	38000	13000
4	23° 01' 58.8″ N 70° 15' 27.5″ E	*A. marina*	13300	5000
5	23° 01' 52.5″ N 70° 15' 29.1″ E	*A. marina*	6600	8350
6	23° 02' 5.9″ N 70° 16' 00.7″ E	*A. marina*	40000	5000
7	23° 03' 45.3″ N 70° 13'37.21″ E	*A. marina*	86600	10000
8	23° 06' 55.6″ N 70° 16' 36.7″ E	*A. marina*	100000	8300
9	23° 06' 55.0″ N ; 70° 16'25.5″ E	*A. marina*	6600	5000
10	23° 06' 52.5″ N ;70° 16' 25.5″ E	*A. marina*	6600	1600
11	23° 08'13.2″ N ;70° 18'19.8″ E	*A. marina*	3300	1600
12	23° 08' 20.9″ N ;70° 18' 16.6″ E	*A. marina*	3300	1000
13	23° 08' 29.7″ N ;70° 18' 17.8″ E	*A. marina*	6600	1600
14	23° 05' 03.5″ N ;70° 16' 18.0″ E	*A. marina*	6600	3300
15	23° 05'07.1″ N ;70° 16'23.8″ E	*A. marina*	6600	1600
16	23° 05' 10.4″ N ;70° 16' 25.2″ E	*A. marina*	16600	3300
17	23° 10' 35.9″ N ;70° 35' 28.2″ E	*A. marina*	60000	5000
18	23° 10' 38.6″ N ;70° 35' 31.3″ E	*A. marina*	55000	6600
19	23° 10' 30.6″ N ;70° 35' 28.3″ E	*A. marina*	10000	3300
20	23° 10' 36.5″ N ;70° 35' 39.0″ E	*A. marina*	8300	30000
21	23° 10' 41.6″ N ;70° 35' 35.4″ E	*A. marina*	8000	56600
Cumulative Average			**23423.81**	**8888**

4. PHYSICO-CHEMICAL PARAMETRS*:*

4.1 Introduction:

Range of physico-chemical parameters determines the creek water quality and assessing these parameters are essential in order to understand the governing factors of mangrove environment (Reddi et al., 1993). The mangrove system plays a major role in the global cycle of carbon, nitrogen and sulphur and acts as reservoirs of waste materials (Kathiresan and Bingham 2001; Kathiresan, 2000). Many works are available on the physical and chemical characters of some Indian estuaries and mangroves (Satpathy, 1996; Govindasamy et al., 2000; Rajasekar et al., 2003 and Asha and Diwakar 2007). Salinity, redox potential, pH and sulphide concentration in pore-water parameters play key roles in the development of mangroves and their spatial distributions. To cope with the variation of these properties, mangroves have developed many adaptations that give them wide ranges of tolerance. Additionally, climate, tidal flooding, vegetation evolution, bioturbation and organic matter content are parameters that also contribute to the complexity of the geochemistry of mangrove soil. The physico-chemical parameters like pH, pore-water salinity, sediment texture and Total Organic carbon (TOC) are direct indicators for the healthiness of mangrove stands and also influence vegetation structure of mangroves. In the present attempt some vital parameters that influence the mangrove vegetation structure have been studied and presented below.

4.2 Methodology:

4.2.1 Water Analysis:

Standard protocols (APHA, 1995) were followed for the sample collection and analysis. Water samples were collected using sterile polyethylene containers. Salinity (ppt- ‰) was estimated using a pre-calibrated Refractometer (Aatago–Japan). Collected pore water was analyzed for pH and Salinity.

4.2.2 Sediment Analysis:

Sediment samples of 1 kg weight were collected from random locations; two from each transect to cover the entire study area. The sediment texture was determined by the *Sand- Silt- Clay method* which is based on the particle size distribution after sieving the soil using grading sieves. The sediment texture results are expressed in percentage.

4.2.3 Pore-Water Analysis:

The pore water samples were collected from the random locations of the study site. About 20 cm pit was dug using a spade and water was allowed to seep inside the pit. The clean water in the pit was collected using a syringe from the surface to avoid sediment deposition (Figure 4.1).

Figure 4.1: Collection of Pore-water samples in the sampled locations of KPT

pH was measured in situ using a pre-calibrated handheld pH meter (Hanna make) and the salinity was determined by a Refractometer (Fisher Scientific). The basic nutrients (Nitrate, Nitrite and Phosphate) were determined within 6 hours of sampling. For all analysis protocol given in *Standard methods for the examination of*

water and wastewater, 17th Ed. by American Public Health Association (APHA, 1995) was followed.

4.3 Result:

4.3.1 Salinity:

Seawater salinity is the most important factor that determines many life processes of mangrove ecosystem. The surface water salinity concentration of the 21 sampled mangrove stands varied from 35 to 43‰ with an overall average value of 38.95‰ (Table 4.1). The surface salinity was maximum (43 ‰) at 23° 01' 58.8″ N 70° 15' 27.5″ E. The recorded values of surface salinity are very common in the mangrove ecosystem of Kachchh.

The pore water salinity of the present investigation ranged from 47 to 62‰ with an overall average value of 53.71 ‰. Pore-water salinity is uneven in all the 21 sampled locations of KPT. The pore water salinity was found to be maximum at 23° 05' 10.4″ N 70° 16' 25.2″ E. Pore-water salinity in general is influenced by tidal pattern.

4.3.2 Hydrogen Ion Concentration:

The water pH value was varied from 7.1 to 7.8 with a cumulative average value of 7.4. The pH concentration of the present study was maximum at 23° 06' 52.5″ N 70° 16' 25.5″ E. The pore-water pH ranged from 7.9 to 8.7 with a cumulative average value of 8.21(Table 4.1). The pore-water pH concentration is always higher than surface water pH which is very common in the mangrove environment.

Table 4.1: Physico-Chemical parameters of water in the sampled locations of KPT

		Temperature-°C		Salinity		pH	
Sample No	**Sampling Co-Ordinates**	**Surface Water**	**Porewater**	**Surface Water**	**Porewater**	**Surface Water**	**Porewater**
S1	23° 03' 41.1″ N; 70° 15' 27.5″ E	29	22	38	54	7.4	8.3
S2	23° 02' 48.3″ N; 70° 13' 34.0″ E	28.5	23.8	37	52	7.2	8.1
S3	23° 02' 24.9″ N; 70° 13' 45.4″ E	31.3	23.6	42	58	7.7	8.5
S4	23° 01' 58.8″ N; 70° 15' 27.5″ E	28	25.2	40	55	7.3	8.2
S5	23° 01' 52.5″ N; 70° 15' 29.1″ E	30.8	25.5	43	60	7.6	8.5
S6	23° 02' 5.9″ N; 70° 16' 00.7″ E	29	25.3	36	51	7.2	8.0
S7	23° 03' 45.3″ N; 70° 13'37.21″ E	31.2	28.2	35	47	7.6	8.5
S8	23° 06' 55.6″ N; 70° 16' 36.7″ E	28.2	25.5	37	49	7.3	8.1
S9	23° 06' 55.0″ N; 70° 16'25.5″ E	30.8	23.8	41	54	7.5	8.2
S10	23° 06' 52.5″ N; 70° 16' 25.5″ E	29.5	25.5	40	53	7.8	8.7
S11	23° 08'13.2″ N; 70° 18'19.8″ E	27.8	25.7	40	51	7.4	8.1
S12	23° 08' 20.9″ N; 70° 18' 16.6″ E	30	25	38	48	7.1	7.9
S13	23° 08' 29.7″ N; 70° 18' 17.8″ E	29.5	23	39	54	7.5	8.3
S14	23° 05' 03.5″ N; 70° 16' 18.0″ E	28.5	23.6	36	55	7.2	8.0
S15	23° 05'07.1″ N; 70° 16'23.8″ E	28.6	23	38	54	7.4	8.1
S16	23° 05' 10.4″ N; 70° 16' 25.2″ E	28.9	25.7	42	62	7.7	8.5
S17	23° 10' 35.9″ N; 70° 35' 28.2″ E	29.8	28.9	40	57	7.3	8.1
S18	23° 10' 38.6″ N; 70° 35' 31.3″ E	30.9	26.8	41	54	7.4	8.0
S19	23° 10' 30.6″ N; 70° 35' 28.3″ E	29.2	23	38	52	7.6	8.4
S20	23° 10' 36.5″ N; 70° 35' 39.0″ E	28	23.2	39	53	7.2	7.9
S21	23° 10' 41.6″ N; 70° 35' 35.4″ E	29.5	24.3	38	55	7.1	8.0
Cumulative Average		**29.38**	**24.79**	**38.95**	**53.71**	**7.4**	**8.21**

4.3.3 Nutrient Concentration:

During the present study, nutrient concentration was determined by estimating the nitrite, nitrate and phosphate. Nitrite concentration ranged from 0.1 to 0.9 mg/L with an overall average of 0.635 mg/L. The nitrite concentration recorded maximum at 23° 05' 07.1″ N 70° 16' 25.2″ E, while the lower concentration was recorded at 23° 03' 45.3″ N 70° 13' 37.21″ E. Nitrate content of the present study varied from 0.9 to 1.9 mg/L with a cumulative average of 1.45 mg/L. The nitrate content at 23° 01' 52.5″ N 70° 15' 29.1 shows highest level (1.9 mg/L) than that of all other sampled locations. Phosphate concentration ranged from 0.1 – 1.8 mg/L with an average of 0.75 mg/L with maximum at 23° 03' 45.3″ N 70° 13' 37.21″ E and minimum at 23° 08' 29.7″ N 70° 18' 17.8″ E. The recorded nutrient contents are sufficient to support the growth and vegetation structure of the KPT mangroves (Table 4.2).

Table 4.2: Pore-water nutrient concentration of in the KPT sampled locations

Sample ID	Location Coordinates	Nitrite (mg/L)	Nitrate (mg/L)	Phosphate (mg/L)
S1	23° 03' 41.1″ N; 70° 15' 27.5″ E	0.4	1.4	0.8
S2	23° 02' 48.3″ N; 70° 13' 34.0″ E	0.2	1.5	0.6
S3	23° 02' 24.9″ N; 70° 13' 45.4″ E	0.6	1.2	1.3
S4	23° 01' 58.8″ N; 70° 15' 27.5″ E	0.3	1.0	1.1
S5	23° 01' 52.5″ N; 70° 15' 29.1″ E	0.2	0.9	0.9
S6	23° 02' 5.9″ N; 70° 16' 00.7″ E	0.2	1.4	1.1
S7	23° 03' 45.3″ N; 70° 13'37.21″ E	0.1	1.2	1.8
S8	23° 06' 55.6″ N; 70° 16' 36.7″ E	0.8	1.9	1
S9	23° 06' 55.0″ N; 70° 16'25.5″ E	0.1	1.6	0.8
S10	23° 06' 52.5″ N; 70° 16' 25.5″ E	0.6	1.2	0.6
S11	23° 08'13.2″ N; 70° 18'19.8″ E	0.8	1.0	0.4
S12	23° 08' 20.9″ N; 70° 18' 16.6″ E	0.7	1.4	0.2
S13	23° 08' 29.7″ N; 70° 18' 17.8″ E	0.7	1.4	0.1
S14	23° 05' 03.5″ N; 70° 16' 18.0″ E	0.8	1.8	0.8
S15	23° 05'07.1″ N; 70° 16'23.8″ E	0.9	1.6	1.3
S16	23° 05' 10.4″ N; 70° 16' 25.2″ E	0.2	1.2	1.5
S17	23° 10' 35.9″ N; 70° 35' 28.2″ E	0.5	1.4	0.8
S18	23° 10' 38.6″ N; 70° 35' 31.3″ E	0.4	1.5	1.1
S19	23° 10' 30.6″ N; 70° 35' 28.3″ E	0.8	1.8	1.0
S20	23° 10' 36.5″ N; 70° 35' 39.0″ E	0.8	1.3	0.8
9S21	23° 10' 41.6″ N; 70° 35' 35.4″ E	0.8	1.2	0.2
Cumulative Average		0.635	1.45	0.757

4.3.4. Sediment Quality:

4.3.4.1 Sediment Texture:

During the present investigation, sediment texture varied widely among all the 21 sampled stations. Sediment texture typically represents the percentage composition of sand, silt and clay. Percentage composition of sand was maximum 38.1% and minimum 20.5% at the coordinates of 23° 06' 55.0″ N, 70° 16'25.5″ E; 23° 01' 52.5″

N, 70° 15'29.1″ E; respectively (Table 4.3). Overall average of all the 21 study sites sand constituted 30.09%. The silt composition was maximum at the study site 23° 06' 55.6″ N, 70° 16' 36.7″ E (16.5%) followed by the site at of 23° 09' 5.9″ N, 70° 16' 00.7″ E (16.1%) and minimum at 23° 03' 41.1″ N, 70° 15'27.5″ E(7.6%) with a cumulative mean value of 11.89%. Percentage composition of clay varied from 47.3% to 64.6% with an average value of 58.02%. Higher composition of clay was recorded at23° 01' 52.5″ N, 70° 15'29.1″ E. The cumulative average of the sediment indicated that in all the 21 sampled locations clay was the dominant fraction followed by silt and sand.

4.3.4.2Total Organic Carbon:

The total organic carbon in the sediment ranged from 0.51% to 0.8% with a cumulative mean value of 0.644% (Table 4.3). The higher TOC value was recorded at the site at 23° 10' 41.6″ N, 70° 35' 35.4″ E (0.8%) followed by the site at 23° 10' 30.6″ N, 70° 35' 35.4″ E (0.75%) and it was lower at 23° 02' 5.9″ N, 70° 16' 00.7″ E (0.51%).

Table: Percentage of Sediment texture and TOC in the sampled locations of KPT

Sampling Point No.	Sampling Coordinates	Post-Monsoon Texture (%)			Total Organic Carbon (%)
		Sand	Silt	Clay	
S1	23° 03' 41.1″ N; 70° 15' 27.5″ E	31.1	7.6	61.3	0.6
S2	23° 02' 48.3″ N; 70° 13' 34.0″ E	35.5	11.6	52.9	0.525
S3	23° 02' 24.9″ N; 70° 13' 45.4″ E	33.1	10.9	56	0.6
S4	23° 01' 58.8″ N; 70° 15' 27.5″ E	29	15.8	55.2	0.712
S5	23° 01' 52.5″ N; 70° 15' 29.1″ E	20.5	15	64.5	0.675
S6	23° 02' 5.9″ N; 70° 16' 00.7″ E	26.9	16.1	57	0.51
S7	23° 03' 45.3″ N; 70° 13'37.21″ E	23.2	12.2	64.6	0.6
S8	23° 06' 55.6″ N; 70° 16' 36.7″ E	28.9	16.5	54.6	0.58
S9	23° 06' 55.0″ N; 70° 16'25.5″ E	38.1	10	51.9	0.8
S10	23° 06' 52.5″ N; 70° 16' 25.5″ E	32.3	15	52.7	0.721
S11	23° 08'13.2″ N; 70° 18'19.8″ E	37.5	15.2	47.3	0.628
S12	23° 08' 20.9″ N; 70° 18' 16.6″ E	22.6	14.1	63.3	0.538
S13	23° 08' 29.7″ N; 70° 18' 17.8″ E	30.1	8.7	61.2	0.6
S14	23° 05' 03.5″ N; 70° 16' 18.0″ E	33.2	9.8	57	0.712
S15	23° 05'07.1″ N; 70° 16'23.8″ E	29.2	9.5	61.3	0.52
S16	23° 05' 10.4″ N; 70° 16' 25.2″ E	31.0	11.2	57.8	0.6
S17	23° 10' 35.9″ N; 70° 35' 28.2″ E	26.5	11.5	62	0.728
S18	23° 10' 38.6″ N; 70° 35' 31.3″ E	29.2	9.5	61.3	0.73
S19	23° 10' 30.6″ N; 70° 35' 28.3″ E	28.6	10.6	60.8	0.75
S20	23° 10' 36.5″ N; 70° 35' 39.0″ E	32.2	9.3	58.5	0.61
S21	23° 10' 41.6″ N; 70° 35' 35.4″ E	33.1	9.5	57.4	0.8
Cumulative Average		**30.09**	**11.89**	**58.02**	**0.644**

4.3.5 Conclusion

Assessment of mangrove health through vegetation structure and its status and water and sediment quality in 21 sampling locations within the boundary of Kandla Port indicated that most of the governing physio-chemical parameters of mangrove formations are within the prescribed limits. Essential parameters like surface water and pore-water salinity of the present study are comparable with other mangrove environment are within the prescribed limits. The high level of salinity is mainly due to the arid condition of the zone and resulting high evapo-transpiration rates prevailing in Gulf of Kachchh waters.

The status of mangrove within Kandla Port premises were characterized by evaluating their vegetation structures such as stand density, diversity, Girth at Breast Height (GBH),Canopy length and canopy width cover in 21 sampled locations. During the present study, mangrove stand at 23° 10' 41.6″ N, 70° 35' 35.4″ E is structurally better than other stands. The cumulative average mature tree density of 4124 trees/ha recorded in all the 21 sampled stands indicated that this mangrove formations is structurally dense than other mangrove formations of Kachchh. Tree height in all the 21 sampled stands showed noticeable variation which ranged from 171 cm to 341 cm with an cumulative average of 254cm.Mangrove trees were considerably taller at 23° 05' 07.1″ N, 70° 16' 23.8″ E, which is higher than all other samplings stands of KPT. Mangroves had highest GBH of 26.5 at 23° 02' 24.9″ N, 70° 13' 45.4″ E. The canopy cover in mangroves of Kandla port is rather small and comparatively lesser than other formations of Kachchh. This is solely attributable to the prevailing ambience like high pore-water salinity and other natural factors. Overall average density of regeneration class from 21 sampling locations is 23423.81 plants/ha, which indicate that the regeneration potential of mangroves of Kandla Port is good. Similarly, overall average density of the next younger class namely recruitment class was equally good establishing the high regeneration potential of the mangrove formation. Density Investigation of younger classes like regeneration and recruitment classes of the present study generally indicated that vegetation structure of the mangroves has high potential to sustain its structural integrity in future.

5. MANGROVE LAND COVER STUDIES IN KPT AREA

5.1 Introduction:

Kachchh mangroves are the largest single stand in the west coast with the extent of 789sq.Km (FSI, 2009). An increase of 11 sq. km was reported from the earlier estimates (FSI, 2013). Harsh environmental settings like arid hinter land minimal rainfall (458mm/year) and extreme evapo-transpiration rate have rendered these mangrove formations to a single species stand comprising hardy *Avicennia marina*, though sporadic occurrence of other species such as *R. mucronata*, *C. tagal* and *A. corniculatum* has been reported in very few coastal stretches.

Gandhidham taluka of Kachchh district where Kandla port is located is estimated to have 61.97sq.kmof mangroves (GEC&BISAG, 2009). In the present study dense and sparse mangrove formations within the jurisdiction of Kandla Port have been estimated tobearound13841.4ha (13234.2 ha area located in Kandla region). In the present GIS study, land-cover estimation of within the boundary of Kandla port was carried out to understand mangrove distribution.

Kandla Port Jurisdiction includes mainly Kandla port, Tuna port, Sat Saida bet and surrounding area of the port. Kandla creek on whose bank the port is located runs into the Gulf of Kachchh at a distance of 90 nautical miles from the port. The width of the channel varies from 200 meters to 1,000 meters. The contour depth along the shipping channel is around 10 meters. The study site falls under the co-ordinates of latitude between $23^0$12’ 20.49”N to $23^0$53’ 35.64”N and Longitude between $69^0$59’ 35.64”E to $70^0$37’ 51.40”E as given in Figure 5.1 (Annexure). It encompasses an approximate area of 120206.1 ha (1202.06 sq. km). This includes terrestrial and part of Gulf systems which fall within the port boundary.

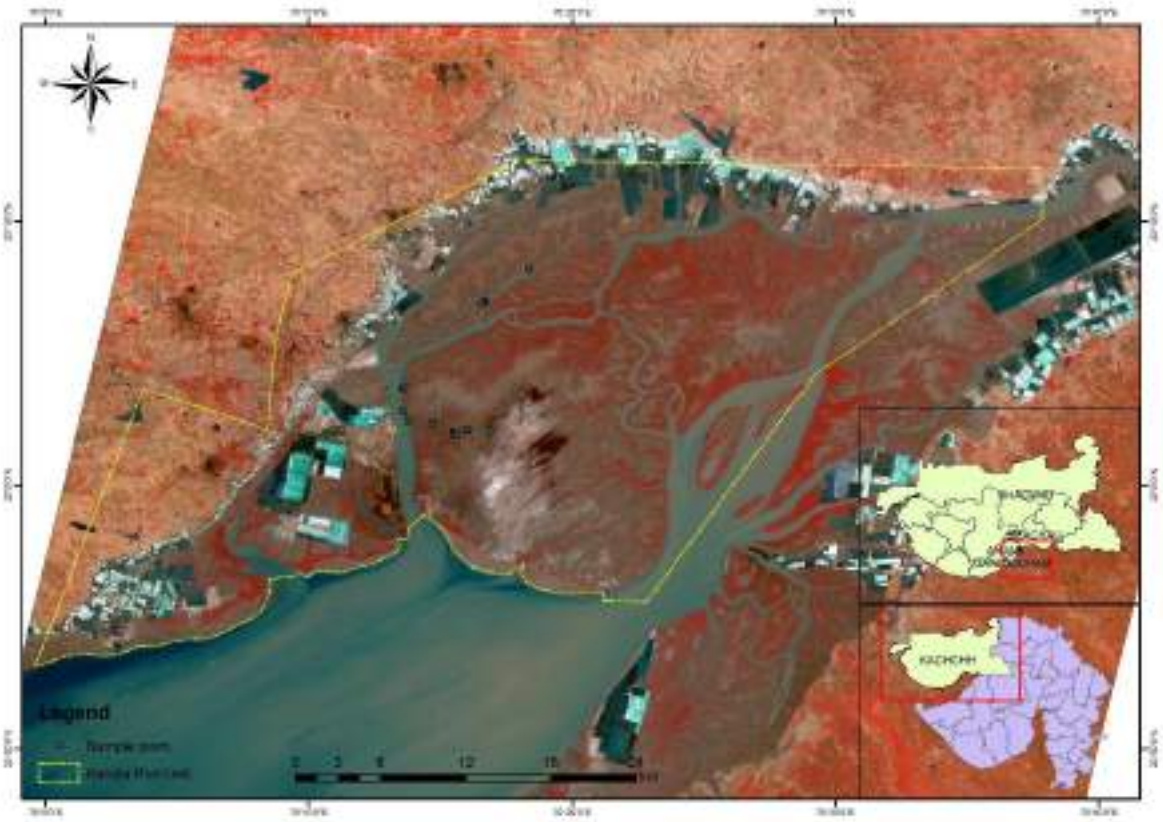

Figure 5.1: Sampling Points of Kandla Port Jurisdiction

5.2 GIS and Remote Sensing:

LISS 4 Satellite imagery of pre-monsoon season procured from NRSC, Hyderabad was used for the present study. The procured imagery has a resolution of 5.8 m with UTM projection with spheroid and datum named WGS 84 in UTM zone 42 north, which will meet the requirement of estimating the areal extent of mangroves within marked port limit area and its current status. Supervised Classification Method is applied to delineate the mangrove area and other natural areas. The details of the satellite imagery used are given below.

Satellite	Year	Month	Sensor	Bands	Pixel Resolution
IRS P6	2014	14,Dec	**LISS 4**	3	5.8 m

5.3 Pre-Processing:

Pre-processing of satellite data including geometric correction, atmospheric correction and radiometric correction and clipping of the area has been carried out. The rectification operation aims to correct distorted images to create a more faithful representation of the original scene. It typically involves the initial processing of raw image data to correct for geometric distortions.

5.3.1 Radiometric correction:

Radiometric correction addresses variations in the pixel intensities (DNs) that are not caused by the object or scene being scanned. These variations include differing sensitivities or malfunctioning of the detectors, topographic effects and atmospheric effects.

5.3.2 Geometric correction:

Geometric correction addresses errors in the relative positions of pixels. These errors are induced by sensor viewing geometry or terrain variations. Geometric correction was done based on Ground Control Points (GCPs) and the image was re-sampled using nearest neighborhood interpolation method.

5.3.3Supervised classification:

Supervised classification can be defined normally as the process of sample of known identity to classify pixels of unknown identity. Samples of known identity are those pixels located within training areas. Pixels located within these areas term the training samples used to guide the classification algorithm to assigning specific spectral values to appropriate information class.

Preliminary surveys were conducted on the ground to collect training samples for different Land cover using Garmin GPS with the help of training sample, classification map was generated based on Maximum Likelihood Supervised Classification model using ERDAS Software.

5.4 Land Cover classification for 2014:

Land Cover as observed in the imagery of December 2014 was classified in 10 classes namely Dense mangrove, sparse mangrove, Saltpan, mudflat, other vegetation,

settlement, water, agriculture, fallow land and barren land. This imagery classification was supported by ground truthing through fieldwork as it is a very important to check and collect most of the ground information required for mapping.

Reconnaissance field survey was undertaken to get acquainted with the general land cover pattern of the area. Different patches of mangrove area characteristics were recorded. The variation and tonal patterns observed in the ground truthing was recorded on the existing images. Traverses along Kandla main creek and subordinates creek of Kandla, mangrove area, saline area, saltpan and other vegetation was made for ground truthing the patterns and characters recorded in the image. Various features identified in the ground truthing were correlated with the image element and GPS observations was obtained for various land cover by superimposing on the satellite image.

5.5 Result:

5.5.1 Land Cover Mapping:

The land cover map based on supervised classification of LISS IV December 2014 is given in Fig.5.2and the area analysis of land cover is given in hectares.

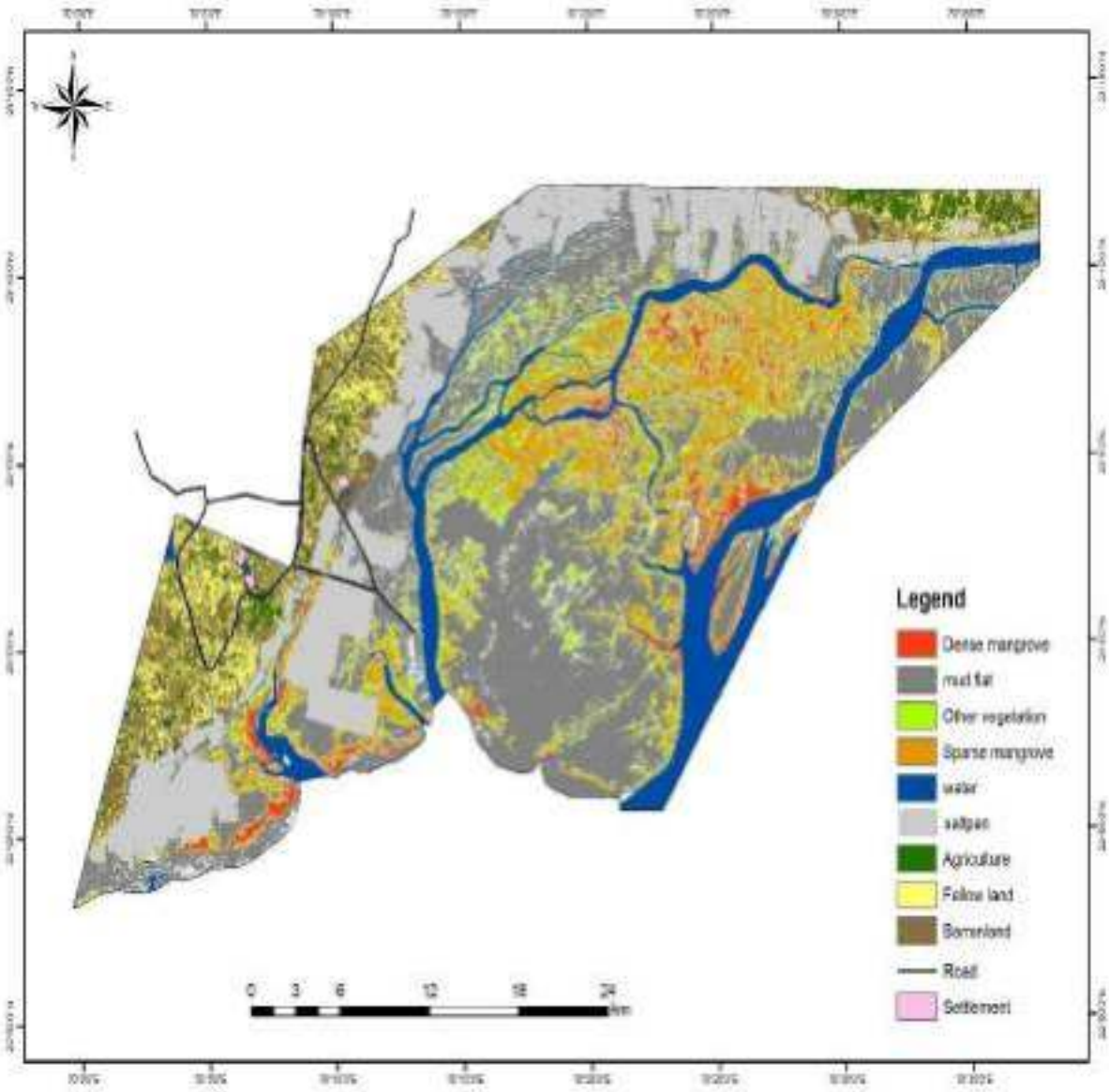

Fig.5.2: Land cover classification map of the study area -December2014

As per this classification different land cover category has been estimated in hectares (Figure 5.3). Total mangrove cover constitutes 15.3% with dense mangroves constituting 3.8% and sparse mangrove 11.5 %. Highest land cover is occupied by mudflats to the tune of 36.9% followed by water spread (11.5%) whereas cover of settlement (01%) and agriculture (1.7%) was lowest (Table 5.1).

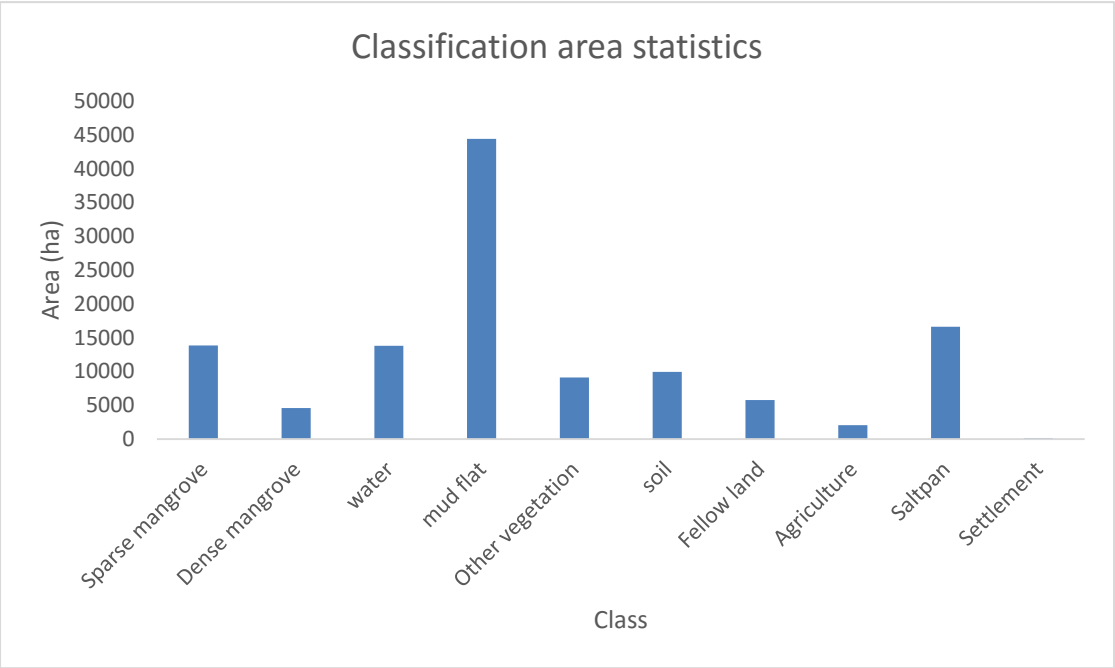

Fig. 5.3: Total Land Cover Classification Statistics in Hectares

Table 5.1: Percentage of Land Cover Classification in Kandla Port Area

Sr. No.	Class	Kandla Area (ha)	Tuna Tekra Area (ha)	Total Area (ha)	Total Area Percentage (%)
1	Sparse mangrove	13234.2	607.03	13841.2	11.5
2	Dense mangrove	4025.1	565.38	4590.4	3.8
3	Water	13117.3	671.54	13788.8	11.5
4	mud flat	41310.4	3080.69	44391.1	36.9
5	Other vegetation	8655.2	439.76	9095.0	7.6
6	Soil	5097.1	4840.60	9937.7	8.3
7	Fellow land	2582.7	3177.75	5760.4	4.8
8	Agriculture	1241.2	817.48	2058.7	1.7
9	Saltpan	12843.6	3754.50	16598.10	13.8
10	Settlement	49.7	94.96	144.7	0.1
	Total	**102156.5**	**18049.68**	**120206.18**	**100.0**

6. MANGROVE MANAGEMENT PLAN FOR KPT

6.1 Background:

The Kandla Port Trust envisages several facilities to be built at the location. The establishment of facilities over the years, buildings, etc. involves notable changes in the landscapes including natural environment as a result of intensive activities. Doubtlessly, this will alter the local ecological makeup of the area. Any long term human centered activity in any coastal belt will have serious repercussions on all its natural resources and ecosystems in the vicinity. Thus, measures should be taken to conserve and preserve KPT mangroves, thus retaining several visible and invisible ecological services of mangrove. As a first and foremost step it is imperative that no mangroves in the region are to be cleared for any activities and more mangrove plantation/ restoration work should be undertaken. Dumping of any materials such as cement, rubble, sand, steel, spilling of materials, etc. should be strictly avoided.

Regular monitoring programmes at fixed intervals are crucial to assess any change in mangrove diversity during different developmental activities. Therefore, KPT would be explored the possibility to engage an experts for monitoring the area regularly as ecological perspective. Emphasis on growth with respect to survival percentage, height, density, regeneration and recruitment classes, frequency class, etc. should be given during regular monitoring. Other phyto-sociological parameters should also be addressed during regular monitoring programme. Mangroves being a dynamic ecosystem such changes may be studied annually. Nevertheless, in areas with new mangrove growths/restoration the monitoring may be more frequent in order to arrest any adverse impact. Regular monitoring of these factors will facilitate the KPT authorities to understand the impact of the ongoing activities, if any. This would, inturn, help in mangrove conservation and management of the region. The data generated as an outcome of regular monitoring should be collected from predetermined/identified locations to avoid any sampling error. A team of expert groups should be engaged by KPT, in order to assess/evaluate the mangrove growth and vegetation structure.

The expert team may also help to conducting appropriate awareness programmes to the workers, supervisory staff and contract labours of KPT. Thus, environmental training and awareness creation should be undertaken for all jetty staff and contractors during their initial induction period. The training should involve both ecological and environmental importance of mangroves and measures to be taken in order to protect and preserve them during their activities in the areas contiguous to mangroves. Signboards and hoardings at appropriate places should be placed reflecting mangroves importance. These hoardings should be in easily understandable languages and in pictorial forms. Restricted entry/no entry boards may also be placed at appropriate places to regulate/monitor the frequency of visiting labours. This way, any illegal cutting, etc. can be immediately reported to KPT Environment Cell. This must involve a routine system of reporting such incidences. Similarly, KPT should hold an active Environment Cell to handle such problems cases. The consultancy peoples may also help in conducting awareness programs to the workers, supervisory staff and contract labours of KPT.

6.2 Other Activities:

Immense care should be taken to avoid any oil spillage from calling ships and other machineries in the vicinity of mangroves. Any unauthorized entry, cattle grazing and collection of mangrove forest products should be timely reported and entered in the register. Utmost care is required for any chemical/hydrocarbon spillage in the vicinity. Environment Division of KPT should investigate such incidences and take measures to arrest these activities. Further strengthening of this Division is essential as indicated in chapter 7.

No clearance and disturbance to soil surface in the areas close to mangrove formations should be done which would otherwise lead to increased turbidity of run-off. For such purpose it is suggested to earmark the area into buffer zone and core zone and no activity should take place in core zone including the earthmoving machineries. In some places scrub-rolling should be followed to allow resprouting/germination. No oil, loitering, rubbles, etc. should disposed off. In buffer

zone, these items are to be managed, collected, transported and disposed following GPCB norms.

Kachchh being arid zone, encounters dust storms. Thus, to minimize/avoid dust spreading into these ecologically important areas sprinklers should be used to arrest air borne dust and this frequency should be increased based on wind and weather conditions.

6.3 Significant Ecological Parameter:

Pore-water properties in mangroves ecosystem play a major role in determining the health of the mangrove forest. Alteration in the pore-water chemical and physical characteristics, especially salinity is a reliable indicator of changing physical condition in the mangrove. If any alteration in pore-water salinity and conductivity beyond the limit is reported during monitoring, immediate investigation should be carried out to identify the reason and appropriate remedial measures should be taken. For such purposes, constructing canal system to ensure increased flushing, groundwater recovery bores and interceptor channels which would facilitate increased water flushing to mangroves in the event of changed tidal pattern may be included. The construction of such a canal system should be in a well planned manner using the expertise of civil engineers. Since *Avicennia marina*, takes several years to respond to any of these changes, a long term sustained monitoring as mentioned earlier is vital.

6.4 Mangrove Rehabilitation:

At the same time KPT has carried out mangrove plantation and rehabilitation in 1000 ha (excluding 200 ha of IFFCO plantation site and 250 ha by M/S AKBTPL), the efforts are restricted to the tidal flats of Sat Saida Bet and Nakti creek (Refer Table 7.1). Thus, it is recommended to extend mangrove plantation and rehabilitation activities at Sat Saida Bet region. Such activities should be carried out through mangrove experts of consultancy.

6.5 Biodiversity Monitoring Committee:

Macrofauna is an integral part of mangrove ecosystem. Macrofaunal diversity in mangrove ecosystem reflects its health. It is well known that a steady mangrove

system supports rich faunal diversity/density. The faunal diversity in mangrove ecosystem is very sensitive to alterations in the habitat. Thus, monitoring faunal diversity would directly alert the KPT authorities about at any changes happened/ happening in the area. Thus, it is suggested to carry out regular monitoring of macrofauna in the mangrove area.

6.6 Mangrove Plantation and Restoration Activities:

It is known that mudflats experiencing favourable tidal amplitude are suitable for mangrove plantation. Sat Saida Bet area has widespread mudflats and suitable environmental conditions, Therefore, Sat Saida Bet area is recommended to carry out the future mangrove plantation and restoration activities. Being at the tail end of Gulf, the vicinity of Kandla port abounds with networks of creek systems, mudflats and tidal swamps with pronounced tidal amplitude of 6.66 m (Mean High Water Spring-MHWS) that inundates a vast intertidal belt rendering it suitable for plantation. It is noticed that the substrate nature is silty-clay which favours mangrove growth. The areas at Sat Saida Bet can be explored for mangrove plantation in available mudflats. However, this should be carried out in consultation with experts and should also involve long-term monitoring to ensure the growth of mangroves. Any impacts on mangrove health should be studied and measures should be taken to revive the growth. Such impact can be understood by studying faunal diversity as mentioned above.

KPT should undertake restoration activities to replenish the growth of mangroves in areas with stunted growth. This may be based on existence of creeks, removal of blockages in the natural minor creeks, and creation of new tidal regimes through fish bone canals. To undertake such activities, it is suggested to study the area characteristics and relate it with existing scientific knowledge. Thus, this should be carried out in consultation with the experts. It is envisaged that correlating long-term mangrove conservation and preservation with KPT's foreseen expansion would improve its greener outlook and enable KPT to get environmental clearance of its future projects/activities.

Desiltation of natural canals, increased frequency of tidal flushing, should be carried out in areas with natural stunted growth areas in order to improve mangroves

health, and ecological functions and services. Thus, for all such activities, and mangrove plantation and restoration activities creation of a Separate Mangrove Monitoring Cell under the Environmental Division is suggested. For any plantation activity the in site selection is foremost. Nevertheless, protocol involved during site identification as well as selection will play an important role in long term survival of mangroves areas and their well being. Thus, it is recommended to select the future plantation sites in consultation with experts. Experts ought to have a thorough knowledge and experience on ecology, faunal diversity, sediment quality assessment, pore-water quality assessment and impact of other factor on mangrove formations / growth.

It is suggested that other candidate species of mangroves *viz*., *Aegiceros corniculatum*, *Ceriops tagal* and *Rhizophora mucronata*, should also be attempted in natural areas. These species area likely to improve/increase the diversity of the area and thus improving mangrove health.

For any plantation activity, improved techniques as elaborated in earlier sections should be followed. Raised bed (*Otla*) method should be followed in sites experiencing high tidal currents. However, such plantation technique should be carried out in previous existing mangroves stands and new areas should be completely avoided. Also, sediment erosion monitors and in plantation areas following *Otla* method should be carried out. Kandla port premises especially Sat Saida Bet receives gentle tidal currents, therefore, open mudflats here should have nursery raised sapling or direct dibbling of seeds in a pit.

In order to ensure any negative impact on the health of mangrove ecosystem in Kandla Port region, long term planning and conservation strategies should be attempted and most vulnerable mangrove stand should be identified and exposed to conservation efforts. Thus, special efforts should be taken to conserve these stands.

7. MANGROVE PLANTATION AND REHABILITATION EFFORTS

7.1 Background:

Among Kachchh mangroves with a spread of 789 sq.km, Gandhidham taluka, where Kandla Port is located, has a mangrove formation of 61.97 sq. km. Extent of dense mangrove within this taluka is only around 2.89 sq.km whereas sparse mangroves are 59.07 sq. km (GEC & BISAC, 2009). Potential mudflat area within the taluka is estimated to be 55.47 sq.km presenting a vast scope for mangrove plantation and rehabilitation. Kandla Port Trust within its jurisdiction encompasses a total land area (excluding water) of 893.03 sq. km rendering it the largest land holder in Kachchh district. Extent of mangroves within the Jurisdiction of Kandla Port is estimated to be 18831.64ha with the inclusion of 4990.4 and 13841.2 sq.km sparse and dense mangroves, respectively; a largest patch outside the administrative jurisdiction of forest department. During early 1960s mangrove cover in Kandla-Surajbari belt was reported to be 506 sq.km which ultimately shrank to 49 sq.km during 2002 due to various human and natural factors.

Cargo handling in Kandla Port consistently recorded an increasing growth trend; the total cargo traffic handled by the port has increased from 24.5 million tons in 1993-94 to 82.5 million tons in 2011-12. Moreover, KPT handled 87.005 MMT cargo during the year of 2013-2014 and 92.5 MMT in the financial year of 2014-2015 Additionally, it is planned to construct four dry cargo berths within the Kandla creek; it is also planned to develop two Multi-Product Special Economic Zones (MPSEZ) at Kandla (3400 ha) and at Tuna Tekra (1400 ha). Out of 12 existing cargo berths, six berths have already served their lifespan of 50 years. In addition, existing vessel traffic, congestion in the main port and draft restrictions demand expansion of the port facility to adjacent creek systems.

Due to these commercial, operational and economic reasons and to meet the demands of the expanding trade, KPT has to increase its cargo handling capacity in the future while simultaneously caring for the ecological wellbeing of mangroves in its port vicinity. As expected, these developments will have their own repercussions on the surrounding port environ. Mangrove being a major ecological entity within the

port premise, it is imperative that a well planned, long term conservation measure in terms of aggressive mangrove plantation and rehabilitation has to be initiated in order to bring back the mangrove cover to the pre-port era of pristine nature and also to conserve the existing mangrove formations intact in a sustained long term basis. This calls for consistent effort both for preserving and improving the mangrove formation. This chapter narrates the ongoing mangrove plantation activities by the port authorities and recommend future plan of action for long term conservation. Recommendations on the monitoring programmes to be initiated in order to keep track of the ecosystem health and to initiate course corrections and remedies, if any impacts are felt is also narrated.

7.2 KPT-Present Mangrove Plantation/Rehabilitation Efforts:

Three different terminologies namely Rehabilitation, Restoration and Plantation are interchangeably used to denote human interventions to improve mangrove condition. Field (1999) defines 'Rehabilitation' as 'return of degraded mangrove land to a fully functional mangrove ecosystem'; the term 'Restoration' is defined by him as 'returning the degraded mangrove land to something like its presumed original state'. The term, 'Plantation' could be considered as raising mangroves in a technically suitable coastal belt where mangroves were absent earlier. Going by this definition most of the activities undertaken by Kandla port or any other stake holder agencies until now is only plantation with restoration and rehabilitation activities seldom attempted.

With a vast wide mudflat area extending up to 44391 ha and numerous network of creek systems enabling a rich and conducive environment for mangrove growth, Kandla port environ is an ideal location for mangrove plantation and restoration efforts. These possible mudflats for mangrove plantation are available along the creek systems of Sat Saida Bet. Similarly, many earlier pristine mangrove stands that are now degraded within Kandla port offers equally high opportunity to restore them.

Mangrove plantation activity by Kandla Port was initiated during 2002 as mandated by the Ministry of Environment Forests and Climate Change (MoEF). The first mangrove plantation activity was during 2002 with the development of 20 ha at

Sat Saida Bet, a vast tidally flushed area along the northern bank of Kandla creek opposite to Kandla port. Subsequently, 1200 ha of mangrove plantation has been completed till the end of 2014 in order to meet the legal mandate of Ministry of Environment, Forests and Climate Change (Table 7.1).

Table 7.1: Details of implemented Mangrove Plantation by Kandla Port Trust

Sr. no.	Year of Plantation & Site	Area-ha.	Species	Survival -%	Agency
1	2005-2006 (Sat Saida Bed)	20	*A.marina*	98	M/s Gujarat Ecology Commission
2	2008–09 (Nakti Creek)	50	*A.marina*	71	M/s Gujarat Ecology Commission
3	2010–11 (Nakti Creek)	100	*A.marina, R. mucronata, C. tagal*	68	M/s Gujarat Ecology Commission
4	2011–12 (Sat Saida Bed)	200	*A.marina*	74	Forest & Environment Department, GoG
5	2012-13 (Sat Saida Bed)	300	*A.marina*	71	Forest & Environment Department, GoG
6	2013–14 (Sat Saida Bed)	330	*A.marina*	69	Forest & Environment Department, GoG
Total Mangrove Plantation carried out by KPT – 1000 ha					
7	2013-14 (Sat Saida Bed)	250	*A.marina*	70	M/s AKBTPL
8	2013-15 (Sat Saida Bed)	200	*A.marina*	74	IFFCO through GUIDE
9	2015-17	300	-	-	MoU signed with Gujarat Ecology Comission (GEC), Government of Gujarat

In all these plantations the following three different methods were followed.

1. Raised Bed Method (Otla method)
2. Transplantation of nursery raised saplings (Nursery method)
3. Direct Seed Sowing Method

7.2.1 Otla Method:

In majority of the plantation sites raised bed method (*Otla* method) was followed as it is believed to give better results than other methods. Further, this method is perceived to be less cost and labour intensive. This method is especially suitable for sites with high tidal currents. In this method, square earthen mounts of 10-15 cm height were raised and propagules numbering 50-60 were dibbled on the surface of the mount. Generally, number of raised beds per hectare is around 1000 with a spacing of less than 1 × 1 m. In case of plantation among gaps of natural mangroves, clusters of *Otlas* mostly exceeding the density of 1500/ha were made closely.

7.2.2 Direct Propagule Dibbling:

Next to raised bed method, direct propagule dibbling (locally called '*Sing'* Plantation) was attempted in many sites. This method is less labour and cost intensive, though repeated dibbling was often required in order to obtain desirable survival rate. In this method, mature propagules are dibbled in open empty mudflats or among gaps of natural stands. Spacing maintained between each dibbled propagule varied differently and in some sites it was as close as 75×50 cm, especially in plantation raised among gaps of natural mangroves. Propagules used were collected freshly from the nearby mangrove formations which are thought to give better results and no pre-dibbling seed treatments were used. Often propagules were dibbled repeatedly in order to increase survival rates and in raised (O*tla*) bed and nursery plantation sites, dibbling propagules was resorted to increase survival.

7.2.3. Nursery Methods (Polybag Method):

Transplantation of nursery raised saplings was also followed as its success rate is much higher than any other method. Unlike raised bed and direct dibbling methods, this method is labour and cost intensive and time consuming. Nursery raised saplings are transplanted as individual plants either in open intertidal mudflats or along the banks of the creek systems. Saplings in the polythene bags were allowed to attain a height of 40-50 cm before transplantation in a period of 3-4 months. This method was found to be promising and yield better survival rate wherever it was attempted. While

transplanting, varying density, ranging from 3000 to 6000 saplings/ha as dictated by the site condition were followed.

7.3 Mangrove Plantation Targets Achieved:

The targeted plantation area of 1000 ha, Kandla Port Trust has been carried out plantation in two sites namely Sat Saida Bet on the banks of Kandla creek opposite to Kandla Port and along the Nakti creek till the end of 2013-14. Year-wise target achieved and other details of plantation are given in table 7.1. Sat Saida Bet opposite to the port bank of Kandla was chosen to implement the mangrove plantation at Sat Saida Bet, it is a vast mudflat area receiving adequate tidal flushing to support a healthy plantation. Numerous minor tidal creeks criss-cross the mudflat producing very conducive conditions for undertaking plantation activity. Out of the 1000 ha completed till 2013-14, 850 ha of plantation were carried out in Sat Saida Bet which yielded better results with high survival rate of more than 80%.

In all plantation years, except 2008-09, the candidate species was *Avicennia marina*. This is the dominant species occurring in the mangrove formations of Kachchh, though sporadic occurrence of other two species, *Rhizophora mucronata* and *Ceriops tagal* has been reported. *Avicennia marina* is known to survive in very high water and soil salinity due to its extreme tolerance to different environmental conditions. Kachchh coastal region experiences elevated water and soil salinity levels due to aridity and very high evaporation rate. In this prevailing ambiance of high salinity, growth of *A. marina* is fairly good comparing other mangrove species since it is due to its high tolerance to higher salinity ranges. Obviously, *A. marina* is the candidate species in the whole of Kachchh and Gujarat coast due to these reasons. Earlier attempts during 2008-09 to plant *Rhizophora mucronata* and *Ceriops tagal* at Sat Saida Bet yielded only very limited success rates in terms of survival.

7.4 Potential for Plantation and Restoration Activities in Kandla Port Area:

Scope for successful mangrove plantation and restoration activities in Kandla Port area is plenty as basic environmental requirements and conditions are quite conducive. Presence of extensive mudflats, favourable tidal amplitude and conducive

substrate nature favours mangrove plantation in vast areas. The vast mudflat area is around 44391 ha located in the Kandla port premises, around 20000 ha receives good tidal flushing rates which exactly located in Sat Saida Bet region. Being at the tail end of Gulf, the vicinity of Kandla port abounds with networks of creek systems mudflats and tidal swamps with pronounced tidal amplitude of 6.66 m (Mean High Water Spring-MHWS) that inundates vast intertidal belt, rendering it suitable for plantation. Substrate nature is silty-clay which favours luxuriant mangrove growth. Despite factors like high aridity, water salinity and poor rainfall (340 mm/year), growth of mangrove species, especially *A. marina* is favoured by other positive factors. It is estimated that out of available extent of 44391.1 ha of mudflats, nearly 20000 ha has high potential for mangrove plantation. About 830 ha out 1000 ha of plantation executed so far by Kandla port has been carried out at Sat Saida Bet, since it has vast extent of mudflats and tidal swamps. Network of creek systems at Sat Saida Bet and adjacent mudflats in the creek system on its northern extent has vast potential mudflats for mangrove plantation. Other than this, creek systems like Nakti and Khori has extensive mudflats along their banks which are suitable for mangrove plantation.

Similar to plantation potential, potential for mangrove restoration activities are equally high in and around Kandla port. It is estimated that out of total mangrove extent of 18431.6 ha within the port jurisdiction, 4590.4 ha are dense and 13841.2 ha are sparse. Potential for developing the sparse mangroves into a healthy and dense mangrove habitat is plenty by undertaking restoration activities such as deepening the existing minor creek systems, creating new tidal regimes through fish bone canals and removing blockages in the natural minor creeks. Most of these sparse mangroves were once reported to be dense and healthy (ICMAM, 2004) and they were rendered sparse due to micro-level changes in the topography and geomorphology due to various natural and anthropogenic factors.

Majority of the mudflat area in the Tuna region do not support mangrove growth in spite of adequate tidal flushing solely due to lack of geomorphic and tidal factors which prevent effective mangrove seed dispersal. Potential mangrove

plantation sites at Sat Saida Bet is enabling by broadcasting or by other means of most likely convert these mudflats into mangrove formations.

7.5 Recommendation for Future Mangrove Plantation:

Given the vast extent of natural mangroves within the port environ and the ecological sensitivity of mangroves, it will be in the long term commercial interest of Kandla port to ensure that a committed management plan encompassing conservation of natural stand and further areal expansion through plantation and restoration is in place with appropriate budgetary allotment. Since Kandla port is poised for further growth in the future, linking long term mangrove conservation and preservation with its entire future expansion plan will manifold enhance its greener outlook and enable easy environmental clearance of its future project activities. Sustained and planned effort with a strong will and determination will render Kandla Port a truly green port surrounded by thick, dense and luxuriant mangroves. Recommendations to this effect are presented below.

7.6 Long term Plan for Mangrove Plantation or Restoration:

Creation of a separate mangrove cell manned by scientific manpower with clearly defined timely goal could be the first step towards mangrove conservation. Kandla port may create its own cell or it could be assigned to a competent organization with adequate experience in mangrove conservation such as forest department and Gujarat Ecology Commission (GEC). With parallel planning and execution for plantation and restoration, yearly target of plantation and restoration are fixed and met with adequate fund support from port authorities. A long term plan with yearly target of plantation/restoration irrespective of ministry mandate could be drawn by this cell. This plan, to begin with, will identify and demarcate potential mangrove sites separately for plantation and restoration activities through application of GIS and RS tools. Similarly, patches that are likely to face impact due to different anthropogenic activities could be identified and appropriate mitigation measures initiated.

7.6.1 Restoration along with Plantation:

Until now, outright plantation is the sole measure of mangrove conservation while restoration of degraded stand has never been attempted. It is recommended that restoration by bio-physical amendments along with plantation could be attempted in future conservation activities; especially in identified scrubby/stunted stands facing inadequate tidal flushing this restoration effort will yield better results rather than direct plantation. Desiltation of natural canals and enhancing tidal flushing rates through canal systems and increasing number of tidal days in such natural stunted stands by physical amendments will render the scrubby formation healthy, viable and a functional mangrove ecosystem. This could be done in a cost effective manner yielding better results than direct plantation. A thorough and detailed surveillance and categorizing the sites requiring different approaches/treatments could be undertaken in future mangrove conservation efforts. Through application of GIS tools, this task could be done in a scientific manner. These restoration activities could be delinked from ministry mandated conditional plantation for different project setting/expansion and are to be carried out as per the yearly targets set out by Kandla port itself. This will be a time saving and proactive measure to meet conservation mandate that will be imposed by the ministry in future for different project implementation.

7.6.2 Improved Plantation Techniques:

As narrated in section 7.2 three basic techniques for plantation is followed namely, raised bed (Otla) method, Plantation of nursery raised saplings and direct seed dibbling. While raised (Otla) method is predominantly followed, other two methods are supplementary. Raised bed (*Otla*) method is more suitable for sites which experiences heavy tidal currents. Since raised beds control the velocity of receding tidal waters, germinating seedlings do not get dislodged. Though raised bed method initially results in high survival rate, in due course of time, sediment in the bed gets eroded in the receding tidal currents and saplings gets uprooted when their root system are exposed to the currents. In majority of the sites where raised bed method was attempted initial high survival rates is followed by heavy mortality and survival becomes poor after six months. However, this method is satisfactory if the plantation

is carried out among existing mangrove stands which effectively checks and slow down the receding tidal currents. Hence, caution is to be exercised whole adapting raised bed method of plantation. It is suggested that this method could be used as a last resort and only in sites facing heavy tidal currents. For the mudflats of Kandla port region, where tidal currents are mostly gentle due to gradual intertidal gradient raised bed method may not be suitable. Either plantation of nursery raised sapling or direct dibbling of seeds in a pit will be more appropriate method.

7.6.3 Site Selection:

By far, suitable site selection in the intertidal belt is foremost criterion determining success of mangrove plantation. A list of bio-physical parameters like gradient of the chosen intertidal belt, soil nature, number of days of tidal flushing, presence/absence of natural mangroves in the vicinity and availability of adequate intertidal extent are to be carefully considered for choosing plantation site. More emphasis is to be given to tidal flushing; only sites that receive good tidal flushing for 15-20 days in a month are to be chosen for plantation activities. A suite of 12 parameters indicated in the table 7.2 are to be meticulously considered before choosing a site. In earlier plantation attempts by Kandla Port, sites among existing natural mangrove formation with good tidal flushing and regeneration potential were taken up. In other cases, plantation was raised along the banks of natural creeks or in the gaps among scrubby mangrove formations and open mudflats close to the coastal belt after ascertaining adequate tidal inundation. In short all bio-physical characters (Table 7.2) are to be carefully considered before choosing plantation sites. Based on bio-physical characteristics of sites, few areas at Sat Saida bet was suggested here for future mangrove plantation activities (Figure 7.1).

Table 7.2: Criteria Adapted by Forest Staff for site selection

Priority Order	Criteria	Preferred Conditions
1	Site Nature- Open coast/creek/Natural Mangrove formations	Creek systems and estuaries with freshwater input is preferable- In open coast sites gentle gradient preferred. In natural mangroves, adequate gaps with good tidal flushing considered.
2	Intertidal Gradient	Intertidal extent with gentle slope preferred-Steep intertidal gradient and those with convex morphology avoided to prevent water logging.
3	Tidal inundation	Only sites with gentle gradient with minimum 15 days

		tidal flushing per month mostly preferred
4	Soil Texture	Silty-clay or muddy soil preferred
5	Water Salinity	Sites close to discharge points of run-off preferred which controls salinity fluctuations -Based on this candidate species are selected.
6	Intertidal Extent/Width	Sites with minimum 150-200 m width and gentle gradient close to the waterfront preferred
7	Tidal Currents	Sites with gentle and low velocity currents preferred
8	Mangrove Presence/ Absence in the Vicinity	Presence of natural mangroves in the vicinity is a reliable indication that the site can support good mangroves.
9	Accessibility of the site	Mostly considered in site where plantation was implemented in EDC mode.
10	Labor Availability	Availability of good labour in nearby villages was considered as a major factor
11	Seed Source	Seed source was from nearby mangroves-If new species were attempted seeds/propaguleswereacclimatized to higher salinity
12	Pressure-Grazing, Cattle visit, resource gathering etc.	Avoided through constant vigil- EDC village partners were educated not to send their cattle to the natural or planted mangroves.

Figure 7.1: Suggested plantation sites at Sat Saida Bet

7.6.4 Biodiversity Enrichment:

In most of the plantation sites, *A. marina* was the natural candidate species as they are the most predominant in all natural mangrove stands indicating nature's preference to this species. Environmental plasticity of *A. marina* to tolerate extremes of salinity, temperature and light intensity and its adaptation to different soil conditions is scientifically well proven. In addition, easy seed availability, faster

germination in high saline water, tolerance to prolonged drought situation and higher growth rates enables good success rates with *A. marina*. Nevertheless, other candidate species such as *R. mucronata, C. tagal* and *Aegiceras corniculatum* could be planted in small areas following their natural zonation pattern. *C. tagal* and *A. corniculatum* occur sporadically in Kandla port region. Though these species are less salinity tolerant, planting them close to the water front where they will get inundated daily will enhance diversity of true mangroves in Kandla port to ensure better ecosystem function.

7.6.5 Monitoring and Arresting Stand Degradation:

In the last five decades since inception of port activities during 1960s mangrove formation in and around Kandla port seems to have undergone degradation due to various human and natural factors. The stand with an extent of 506 sq.km at the tail end of GoK during 1960s has reduced to 49 sq.km during 2002 (ICMAM, 2004). This calls for immediate measures by port authorities to arrest further stand degradation by appropriate action oriented management measures. Following measures are suggested in this line.

Exhaustive GIS mapping with corresponding ground truthing to record and document different stand characteristics such as dense, sparse, moderate stands and identifying stands that are prone to immediate stand degradation.

Earmarking core pristine stands at Kandla and Tuna areas within port limits as reserve forests that are to be protected where further port activities are not to be taken up in future. This earmarked core mangrove formation deserves total protection and preservation against all developmental activities and disturbances.

Rapid and short mangrove monitoring programs at a spatial interval of one year is to be instituted in order to keep track of changes that may happen due to further construction and operation of jetties and other port related structures. Kandla port has already generated considerable primary data on its mangrove formation through various project reports. Consolidating this data and filling the lacunae in the data through further monitoring is suffice to generate up to date baseline data on mangrove

vegetation stand of Kandla port; special attention could be paid to document segment wise data on density, tree canopy, tree diameter classes, stand dynamics, pore-water chemistry, etc. This baseline creation and further yearly monitoring will enable the port authorities on the time series changes happening in the vegetation. Table 7.3 presents different components of the monitoring program, time schedule and other details. Regular monitoring of the chosen parameters in the mangroves of port environment will enable the port authorities to gain knowledge about the impact of the ongoing activities as it is the primary step to device management options to ensure mangrove preservation and health in a holistic manner.

Table 7.3: Mangrove Monitoring Program Components and other Details

Component	Details	Inference to be derived
GIS & RS Mapping	GIS maps for Port limit procured from NRSC and mangrove distribution to be studied-Delineation of different density classes such as dense, moderately dense and sparse mangroves, potential mudflats for plantation, sparse patches for restoration could be earmarked on the map	Changes in the physical extent could be traced by overlaying the subsequent maps on the baseline maps. Changes in areal extent to be gleaned- Potential sites for plantation and restoration identified
Vegetation Structure	Mostly vegetation characters like density, Canopy cover, health in terms of regeneration potential to be established as baseline	General regeneration potential of mangrove stand inferred. This data is to be considered along with pore water parameter like salinity, pH and conductivity in subsequent monitoring to glean information on changes.
Sedimentation Process	To monitor potential changes in sedimentation rate in the mangrove proper due to port activities	To be considered in conjunction with dredging and other civil engineering activities of the port to derive possible correlation
Porewater Chemistry-Salinity, pH, conductivity	Representative samples in a gradient to be collected for better comparison with the baseline data	Produced structural and physiognomic zones to be compared for changes with the baseline data
Photographs	Photographs to be taken from a reference standard points fixed during baseline studies	Visual comparison with the earlier baseline photos establishes changes.

For gathering monitoring data, reference points fixed during baseline collection is to be strictly maintained in order to avoid ambiguous and misleading results during the monitoring activities.

For all the above mentioned parameters a threshold limit of 20% could be kept as standard margin and deviation more than this from the baseline data could be treated as the signs of degradation that calls for appropriate management plan and options to be exercised to control the impact. Some of the options are as follows.

Analyzing the causative factor(s) for the degradation such as physical, geomorphological, biological and exploring the possibility of remedial measures to mitigate the problem that cause stand degradation is the first step. Increased sedimentation due to port activity and resultant micro-level change in geomorphology is often the major cause for mangrove degradation. Other natural causative factors such as cattle grazing and mangrove resource collection is negligible in Kandla though natural coastal erosion is noticed in certain pockets.

In the event of excessive sedimentation in mangrove proper, causative factors like source of sediment load reaching mangroves is to be investigated thoroughly. Measures to ameliorate the impact like reducing the sediment load through changes in operational procedure may be considered.

Efforts to trap run-off slurry and sediment plume from the dredging area by means of silt traps may be attempted and the trapped sediments will be responsibly disposed in pre-designated sites.

Similarly, a safety exclusion zone will be required around the dredging vessel whose size will depend on the final dredging plan and will range from 150 m to 500 m in accordance with the international standards and best practices.

Altered tidal flushing due to various reasons in and around the creek system is a possibility which may affect mangroves on the creek banks leading to erosion. Tidal water flow in small intertidal canals that feed isolated mangrove stands generally get disrupted due to sedimentation with the possibility of complete filling. This could be best managed through micro-level study of the degrading patch and ensuring adequate

and proper tidal flushing through measures narrated in section 7.6. Majority of the problem of stand degradation could be addressed by ensuring adequate tidal flushing, which is the single most important factor for stand degradation.

7.6.6 Erosion:

Fringes of Sat Saida Bet as well as parts Tuna are directly exposed to high tidal currents and erosion. This ongoing natural process is taking a heavy toll of many fully grown and healthy mangrove trees on the mudflat periphery. Following actions are recommended for controlling erosion and check further uprooting of mangroves.

- ♣ Initial earmarking of erosion prone sites along all the creek system.
- ♣ Since the process of erosion is highest along Sat Saida bet, it could be controlled only by physical means by constructing appropriate civil engineering structures. Erosion control structures or constructing embankment of stones or any suitable material along the erosion site is strongly recommended if the problem is too heavy. The proposed embankment should be eco-engineering design with a gentle slope of appropriate angle to the tidal action that will allow natural flushing while totally controlling erosion.
- ♣ Oceanographic factors that cause erosion in the immediate port vicinity need to be understood. Whether the erosion is caused due to ongoing port activities and other port structures or natural cause needs to be ascertained. Coastal stretch of Kandla is stated to fall either under a low or medium erosion category (National Assessment of Shoreline changes, 2011). The erosion map prepared by Ministry of Environment and Forests (MoEF, 2011) marks certain parts of Kandla region and nearby stretches as stable or high accretion coast. Contrarily, erosion of high intensity has been witnessed during this study indicating that this might be due to ongoing port activity.
- ♣ A rapid survey through the survey department of Kandla Port could be undertaken at regular time intervals to identify coastal stretches within the port limit which are prone to high erosion. These high erosion coastal stretches could be provided with gentle slopes with stone pitching and other civil

engineering works which will reduce the rate of erosion. These measures are required only if mangroves are present in vast areas in this stretch.

8 SUMMARY:

Kandla Port is one of the biggest port of India situated in the northwestern part of Gujarat. Mangrove forest is a conspicuous ecological entity within Kandla Port area. Due to the major port activities and accompanying development, mangroves within the premises of KPT have become vulnerable, susceptible and fragile over the years. Consequently, conservation and management of this mangrove formation has become imperative and an environmental responsibility of the Kandla port authority. In view of the continued port expansion and development, Department of Forest and Environment, Government of Gujarat, Gandhinagar has mandated KPT to investigate the current ecological status of mangroves in the KPT premises through proper scientific assessment and formulate long term conservation and management plan. Kandla Port authorities assigned the task of investigating the mangrove ecology within the port jurisdiction to Gujarat Institute of Desert Ecology (GUIDE), Bhuj.

In the present study conservation and management measures for the long term wellbeing of mangroves of Kandla Port is suggested based on intensive field visits, analyzing the existing management practices of the port *vis-à-vis* mangroves and plantation and other conservation activities carried out by port authorities under different projects of the port.

In order to understand the present status in terms of overall mangrove forest structure, stand health and governing physio-chemical factors a detailed field based investigation was carried out. For delineating mangrove characteristics, 21 transects were sampled covering various patches of Kandla port premises. Parameters like density, tree height, GBH, canopy length, canopy width, vegetation frequency and regeneration and recruitment potential were investigated. The mangrove vegetation structure of 21 sampled locations shows an average tree density of 4124/ha and tree height of 254cm and GBH of 40.4 cm. During the present study, mangrove tree density in all the 21 sampled locations ranged between 1500/ha and 7800/ha. Mangrove tree height ranged from 171 cm m to 431 cm with average value of 254cm. The Girth at Breast Height (GBH)of at different patches was from 31 cm to 49.5 cm with an average value of 40.4 cm. Regeneration class density ranged between 3300 to

100000/ha whereas recruitment class density were ranged from 1000 and 56600/ha. In general, mangrove vegetation structure at KPT premises demonstrated that mangrove patches are healthy with very moderate density and with good regeneration potential as evidenced by the ratio between mature trees and younger classes (recruitment and regeneration).

Water and sediment health status of KPT premises examined indicated that majority of the parameters are well within the prescribed limits and no pollution could be distinguished showing that the water and sediment at KPT premises is clean. Important parameters like salinity and pH of both surface water and pore-water are within expected level of any mangrove formation. Observed average pore-water salinity was 53.7 ppt and pHwas8.21. Nitrite concentration ranged from 0.1 to 0.9 mg/L with an overall average of 0.63 mg/L. Nitrate content of the present study varied from 0.9 to 1.9 mg/L with a cumulative average of 1.45 mg/L. Phosphate concentration ranged from 0.1 – 1.8 mg/L with an average of 0.75 mg/L. The recorded nutrient concentrations of the present investigation are good enough to support the growth and vegetation structure of the KPT mangroves.

Land cover category of KPT jurisdictions has been estimated in hectares and area contribution are expressed in percentage. Total mangrove cover constitutes 15.3% with dense mangroves constituting 3.8% and sparse mangrove 11.5 %. Highest land cover is occupied by mudflats to the tune of 36.9% followed by water spread (11.5%) whereas cover of settlement (01%) and agriculture (1.7%) was lowest.

During the present study, following impacts were recorded due to coastal modification, tidal regime and water currents.

1. Erosion of the creek banks in the immediate vicinity of water front.
2. Reduced tidal flushing and decrease in the tidal flat in and around the construction points.

Following the forecast of impacts, effective mangrove management plan for the preservation of KPT mangroves, suggestions which covers the following three important aspects.

- Creation of Baseline Information to track subsequent changes in mangrove vegetation structure due to port activities and related development activities.
- Periodic monitoring programs are to be organized whose results in comparison with baseline data will assist to formulate appropriate management options to check any stand degradation.
- Preservation measures to be undertaken in the event of signs of impact

Mangrove monitoring programs at a regular interval of one year for gathering all baseline parameters in the same GPS referenced points is suggested. Overlaying the data generated during monitoring program with those of baseline data will help the port authorities to track changes happening in KPT mangroves. Regular monitoring of the chosen parameters in KPT mangroves will highlight the impact of the ongoing activities. Management alternatives to preserve mangroves could be contemplated based on this changes detected during monitoring phases.

Suggested mangrove preservation measures include the following. These preservation measures are parallel and consequent to monitoring programs.

Incidences that are detrimental to mangroves like Oil/fuel and other hydrocarbon spillage from earthwork machineries, fire, unauthorized entry of personnel, trespassing and grazing by cattle and collecting forest produce from mangroves are to be reported which will be investigated and appropriate follow-up action taken.

Washing frontline mangrove foliage through pressure hosing if dust deposition is notices in frontline mangroves along with a thorough review of dust control measures.

Since developmental activities in the intertidal and near intertidal regions are perceived to cause impact to a large extent, various measures to preserve mangroves from port development impact are suggested. Undertaking mangrove rehabilitation activities in the KPT premises is also recommended in technically suitable sites.

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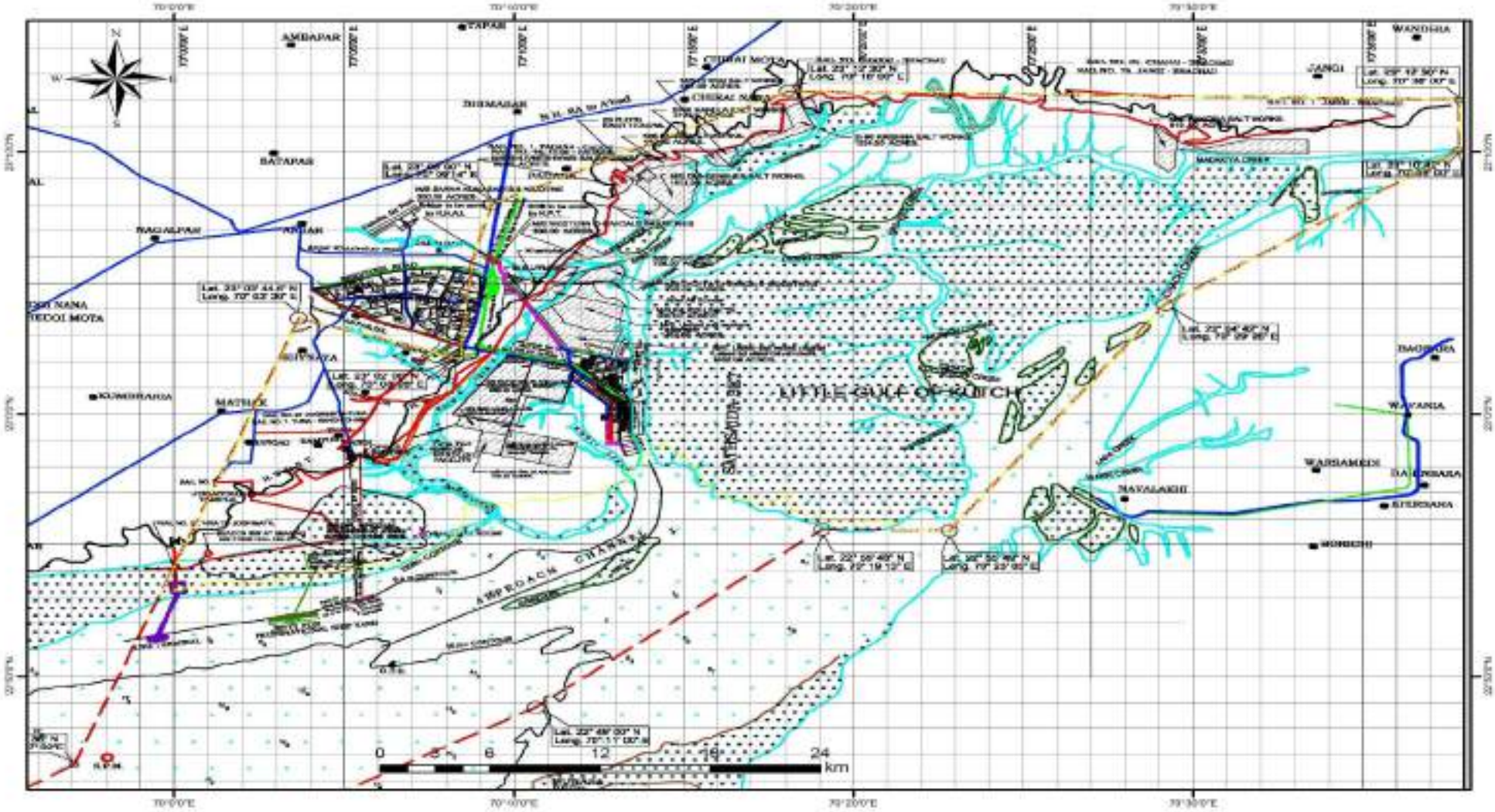
Annexure I. Location Map of the Kandla Port Premises



ANNEXURE – I

Regular Monitoring of Mangrove Plantation

Assessment and Monitoring of Mangrove Plantation (1300 Ha) carried out by Deendayal Port Trust, Kandla

Final report submitted to

Deendayal Port Trust
Gandhidham

Submitted by

GUJARAT INSTITUTE OF DESERT ECOLOGY

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Snapshot of the Project," Assessment and Monitoring of Mangrove Plantation (1300 Ha) carried out by Deendayal Port Trust, Kandla"

S.No	Components of the Study	Remarks
1	Deendayal Port letter sanctioning the project	NO.EG/WK/4751/CRZ II Letter dated : 01/09/2017
2	Duration of the project	One year-from 15.09.2017 to 15.09.2018
3	Period of survey carried out for various components	November 2017 – August 2018
4	Survey area within the port limit	Sat Saida Bet, Nakti creek and Kantiyajal mangrove plantation sites
5	No of locations sampled within the port limits	04 blocks in Sat Saida Bet, 02 blocks each in Nakti creek and Kantiyajal
6	Components of the report	
7a	Mangrove density	*Sat Saida Bet:* average density of *A. marina* varied from 2031 to 5387 individuals/ha with average height ranging from 39 - 113 cm *Nakti creek:* average density of *A. marina* varied from 2340 – 2370 individuals/ha with average height from 53 - 84 cm. *Kantiyajal:* average density of *A. marina* varied from 1460 - 2220 individuals/ha with average height from 32 -37 cm. Average density of *R. mucronata* at Kantiyajal was 1280 individuals/ha with an average height of 30 cm
7b	Mangrove survival	Highest survival rate (88.8%) for *A. marina* plantation in 150 ha at Kantiyajal followed by *A. marina* plantation in 20 ha at Sat Saida bet (81.6%).
7c	Carbon sequestration potential	The carbon biomass of *A. marina* plantation varied from 0.041 to 0.202 Mg/ha. The highest Carbon sequestration potential was of Nakti creek.
7d	Management Suggestions	The sparse mangrove patches need to be made dense through restoration efforts following multi-species plantation, more restoration efforts, bio-physical amendments to promote natural regeneration and long term voluntary restoration and plantation efforts.

1. INTRODUCTION

1.1. Background

Mangroves are complex ecosystems that provide coastal bioshield to habitats and societies from natural disasters. Mangrove ecosystems, making up less than 0.4% of the world's forests (Spalding *et al*., 2010), are being lost at the rate of 1% per year (FAO, 2007). In some areas the rate of mangrove loss is between 2 and 8% per year (Miththapala, 2008). By 1970's decline in mangrove ecosystem was drastic due to both natural and anthropogenic activities. Since 1980, around 20% to 35% of the world's mangrove areas were lost. The mangrove loss has been higher in most of the developing countries for want of space to accommodate various coastal and maritime development activities. Over the years the ecological role of mangroves and the services they provide have been widely realized by the global scientific fraternity. Thus, several researchers eventually targeted mangrove restoration in order to restore their ecological and economical values. The state of Gujarat is no exception to this.

India is lined with a 7516.6 km coastline distributed among nine coastal states and four Union Territories (Anon 2001). Gujarat possesses the longest coastline extending to 1650 km among all the maritime states in India. Mangrove ecosystem in Gujarat is important and is the second largest after Sundarbans in West Bengal. Though contentious, around 15 mangrove species are reported from 13 coastal districts of Gujarat. Of these, the Southern coast of Gulf of Kachchh and South Gujarat are the important districts for mangrove diversity. In Gujarat, the coastal stretch of Gulf of Kutch (GoK) has the largest mangrove extent of 986 km^2 out of 1140 km^2. Kachchh district, constituting the northern coast (northern shore) of GoK alone has 798 km^2 of mangroves constituting 70% of the whole Gujarat mangroves.

True mangroves are taxonomically diverse group, majority of which fall under four genera: *Avicennia*, *Rhizophora*, *Sonneratia* and *Bruguiera*. Though mangrove restoration activities in Gujarat are one of the best examples of habitat restoration

in the world, the mangrove formation / restoration in GoK is largely single species, comprising of *Avicennia marina*. Majority of the mangrove species require fresh water inundation at certain time intervals for propagation. Given the topography of Gujarat state and in particular Kachchh region, finding continuous fresh water sources is atypical. Aridity is the most striking feature of the coastal belt of GoK which often renders plantation of mangrove species other than *A. marina* least promising. This, in turn, makes mangroves restoration / plantation work more challenging and uncertain in semi-arid regions such as Kachchh.

1.2. Rationale

Deendayal Port Trust (DPT) is one of the largest ports of India in terms of volume of cargo handled. Among Indian ports, this port also has the largest coastal habitats such as mangroves (193.1 km^2) and mudflats (312.9 km^2). Due to this vast coastal resources under its jurisdiction, the port authorities besides legal mandate, desire to conserve, protect and enhance these coastal habitats. The establishment of facilities over the years, buildings, etc. involve notable movement of materials and people in the area. Doubtlessly, this will alter the local ecological makeup of the area. Any long-term activity in the adjacent place will have serious repercussions. Thus, measures should be taken to conserve and preserve KPT mangrove area, thus retaining several unsung ecological services of mangroves. Accordingly, DPT has implemented mangrove plantation in 1300 ha during 2005 - 2017 through various implementing agencies at Sat Saida Bet, Nakti creek and Kantiyajal. The Deendayal Port Trust has entrusted the task of evaluating 1300 ha of mangrove plantation in these three locations to Gujarat Institute of Desert Ecology (GUIDE), Bhuj.

1.3. Objectives of the Study

The overall goal of this study is to assess the mangrove plantation, associated factors affecting mangrove health and suggest tools and techniques of conserving them. The specific objectives are as below:

i. To evaluate 1300 ha of mangrove plantation at Sat Saida Bet, Nakti creek and Kantiyajal in Kachchh coast carried out by Gujarat Ecology Commission (GEC), Forest & Environment Department and GUIDE.

ii. To assess the extent of plantation, health status, sapling survival, mortality rate and growth of the planted mangroves.

iii. To provide a comprehensive overview of both the composition and distribution of the planted mangroves following Phyto-sociological methods.

iv. To assess the Carbon sequestration potential of the mangrove plantation in view of Climate Change.

2. STUDY AREA

2.1. DPT Environ

Deendayal Port in Kachchh District of Gujarat State (formerly Kandla Port) operated by Deendayal Port Trust (DPT) is a gateway Port to the hinterland in western and northern states of India. It is one of the 11 major Ports of India situated at latitude 23°1' N; longitude 70° 13' E on Kandla creek at the inner end of Gulf of Kachchh. Inclusion of Karachi Port in Pakistan after India's partition and heavy traffic congestion at the then Bombay Port gave impetus for the promotion of Deendayal Port during 1950s. During 1955, Deendayal Port acquired the status of a major Port in India. Because of its proximity to the Gulf countries, large quantities of crude petroleum and other assorted cargo are imported through Deendayal Port.

An assortment of liquid and dry cargo is being handled at Deendayal Port. Dry cargo includes fertilizers, iron crap, steel, food grain, metal products, ores, cement, coal, machineries, sugar, wooden logs, salt extractions, etc. Liquid cargo includes edible oil, crude oil and other petroleum products. Total cargo handling was 105 MMTPA during 2016-2017 and 110 MMTPA during 2017-2018. The Port has presently 14 jetties and six oil terminals and several allied facilities for handling dry and liquid cargo. Regular expansion/developmental activities such as the addition of jetties, allied Special Economic Zones, industrial parks and ship bunkering facilities are underway in order to cope with the increasing cargo handling demands.

Developmental initiatives of this magnitude going on in the past six decades will have its own environmental repercussions. Being located at the inner end of Gulf of Kachchh (GoK), Deendayal Port has a fragile marine ecosystem that includes a vast expanse of mangroves, mudflats, creek systems and allied biota. Deendayal Port is a natural harbour located on the eastern bank of North-South trending Kandla creek at an aerial distance of 145 km from the Gulf's mouth. The Port location is marked by a network of major and minor mangrove lined creek systems

with the vast extent of mudflats. Coastal belt in and around the Port has an irregular and dissected configuration. Due to its location, tidal amplitude is elevated, experiencing 6.66 m during Mean High Water Spring (MHWS) and 0.78 m during Mean Low Water Spring (MLWS) with an MSL of 3.88 m. Commensurate with the increasing tidal amplitude, vast intertidal expanses are present in and around the port environ. This, along with the occurrence of mudflats enables mangrove formations at the intertidal belts. Annual rainfall during 2015 was 398 mm, which is often irregular (India Meteorological Office, Ahmedabad). Mean rainfall at Gandhidham taluka where Deendayal Port is located, during 1985 to 2014 was 398 mm (Table 1). There are no perennial or seasonal rivers in Gandhidham taluka. Rain during monsoon is confined to only 15-20 days and occurs as an instant downpour. Freshwater input into the near coastal waters is quite meagre and appears to have less influence on the ambient coastal water quality except during monsoon months during which flash floods are discharged in the near coastal waters. Annual average humidity is 60%, which increases to 80% during south-west monsoon and decreases to 50% during November-December. Average wind speed is 4.65 m/s with a maximum wind speed of 10.61 m/s during June. The phenomenon of drought is common with 2 drought year in a cycle of 5 years. Annual mean maximum and minimum temperature of the area are 41.8°C and 22.9°C, respectively.

Coastal belt in and around Kandla region is characterized by a network of creek systems and mudflats which are covered by sparse halophytic vegetation like scrubby to dense mangroves, creek water and salt encrusted land mass which forms the major land component. The surrounding environment in a radius of 10 km from the Port is mostly built up areas consisting salt works, human habitations and Port related structures on west and north, creek system, mangrove formations and mudflats in the east and south. Deendayal Port and its surroundings have mangroves, mudflats and creek systems as major ecological entities.

Table 1. Environmental setting of the Deendayal Port region.

Sl. No.	Particulars	Details
1	Deendayal Port Co-ordinates	23° 1' N, 70° 13' E
2	Elevation above Mean Sea level	~20 ft
3	Climatic Conditions	As per Meteorological Station, Deendayal Port Annual Mean Max Temp: 41.8°C Annual Mean Min Temp: 22.9°C Rainfall: 398 mm (2015)
4	Land Use of nearby areas	Comparatively flat marshy land with stunted and dense mangrove formation, mudflats, creek systems, coastal halophytes, saltpans and salt swamps
5	Nearest Highway	National Highway 8A
6	Nearest Railway Station	Gandhidham RS
7	Nearest major airport	Bhuj (~60 km, NW)
8	Nearest Village habitation	Tuna (~12 km, North)
9	Nearest Major Town	Gandhidham (12 km, Northwest)
10	Reserved Forest	Nil
11	Historically Important Places	Nil
12	Rivers/streams around the project environs	Nil
13	Major Dams and barrages	Nil
14	Survey of India Topo sheet covering the proposed site and surroundings	F42K1
15	Seismic Zone	Zone -V

2.2. Mangrove Plantation Activities undertaken by DPT

Mangrove plantation activity by DPT was initiated during the monsoon months of 2005 as mandated by the Ministry of Environment Forests (MoEF). Subsequently, 1300 ha of mangrove plantation has been completed till the end of 2017 in different years in order to meet the legal mandate of Ministry of Environment, Forests and Climate Change (MoEF & CC). The mangrove plantation activities by DPT were carried out at Sat Saida Bet, Nakti creek and Kantiyajal of Bharuch district in South Gujarat. At Sat Saida Bet, plantation activities were carried out in phased out manner i.e. 20 ha during 2005-2006, 200 ha during 2011-2012, 300 ha during 2012-2013, and 330 ha during 2013-2014 (Plate1). At Nakti creek plantation was carried out during 2008-2009 and 2010-2011 in 50 ha and 100 ha,

respectively. At Kantiyajal, mangrove plantation activities were carried out in two phases i.e. 150 ha during 2015-2016 and 150 ha during 2016-2017. The details of implemented mangrove plantation by DPT are given in Table 2. *A. marina* was the preferred species for plantation activities in all the three locations due to prevailing high salinity and high success rate of this species. At Nakti creek *Rhizophora mucronata* and *Ceriops tagal* were also planted in small numbers along with *A. marina*. Likewise, at Kantiyajal attempts were made for planting *R. mucronata* along with *A. marina*. All these mangrove plantations in different years since 2005 were carried out to meet MoEF & CC imposed conditions for different port expansion projects and construction of jetties.

Table 2. Details of implemented mangrove plantation activities by DPT

Location	Year of Plantation	Area (ha)	Species planted	Implementing Agency
Sat Saida Bet, Kachchh district	2005-2006	20	*A. marina*	M/s Gujarat Institute of Desert Ecology, Bhuj
	2011-2012	200	*A. marina*	Forest & Environment Department, GoG
	2012-2013	300	*A. marina*	Forest & Environment Department, GoG
	2013-2014	330	*A. marina*	Forest & Environment Department, GoG
Nakti Creek, Kachchh district	2008-2009	50	*A. marina*	M/s Patel Construction Co, Gandhidham
	2010-2011	100	*A. marina* *R. mucronata* *C. tagal*	M/s Gujarat Ecology Commission
Kantiyajal, Bharuch District	2015-2016	150	*A. marina*	M/s Gujarat Ecology Commission
	2016-2017	150	*A. marina* *R. mucronata*	M/s Gujarat Ecology Commission

2.3. Plantation Techniques

For mangrove plantation the following three methods were chosen i) Raised bed method (*Otla* method), ii) Direct propagule dibbling (Seed sowing method), and iii) Transplantation of nursery raised saplings (Polybag method). However, raised

bed and propagules dibbling methods were predominately followed in the majority of the plantation efforts while transplantation of nursery raised saplings were followed in few instances.

2.3.1. Raised Bed Method (*Olta* Methods)

In majority of the plantation sites raised bed method (*Otla* method) was followed, as it is believed to give better results than other methods. Further, this method is perceived to be less costly and labour intensive. This method is especially suitable for sites with high tidal currents since the raised beds resist uprooting of sown seeds in the receding tidal current. In this method, circular earthen mounts of 10-15 cm height and 1 m radius were raised and around 20 seeds/propagules were dibbled on the surface of each bed. Generally, number of raised beds of *A. marina* per ha at Sat Saida bet and Nakti creek was around 3300 with a spacing of 1 x 1 m. *A. marina* survival percentage was calculated based on 6600 saplings/ha for *A. marina* i.e. assuming each *Otla* to has a minimum of two surviving seeds/saplings (3300 *Otla*/ha x 2 surviving saplings = 6600 saplings/ha). In case of plantation where already natural mangroves existed, clusters of *Otlas* mostly exceeding the density of 1500/ha were made closely. In the case of Kantiyajal mangroves 2500 saplings/ha of *A. marina* were considered for calculating survival percentage as per GEC (2015-2017).

2.3.2. Direct Propagule Dibbling (Seed Sowing Method)

Next to raised bed method, direct propagule dibbling (locally called *'Sing'* plantation) was attempted in many sites. This method is less labour and cost intensive, though repeated dibbling is often required in order to obtain desirable survival rate. In this method, mature propagules were dibbled in open empty mudflats or among gaps of natural mangrove stands. Spacing maintained between each dibbled propagule varied and at some sites it was as close as 0.75 × 0.5 m, especially in plantation raised among gaps of natural mangroves. Propagules used were collected freshly from the nearby mangrove formations, which are thought to give better results, and no pre-dibbling seed treatments were used. Often

propagules were dibbled repeatedly in order to increase survival rates and in raised (*Otla*) bed and nursery plantation sites, dibbling propagules was resorted to increase survival.

2.3.3. Translation of Nursery Raised Saplings (Polybag Method)

Transplantation of nursery raised saplings was also followed as its success rate is higher than other methods. Unlike raised bed and direct dibbling methods, this method is labour and cost intensive, and time consuming. Nursery raised saplings were transplanted as individual plants in the open intertidal mudflats. Saplings in the polythene bags were allowed to attain a height of 40-50 cm before transplantation over a period of 4-5 months. Based on site specific conditions, the number of saplings transplanted varied from 3000 to 6000 per ha. In certain instances, nursery raised saplings were used to gap filling in the seed dibbled plantation in order to raise the survival rate.

2.3.4. Mangrove Plantation at Sat Saida Bet

Sat Saida on the eastern bank of Kandla creek is a unique Island of 253.8 km^2 opposite to Deendayal port. As one of the major Islands of Gulf of Kachchh, the Island has sparse mangroves (32.8 km^2) dense mangroves (7.74 km^2) and mudflats (144.73 km^2) and halophytic vegetation other than mangroves (49.6 km^2). Surrounded by Kandla creek and its branches in the west, Navlakhi creek and its branches on the east and Sara and Pang creek on its north, Sat Saida bet is a highly potential site for mangrove plantation with its vast mudflat. Many major, medium and minor creek systems of Kandla and Navlakhi creeks ramify into this Island in varying length and dimension, supplying tidal water to the interior regions. Southern border of the Island represents the innermost end of Gulf of Kachchh with very few minor creek systems. It is known that mudflats experiencing favourable tidal amplitude are suitable for mangrove plantation. Therefore, Sat Saida Bet area was chosen by DPT to carry out the mangrove plantation and restoration activities. The plantation work in this Island was done in four phases

i.e. 2005-2006, 2011-2012, 2012-2013, and 2013-2014, details of which are given in subsequent sections.

2.3.4.1. 2005-2006 Plantation in 20 ha

During 2005-2006, the mangrove plantation work at Sat Saida Bet was carried out at Dharkadia creek banks in 20 ha. Two sites on both the banks of Dharkadia creek were planted with *A. marina* by M/s. Gujarat Institute of Desert Ecology. Transplanting nursery grown seedlings and direct seed sowing for gap filling were followed during mangrove plantation work. Nevertheless, majority of mangrove plantation was through direct seed dibbing.

2.3.4.2. *2011-2012 Plantation in 200 ha*

Mangrove plantation in 200 ha was initiated by Forest Department, Kachchh circle during 2011-2012 on DPT's request. Forest Department (Anjar circle) initiated the plantation activities at Sat Saida Bet during the rainy season of June 2011. The plantation site is opposite to Deendayal port oil jetty and is ~2 km from the bank of Sat Saida bet. A buffer zone of nearly 2 km was allowed between waterfront from the banks of Sat Saida bet and the plantation site. The seeds of *A. marina* were used for plantation activities due to prevailing high salinity in the area. Raised bed method (*Otla*) was followed as the plantation technique and *A. marina* seeds were mostly collected from Kandla mangroves for plantation work.

2.3.4.3. *2012-2013 Plantation in 300 ha*

The mangrove plantation carried out during 2012-2013 in 300 ha was covered by Range office of Forest Department at Anjar. *A. marina* was the candidate species for plantation activities at this site. Initially, raised bed method was followed for mangrove plantation but was eventually replaced by direct seed sowing.

2.3.4.4. *2013-2014 Plantation in 330 ha*

In continuation of previous year activities, mangrove plantation in 330 ha was carried out by Range Forest Office at Anjar of Kachchh Circle. The plantation site

is located at Sat Saida bet northeast of Kandla port where the main Kandla creek bifurcates east and further north. The plantation site is around 5 km from the bank of Sat Saida bet. Akin to other sites, *A. marina* was the preferred species for plantation activities. Raised bed method was largely followed as the plantation technique at this site. In few spaces, direct seed dibbling was also done.

2.3.5. Mangrove Plantation at Nakti Creek

2.3.5.1. *2008-2009 Plantation in 50 ha*

The 50 ha mangrove plantation was carried out at Nakti creek in one block by M/s. Patel Construction Co, Gandhidham. Nursery raised saplings, *Otla* bed, and direct dibbling methods were followed for planting *A. marina*.

2.3.5.2. *2010-2011 Plantation in 100 ha*

This mangrove plantation work was executed by M/s. Gujarat Ecology Commission at different blocks at Nakti creek following raised bed method (*Otla*), direct dibbling, and transplantation of nursery raised saplings. The first block was along the Nakti creek and *A. marina* was the candidate species for plantation. In the second block (other side of Nakti creek) *Ceriops tagal* were also sown. In the third block, located on the eastern side of the second block, seeds of *A. marina* were sown. The fourth block plantation was along the minor creek system along the bund and road where propagules of *Rhizophora mucronata* and *C. tagal* were planted. In this 100 ha, *R. mucronata* and *C. tagal* were sown in 5 ha each, and remaining area was planted with *A. marina*. Around 6 lakh seeds involving three species of true mangroves are estimated to be planted in four different blocks. One lakh saplings each of *R mucronata* and *C tagal* were planted in Nakti creek. Accordingly, 20,000 saplings per hectare were transplanted.

2.3.6. Mangrove Plantation at Kantiyajal

Unlike other plantation sites, which are located in and around Deendayal port, this 300 ha, plantation was carried out at Katpor village of Bharuch district near Kantiyajal in South Gujarat by Gujarat Ecology Commission, Gandhinagar. The

plantation was done in two blocks each with 150 ha during 2015-16 and 2016-17 at the coastal stretch of Katpor, Hansot taluka, Bharuch District. *Koteshwar Paryavaran Vikas Vyavasthapan Samiti*, a Community based Organization was entrusted with the task of executing this plantation. Table 3 gives details about the methods followed, candidate species and the target achieved in each method. The seeds of both *A. marina* and *R. mucronata* were collected from the nearby natural mangrove areas. Village level CBO in association with GEC maintain the plantation by gap-filling activities and protection through social fencing. Saplings of *A. marina* were transplanted at the distance of 2.5 x 2.5 m i.e. 2500 saplings/ha. A total of 4,62,500 plants were transplanted in all plantation years. Further, due to large intertidal region as compared to other costal districts of South Gujarat, human habitations are far off from the mangrove habitats.

In total, 70000 propagules of *R. mucronata* were planted to cover 35 ha of area at intertidal belt. The *R. mucronata* propagules were imported from Sindhudurg district of Maharashtra State and each propagule was planted at the distance of 2.5 x 2 m at the banks of small and medium creeks.

Table 3. Mangrove plantation details of Katpor, South Gujarat

Sl. No.	Year of Plantation	Method	Species	Area (ha)
1	2015-2016	Nursery Method	*A. marina*	70
2	2015-2016	Raised Beds	*A. marina*	80
3	2016-2017	Nursery Method	*A. marina*	115
4	2016-2017	Direct dibbling	*R. mucronata*	35
Total				300

2.3.6.1. ***2015-2016 Plantation in 150 ha***

This site has naturally growing *A. marina* extending from lower littoral to the mid-littoral. The plantation site is near to this luxuriantly growing mangrove patch. The site is behind the naturally growing plants away from the waterline; however, every day flushing keeps this site quite healthy. The 150 ha mangrove plantation

during 2015-2016 at Kantiyajal was carried out in two blocks. Of this 150 ha, 70 ha plantation activities were carried out following nursery method and remaining area following *Otla* bed. The *Otla* beds of 1 x 1 x 1 m were prepared to improve mangrove density. *A. marina* saplings were transplanted at a distance of 2.5 x 2 m. Around 32,000 such beds were prepared in 80 ha. All plantation activities were taken care by M/s. Gujarat Ecology Commission. *A. marina* was the preferred species for plantation in both the blocks.

2.3.6.2. *2016-2017 Plantation in 150 ha*

The plantation site is locally called as "Lalavi area of Alia Bet". The site is little far away from the approach road and is close to water front. The plantation site is near the aquaculture ponds and a small creek passes through the plantation site. The 150 ha mangrove plantation during 2016-2017 at Kantiyajal was carried out in two blocks. Of this 150 ha, 115 ha plantation activities were carried out following nursery method and in the remaining area direct dibbling method was followed. All plantation activities were taken care by M/s. Gujarat Ecology Commission. *A. marina* was transplanted in 115 ha and *R. mucronata* was planted in 35 ha.

3. METHODOLOGY

3.1. Evaluation of mangrove plantation

The field surveys were undertaken during November 2017 to August 2018 to assess the overall plantation success in these eight blocks. To evaluate the *A. marina* plantation success at Sat Saida bet and Nakti creek i.e. survival percentage and growth rate, initial plantation density of 6600 saplings/ha as a baseline density was considered. Since in most of the plantation method a density 1x1.5 m was used this was considered as initial density at Sat Saida bet and Nakti creek. This contention of implementing agencies that 6600 saplings/ha as equivalent to 1 ha of physical extent, irrespective of the area covered was ascertained through estimating density of the *Otla* beds or saplings per unit area which was then extrapolated to 1 ha in order to ensure notional or physical coverage. Often, raised beds or planted saplings were closely made and compacted at different densities in order to use the available suitable sites.

To assess the survival percentage of the mangrove plantation, the area was divided into uniform grids. Sampling grids were randomly chosen and all surviving saplings in that grid were counted to evaluate the survival status, density of transplanted saplings. The assessment was carried out during low tides by quadrate method by laying plots of 10 × 10 m. In each quadrate, number of planted saplings and their corresponding height were recorded. For assessing the mangrove formations along the creeks systems, a fishing boat was used.

Sat Saida bet, where there are four plantation sites, were taken up first for assessment followed by Nakti creek where two plantation sites exist. Later Kantiyajal mangrove plantation sites were assessed. Based on the GIS co-ordinates all plantation sites were plotted on google map (for the details of satellite imageries procurement, please refer to Annexure 1). Detailed discussion was held with the officials of implementing agencies, i.e. Kachchh forest division and the field supervisor and all relevant information and documents such as plantation registers, local maps, address and personnel involved was gathered. The

implementing agencies were requested to intimate the respective range forest office to extend assistance to the study team.

At Sat Saida bet a total of 72 quadrates were laid, which include, 15 quadrates in 20 ha, 17 quadrates in 200 ha, 16 quadrates in 300 ha, and 24 quadrates in 330 ha. At Nakti creek, 10 quadrates each at 50 and 100 ha plantation sites were laid. At Kantiyajal, 20 quadrates at first block and 10 quadrates in second block were laid. Thus, in total 122 quadrates were laid covering Sat Saida bet, Nakti creek, and Kantiyajal plantation sites.

Of the eight plantation sites, four are located in Sat Saida and Nakti sites where approach and labour mobilization has proved extremely difficult. Though a massive plantation effort has been made which was physically inspected and assessed in the present survey, physical, ecological and environmental changes arising out of the created resources will be visible only after ten years when the raised forest matures into a functional ecosystem discharging all its ecological services.

3.2. Carbon Sequestration Potential of Planted Mangroves

The annual per capita emission of CO_2 from India is 1.67 metric ton and the population of India in 2016 was ~1324 million. According to Kaladharan et al. (2009), the total annual CO_2 emission from India is ~ 2211 million tons. Thus, any intervention proposed must aim at balancing this emission. Mangroves are the first defender during any natural disasters and also a sink of 'Blue carbon' (Donato et al. 2011; Alongi et al. 2016). But unlike other terrestrial ecosystems, mangrove carbon is stored mostly below-ground (Alongi *et al.* 2016). Past researches indicate that mangroves are among the most carbon-rich forests in the tropics, containing an average of 1,023Mg carbon per hectare (Donato *et al.* 2011). In view of above specific, the present study attempted to assess the carbon sequestration potential of planted mangroves at all the sites.

3.2.1. Sampling of Soil and Plant Biomass

Sampling sites for soil/sediment and mangroves were identified through reconnaissance survey. The survey and sampling involved (i) identification of sites for sampling in and around the study area, (ii) collection of soil/sediment and mangrove in and around the study area, and (iii) processing the samples for TOC (%), bulk density and plant biomass. Selection of sampling sites was based on different age/height classes of mangroves.

Based on the above criteria one time sampling was carried out following random sampling protocol for all the samples. At Sat Saida Bet and Nakti creek three pits of 100 cm in each block were made. At Kantiyajal, 2 such pits at each block were made. Samples were collected across the layers i.e. 0-30 cm and 30- 100 cm from each pedon/pit using a plastic scoop. The sampling involved packing of soil samples in pre-cleaned airtight plastic bags, labeling with appropriate code numbers, and subsequent transfer to the laboratory for further processing and analysis (Plate 2). The field collected soil samples were air-dried at normal room temperature (Jackson, 1958), homogenized using an agate mortar and pestle, and sieved through a standard sieve of 2-mm mesh (Tandon, 2005). The particles with size less than 2mm were retained in pre-cleaned plastic bottles for bulk density and Total Organic Carbon (%).

Against each pit/pedon, two mangrove plants were collected. Mangrove samples were collected by complete uprooting of the individual at each site. Individual plants were then packed and labeled. The plant samples were washed thoroughly under tap water several times followed by rinsing with deionized water, drained, and then chopped and separated into root and shoot using a plant cutter. Fresh weight of the samples was taken and subsequently oven dried till constant weight. Mangrove biomass and associated carbon stock calculations were done as follows:

3.2.2. Carbon content in Mangrove Biomass

The mangrove girth is generally measured at 1.3 m height for achieving tree diameter. However, since the present stands were young the whole plant was uprooted for assessing biomass. Total biomass was directly estimated by summing the dry weight of above ground and below ground biomass.

3.2.2.1. Carbon biomass

The biomass was then converted into carbon biomass by multiplying by a factor of 0.42, i.e. *Carbon biomass* = Total biomass× 0.42

3.2.2.2. Carbon biomass per hectare

Carbon biomass was calculated per hectare by multiplying the carbon biomass with tree density per hectare, i.e.

Carbon biomass (kg/ha) = carbon biomass x density of plants per hectare.

Carbon biomass (Mg/ha) = (carbon biomass x density of plants per hectare) / 1000

3.2.2.3. Calculation of CO2 equivalent

Carbon biomass value is converted into carbon dioxide equivalent by multiplying carbon biomass with 3.67 i.e. CO_2 *equivalent (%)* = carbon biomass × 3.67

3.2.3. Analysis of soil bulk density, particle density, and air space

Volume of known amount (20 g) of dry soil sample was noted and to this a known volume of water (50 ml) was added. At least 5 ml of water above the soil surface was kept in an undisturbed condition for 30 min. The final volume of soil plus water was noted and bulk density was calculated as follows:

Bulk density = weight of soil (g) / Volume of soil (g/ml)

3.2.4. Total organic carbon in mangrove soil (El Wakeel and Riley, 1956)

TOC (%) was estimated following the chromic acid digestion and phenonthroline indicator method (El Wakeel and Riley, 1956), wherein the organic matter was oxidized with a mixture of potassium dichromate and concentrated sulphuric acid,

utilizing the heat of dilution of the acid to speed up the process. The unspent potassium dichromate was back titrated against ferrous sulphate solution. The total carbon calculation was as follows:

Ferrous ammonium sulphate (ml) (T) = Titre for Blank – Titre for sample

Total organic carbon (TOC) in sediment soil (mgC/g) (X) = 1.14 x 0.6 x T

Total organic carbon (TOC) in sediment soil (%) = X / 10

Total carbon in sediment soil (%) = TOC ÷ 2

3.2.5. Calculation of carbon stock in sediment soil

Carbon stock in sediment soli upto 100 cm was calculated as follows:

Carbon stock in sediment (%) = Bulk density ($g.cm^{-3}$) × Total carbon (%) × Soil depth interval (cm)

3.2.6. Calculation of CO_2 equivalent

CO_2 equivalent was calculated as follows:

CO_2 equivalent (%) = carbon stock × 3.67

4. RESULTS

Evaluated mangrove survival percentage at Sat Saida bet, Nakti creek and Kantiyajal are detailed in Table 4 to Table 11. In total, four blocks at Sat Saida bet, two blocks at Nakti creek and two blocks at Kantiyajal were visited and assessed. The findings based on site visits and subsequent data analyses are given below:

4.1. Mangrove Plantation Evaluation at Sat Saida bet

4.1.1. 2005-2006 *A. marina* Plantation in 20 ha

This was the first plantation carried out by DPT and executed by Gujarat Institute of Desert Ecology, Bhuj. In total 15 quadrates were laid at this site to assess the *A. marina* status and survival percentage. An average density of 5387 individuals/ha was recorded against the planted 6600 individuals/ha. Thus, a total survival percentage of *A. marina* in this block was 81.6%, which was categorized as successful. Average height of *A. marina* plantation at this site was 113 cm (Table 4, Plate 3 – Plate 7). Minimum and maximum GBH recorded for A. marina plantation was 5 cm and 7.5 cm with an average value of 5.7 cm. The minimum and maximum canopy in this plantation stand ranged between 0.49 and 1.19 m2 with a mean value of 0.92 m2. Generally, canopy cover was more for plants near the waterline. Average density of regeneration class in the quadrates was 1400 plants/ha with a range of 800 to 2100 plants/ha. Generally, density of recruitment class is expected to increase in the future as the phonological cycle of the plant has started in the last 4 years. Density of recruitment class ranged from 300 to 450 plants/ha with an average density of 375 plants/ha.

Around 17 species of associated mangrove fauna were recorded during the survey. Based on current high survival percentage, it is evident that nursery bed and direct seed sowing methods are better suited than raised bed (*Otla*) method. Plantation raised through *Otla* method eventually undergoes high mortality rate even when initial survival rates are high.

Table 4. *A. marina* plantation (2005-2006) in 20 ha at Sat Saida bet

Sl. No.	Sampling Location		Density (Ha)	Height (cm)	St. Dev
Q1	23˚ 04” 43.38N	70˚ 16”47.88E	4400	109	28.34
Q2	23˚ 04” 48.18N	70˚ 16”48.18E	4900	115	24.7
Q3	23˚ 04” 43.77N	70˚ 16”48.41E	5600	110	26.2
Q4	23˚ 04” 44.38N	70˚ 16”47.99E	5700	110	27.7
Q5	23˚ 04” 44.10N	70˚ 16”48.18E	5100	124	29.2
Q6	23˚ 04” 48.17N	70˚ 16”48.17E	4900	135	30.7
Q7	23˚ 04” 44.37N	70˚ 16”48.99E	5300	103	32.2
Q8	23˚ 04” 43.49N	70˚ 16”48.69E	5300	100	34.44
Q9	23˚ 04” 44.14N	70˚ 16”48.93E	6100	121	35.2
Q10	23˚ 04” 44.99N	70˚ 16”47.63E	5200	104	36.7
Q11	23˚ 04” 43.07N	70˚ 16”49.06E	4900	136	29.2
Q12	23˚ 04” 43.85N	70˚ 16”49.88E	5200	105	28.22
Q13	23˚ 04” 44.61N	70˚ 16”48.75E	6100	102	32.15
Q14	23˚ 04” 43.53N	70˚ 16”49.25E	6300	110	33.22
Q15	23˚ 04” 44.04N	70˚ 16”50.02E	5800	110	31.2
Average			**5387**	**113**	**--**

4.1.2. 2011-2012 *A. marina* Plantation in 200 ha

At this site, 17 quadrates were laid to evaluate survival percentage. Average density recorded was 2647 individuals/ha against the planted density of 6600 individuals/ha, which projects poor survival i.e. 40.1%. The average height of plantation was 45 cm only (Table 5, Plate 8 - Plate 12). Minimum and maximum girth of the planted saplings at this site was 4.5 cm and 6.5 cm, respectively with an average value of 5.1 cm. The minimum and maximum canopy Index in *A. marina* plantation stands ranged between 0.67 and 1.1 m^2 with a mean value of 0.72 m^2. Only regeneration class (<50 cm) was recorded whereas the recruitment (>50 cm but <100 cm) class was absent. Average density of regeneration class was less to the tune of 400 plants/ha.

Survival of planted mangroves is dependent on several factors, amongst which inundation is a major one. Most of the blocks at Sat Saida bet are inundated only during spring and neap tide i.e. for 6-7 days. Given the scenario, it was apparent that saplings growth and height at Sat Saida bet would be less. Additionally,

Kachchh being an arid zone, rainfall is scanty (340 mm) which adversely affects the growth rate and height of mangroves.

Table 5. *A. marina* plantation (2011-2012) in 200 ha at Sat Saida bet

Sl. No.	Sampling Location		Density (Ha)	Height (cm)	St. Dev
Q1	23˚ 00” 48.4N	70˚ 15”49.5E	3000	33.6	9.6
Q2	23˚ 00” 50.5˚ N	70˚ 15” 50.0 E	0	0	0
Q3	23˚ 00 ”53.1˚ N	70˚15” 49.2 E	2700	55.9	9.5
Q4	23˚ 00 ”50.9˚ N	70˚ 15” 47.2 E	3300	31.8	14.9
Q5	23˚ 00 ”50.1˚ N	70˚15” 45.4 E	3500	43.7	14
Q6	23˚ 00 ”49˚ N	70˚15” 43.5 E	3500	53.5	16.6
Q7	23˚ 00” 49.3˚ N	70˚15” 41.3 E	3500	58.8	26.5
Q8	23˚ 00” 51.4˚ N	70˚15” 42E	1700	47.9	18.7
Q9	23˚ 00” 76.9˚ N	70˚13”.50 E	4000	52.7	18.9
Q10	23˚ 00 ”52.2˚ N	70˚15” 37.9E	4600	53.6	24
Q11	23˚ 00” 51.7˚ N	70˚15” 35.6E	2100	69.9	22.1
Q12	23˚ 00 ”52.4N	70˚15” 34.4E	2600	52.7	19.6
Q13	23˚ 00 ”53.2˚ N	70˚15” 33.3E	3500	63.4	19.2
Q14	23˚ 00” 55.1˚ N	70˚15” 32.4 E	4000	57.6	18.9
Q15	23˚ 00” 57.2˚ N	70˚15” 33.4 E	2500	40.8	15.7
Q16	23˚ 00 ”57.9˚ N	70˚15 ”35.6 E	0	0	0
Q17	23˚ 00” 3.6˚ N	70˚15” 35.6 E	500	46.6	14.9
Average			**2647**	**45**	**--**

4.1.3. 2012-2013 *A. marina* Plantation in 300 ha

To assess the plantation success, 16 quadrates were laid at this site. Average density of 2031 individuals/ha and average height of 39 cm were recorded (Table 6, Plate 13 - Plate 17) at the site during the survey. Thus, survival percentage of *A. marina* in this block was poor and was to a tune of only 30.8%. Sapling stem girth measured at this plantation ranged from 4.1 to 8 cm with an average of 5.1 cm. Plants with maximum girth of 8 cm were few and recorded sporadically. The canopy Index in this block ranged between 0.69 and 1.28 m^2 with a mean value of 0.82 m^2. Canopy cover varied widely among the quadrates in accordance with the growth of the plant. In very few plants, canopy cover was exceptionally high whereas in others it was poor. Similar to earlier stands density of younger classes in this 300 ha plantation was low since this plantation carried out during 2012-13

has yet to attain its full phonological cycle. Average density of regeneration class was less to the tune of 550 plants/ha whereas the recruitment class plants were almost absent. Average height of the saplings in this block was 89 cm with a GBH value of <4 cm showing that these plants are still very young and the phonological cycle is yet to start in the whole plantation. The minimum and maximum canopy Index in this 330 ha mangrove plantation stands planted during 2013-14 was low and ranged between 0.32 and 0.93 m^2 with a mean value of 0.42 m^2. Plants are still in recruitment and regeneration stage recording a poor growth rate explaining the low canopy cover recorded presently.

Growth of planted and natural mangroves in this region was slow which could be attributed to higher soil and water salinity. Further, given the low survival percentage of planted *A. marina* in this block, it is quintessential to check the grazing by camels and other livestock. Low survival of planted mangroves could also be due to wrong selection of plantation site, plantation technique i.e. *Otla* bed method which would have affected survival percentage when compared to direct seed sowing. Thus, it is suggested to follow the direct seed sowing or nursery bed techniques for plantation of this species.

Scientifically poor survival in the mangrove plantation could be attributed to inadequate tidal inundation and wrong plantation method. When a planted mangrove fail to get adequate tidal water either it fails to germinate or its growth becomes stunted. Hence, selection of site plays a crucial role in the mangrove plantation success.

Table 6. *A. marina* plantation (2012-2013) in 300 ha at Sat Saida bet

Sl. No.	Sampling Location		Density (Ha)	Height (cm)	St. Dev
Q1	23˚02.06604 N	70˚ 13.25285 E	3600	68.1	25.9
Q2	23˚01.93788 N	70˚13.244884 E	3700	46.1	19.7
Q3	23˚ 1.507972 N	70˚13 23.2248E	1500	40.9	10.8
Q4	23˚ 14.5986N	70˚15.2648E	1100	35.5	15.6
Q5	23˚15.948N	70˚15.28626 E	0	0	0
Q6	23˚17.128 N	70˚15. 30816 E	0	0	0

Q7	23˚19.636 N	70˚15. 29886 E	0	0	0
Q8	23˚18.814N	70˚15. 27636 E	1000	31.4	13.4
Q9	23˚18.838N	70˚15.27648 E	4200	44.5	20.5
Q10	23˚19.768N	70˚15. 26198 E	1400	31.6	13.8
Q11	23˚11.3704N	70˚15.231 E	2800	59	20.3
Q12	23˚1 1.3644N	70˚15. 231 E	3600	56	22.1
Q13	23˚11.7004N	70˚15.2334 E	2500	70.2	23.5
Q14	23˚16.61N	70˚15.25192 E	2900	59.4	21
Q15	23˚1 1.4514 N	70˚15.27484 E	500	22.2	6.4
Q16	23˚1 1.4418 N	70˚15.27336 E	3700	57.2	22.7
Average			**2031**	**39**	**--**

4.1.4. 2013-2014 *A. marina* Plantation in 330 ha

This plantation site is located northwest of the Deendayal Port and in the northern extent of Sat Saida Bet. The plantation site is tidally fed by branches of Pang creek, which is the northern bifurcation of main Kandla creek. We laid 24 quadrates at this site to assess the *A. marina* survival percentage. An average density of 4133 individuals/ha was recorded against the planted 6600 individuals/ha. The average height of *A. marina* plantation at this site was 89 cm with a survival percentage of 62.6% (Table 7, Plate 18 – Plate 22). Both raised bed method and direct seed dibbling were followed at this site. Since poor tidal flushing was identified as a major issue, care was exercised during plantation to choose sites with good tidal flushing to target good survival percentage.

Table 7. *A. marina* plantation (2013-2014) in 330 ha at Sat Saida bet

S. No.	Sampling Locations		Density (Ha)	Height (cm)	St. Dev
Q1	23°04'48.34" N	70° 17' 10.05" E	4400	109	28.34
Q2	23°04'46.55" N	70° 17' 13.94" E	4900	115	24.7
Q3	23°04'45.14" N	70° 17' 18.65" E	4100	110	26.2
Q4	23°04'41.97" N	70° 17' 16.66" E	5600	110	27.7
Q5	23°04'50.58" N	70° 17' 16.68" E	2900	124	29.2
Q6	23°04'44.43" N	70° 17' 16.54" E	4900	135	30.7
Q7	23°04'49.39" N	70° 17' 15.54" E	2800	103	32.2
Q8	23°04'45.35" N	70° 17' 06.79" E	5300	100	34.44
Q9	23°04'42.94" N	70° 17' 09.32" E	5200	121	35.2
Q10	23°04'40.49" N	70° 17' 13.53" E	2900	86	36.7
Q11	23°04'46.46" N	70° 17' 12.37" E	4900	73	29.2

Q12	23°04'44.26" N	70° 17' 15.86" E	5200	105	28.22
Q13	23°04'48.25" N	70° 17' 12.93" E	6100	102	32.15
Q14	23°04'44.174" N	70° 17' 16.32" E	6300	70	33.22
Q15	23°04'38.25" N	70° 17' 10.33" E	5800	110	31.2
Q16	23°04'40.41" N	70° 17' 12.07" E	3500	62	16.1
Q17	23°04'40.76" N	70° 17' 12.89" E	2600	51	14.7
Q18	23°04'38.16" N	70° 17' 20.60" E	3600	43	12.2
Q19	23°04'38.76" N	70° 17' 10.60" E	3300	45	11.1
Q20	23°04'40.69" N	70° 17' 06.48" E	2300	66	23.7
Q21	23°04'49.68" N	70° 17' 14.62" E	3600	72	9.3
Q22	23°04'47.10" N	70° 17' 03.65" E	3100	78	17.6
Q23	23°04'49.42" N	70° 17' 07.81" E	3300	85	19.2
Q24	23°04'49.87" N	70° 17' 10.23" E	2600	64	17.2
Average			**4133**	**89**	**--**

4.2. Mangrove Plantation Evaluation at Nakti creek

Two mangrove plantation sites of 50 ha and 100 ha were developed at the north-eastern bank of Nakti creek, a major creek system west of Kandla creek. The main creek and its branches are getting inundated by 3-4 m of tidal water during high tide. Two mangrove plantation sites developed in this site are adjacent to each other with good tidal flooding.

4.2.1. 2008-2009 *A. marina* Plantation in 50 ha

At this block, 10 quadrates were laid to evaluate the *A. marina* survival. The results revealed that *A. marina* survival in this block was poor with only 35.5% i.e. average density of 2340 individuals/ha. The average height of this plantation was 53 cm (Table 8, Plate 23 - Plate 27). Stem girth of the saplings in this 50 ha stand at Nakti creek ranged from 3.5 cm to 6 cm with an average value of 4.4 cm. Minimum and maximum canopy cover in this stand ranged between 0.42 and 1.1 m^2 with a mean value of 0.71 m^2. Average density of regeneration class was 2900 plants/ha with a minimum and maximum range of 4900 to 8000 plants/ha showing good regeneration potential of the site. Similarly, recruitment class density ranged from 900 to 1800 plants/ha with an average density of 1100 plants/ha. It is known that direct dibbling and nursery raised transplantation are superior to *Otla* bed technique. Poor survival of planted *A. marina* could be ascribed to mixed

plantation techniques as more than two species, namely *Rhizophora mucronata* and *Ceriops tagal* were planted at this site.

Table 8. *A. marina* plantation (2008-2009) in 50 ha at Nakti creek

Sl. No.	Sampling Location		Density (Ha)	Height (cm)	St. Dev
Q1	22° 57' 12. 9N	70° 09' 04.9 E	3000	53.8	19.6
Q2	22°57' 11.6 N	70° 09'04.5 E	3000	64.8	18.4
Q3	22°57'10.9 N	70°09' 04.7 E	2400	70.5	24.0
Q4	22°57'10.3 N	70°09' 05.4 E	2800	65.8	19.2
Q5	22°57'09.6 N	70°09'06.2 E	2500	63.0	15.9
Q6	22°57'09.1 N	70°09'07.2 E	2700	60.2	15.2
Q7	22°57'09.1 N	70°09'08.2 E	2500	40.9	15.6
Q8	22°57'09.2 N	70°09'08.4 E	0	0.0	0.0
Q9	22°57'08.1 N	70°09'10.0 E	2700	54.1	15.6
Q10	22°57'07.7 N	70°09'10.3 E	1800	60.9	24.6
Average			**2340**	**53**	**--**

4.2.2. 2010-2011 *A. marina* Plantation in 100 ha

4.2.2.1. *A. marina* Plantation in 90 ha

In total, 10 quadrates were laid at this site to assess the A. marina survival percentage. Akin to A. marina plantation in 50 ha of Nakti creek block, this site also showed poor survival of only 35.9%. The average density of 2370 individuals/ha in this block with average height of 84 cm was recorded (Table 9, Plate 28 – Plate 32). Even though the plantation activities were carried out near the creek system, poor survival of planted mangroves could be due to mixed plantation techniques. The GBH in this plantation varied from 2.8 - 5.2 cm with an average value of 3.7 cm. The minimum and maximum canopy Index in this plantation stand ranged from 0.82 to 1.28 m^2 with a mean value of 0.96 m^2. Younger classes were recorded in low density in this block. While regeneration recorded an average density of 2700 plants/ha, the recruitment classes showed a poor density of only 400 plants/ha.

Table 9. *A. marina* plantation (2010-2011) in 100 ha at Nakti creek

S. No.	Sampling Location		Density (Ha)	Height (cm)	St. Dev
Q1	22˚ 57 50.0 N	70˚ 09 40.8 E	1200	55.3	14.7

Q2	22 ˚57 47.8 N	70˚ 09 42.4 E	2000	67.1	21.04
Q3	22 ˚57 46.1N	70 ˚09 42.8E	1200	70.1	29.3
Q4	22˚ 57 42.4N	70 ˚09 44.3E	2000	80.1	41.4
Q5	22˚ 57 41.6N	70˚ 09 46.2E	3200	90.9	28.3
Q6	22˚57 31.1N	70˚ 09 49.6E	2700	90.9	23.4
Q7	22˚57 39.8 N	70˚ 09 48.8E	3400	82.8	19.9
Q8	22˚57 38.6 N	70 ˚09 51.2E	3500	88.9	20.6
Q9	22˚57 38.2N	70 09 54.5 E	2500	115.9	28.2
Q10	22˚57 37.5 N	70 09 52.9 E	2000	99.5	17.8
Average			**2370**	**84**	**--**

4.2.2.2. *R. mucronata* Plantation in 5 ha

During the surveys, we did not record any individual inside the quadrates laid. Nevertheless, *R. mucronata* saplings were recorded outside the quadrates with height varying from 50-60 cm. Around 10 individuals were seen during the entire survey. Thus, it was apparent that plantation of *R. mucronata* in 5 ha was a failure. Unlike *A. marina*, *R. mucronata* needs 20 - 25 days of tidal flushing in a month and can tolerate only moderate salinity. During the field surveys, it was recorded that the saplings were invaded by the alga *Enteromorpha* sp. and regular tidal flushing was lacking. All these factors could be attributed to plantation failure.

4.2.2.3. *C. tagal* Plantation in 5 ha

Similar to *R. mucronata* plantation in 5 ha at Nakti creek, no individuals of *C. tagal* could be recorded inside the laid quadrates. Nevertheless, around 20 individuals *C. tagal* with 40-45 cm height were noticed outside the quadrates. Since, nearly 1 lakh propagules of *C. tagal* were planted in 5 ha, presence of only 20 individuals indicates plantation failure. Similar to *R. mucronata*, plantation site of *C. tagal* was also invaded by algae and lacked regular flushing. *C. tagal* and *R. mucronata* are frontline mangroves and thus regular tidal flushing is essential. Algal infestation on mangroves needs regular monitoring and manual removal to help the plant survive. Physical protection and regular monitoring of mangrove plantation stand are the best conservation efforts that will yield positive results.

4.3. Mangrove Plantation Evaluation at Kantiyajal

4.3.1. 2015-2016 *A. marina* and *R. mucronata* Plantation in 150 ha

The 300 ha plantation was carried out at the coastal stretch of Katpor village near Kantiyajal at Bharuch district. This plantation was carried out in two blocks of 150 ha each during 2015-16 and 2016-17. Gujarat Ecology Commission (GEC), Gandhinagar executed this plantation with the community participation of a formed *Samiti* at the Katpor village.

A total of 30 quadrates were laid in this block for assessing mangrove survival success. As per earlier report by GEC (2015-2017), at this site only *A. marina* individuals were planted. However, our field surveys revealed that this block had *R. mucronata* saplings in addition to *A. marina*. An average density of 1460 individuals/ha was recorded for *A. marina* against 2500 saplings/ha. Similarly, average density of *R. mucronata* was 1280 individuals/ha (Table 10, Plate 33 - Plate 34) against the targeted 2000 individuals/ha. The survival percentage of *A. marina* and *R. mucronata* were 58.4% and 64.0%, respectively. The average height of *A. marina* was 32 cm and that of *R. mucronata* was 30 cm at this block. *R. mucronata* being a frontline mangrove, its plantation was carried out towards the lower intertidal region. Continuous tidal flushing and following appropriate zonation pattern during plantation could be attributed to higher survival percentage of *R. mucronata*.

Table 10. Mangrove plantation (2015-2016) in 150 ha at Kantiyajal

A. marina					
Sl. No.	**Sampling Location**		**Density (Ha)**	**Height (cm)**	**St. Dev**
Q1	21° 28'5.2″ N	72° 38'57.0" E	2000	29.8	9.0
Q2	21° 28' 22.19" N	72°38` 12. 43"	2200	42.4	10.9
Q3	21 °28'14.73"N	72°38`52. 97"	1900	41.1	13.9
Q4	21°28'05.00"N	72° 38`58. 66"	1000	38.1	7.1
Q5	21°28'56.68"N	72° 38`50.88"	0	0.0	0.0
Q6	21°28'59. 18" N	72°38`28.70"	1600	40.9	11.6
Q7	21°28'15.05"N	72°38`32.30"	1900	36.0	11.3
Q8	21°28'17.86"N	72°38`39. 86"	0	0.0	0.0
Q9	21°28'18.73"N	72°38`50.30"	2200	44.2	12.0

Q10	21˚28’00.43"N	72˚38` 08.02"	1800	45.8	9.7
Average			**1460**	**32**	**--**
R. mucronata					
Sl. No.	**Sampling Location**		**Density (Ha)**	**Height (cm)**	**St. Dev**
Q1	21˚ 28’ 20.93″ N	72˚ 38’ 22.20″E	1700	32.5	7.4
Q2	21˚ 28’16.56″ N	72˚ 38’27.88″E	1400	41.4	4.5
Q3	21˚ 28’19.69″ N	72˚ 38’11.96″E	0	0.0	0.0
Q4	21˚ 28’9.32″ N	72˚ 38’7.73″ E	700	39.4	7.4
Q5	21˚ 28’19.73″ N	72˚ 38’57.43″E	0	0.0	0.0
Q6	21˚ 28’11.18" N	72˚ 38’5.68″E	400	36.0	2.0
Q7	21˚ 28’5.26″ N	72˚ 38’4.07″E	300	26.0	1.8
Q8	21˚ 28’8.12″ N	72˚ 38’57.79″E	0	0.0	0.0
Q9	21˚ 28’23.34″ N	72˚ 38’48.32″E	800	45.6	8.6
Q10	21˚ 28’17.6″ N	72˚ 38’40.84″E	800	48.4	13.0
Q11	21°31'7.25"N	72°38'44.82"E	2800	40.6	11.5
Q12	21°31'6.76"N	72°38'52.51"E	2300	43.4	10.4
Q13	21°31'3.83"N	72°38'49.30"E	0	0.0	0.0
Q14	21°31'0.54"N	72°38'45.11"E	2200	35.9	6.8
Q15	21°31'0.58"N	72°38'39.17"E	2600	42.4	8.7
Q16	21°31'1.28"N	72°38'33.98"E	0	0.0	0.0
Q17	21°31'5.42"N	72°38'33.96"E	2300	44.9	9.8
Q18	21°31'7.28"N	72°38'38.40"E	2800	39.4	11.5
Q19	21°31'7.10"N	72°38'42.80"E	2400	42.7	12.7
Q20	21°31'3.75"N	72°38'44.30"E	2100	44.8	12.9
Average			**1280.0**	**30**	**--**

4.3.2. 2016-2017 *A. marina* Plantation in 150 ha at Kantiyajal

At this block, 10 quadrates were laid (Table 11, Plate 35 – Plate 36) for evaluating mangrove plantation success. During field surveys, we did not record *R. mucronata* plantation in this block as mentioned by GEC (2015-2017). Thus, from field data it was evident that single species plantation i.e. *A. marina* was only carried out at this block. Average density of *A. marina* at this site was 2220 individual/ha against 2500 individual/ha which contributes to 88.8% plantation success. Proper site selection, regular inundation and monitoring, etc. are few factors, which affect survival percentage. It was apparent from the field data that this site is good for *A. marina* plantation.

For both the blocks at Kantiyajal, the girth plantation varied from 3.5 - 5 cm with an average of 3.9 cm. Similarly, the canopy cover for both the blocks ranged between 0.42 and 81m^2 with a mean value of 0.67 m^2. In both the blocks of this plantation, younger classes such as regeneration and recruitment were absent as the planted saplings have not yet started their flowering and fruiting cycles.

Table 11. *A. marina* (2016-2017) in 150 ha at Kantiyajal

Sl. No.	Sampling Location		Density (Ha)	Height (cm)	St. Dev
Q1	21° 30 58.13″ N	72° 38 59.38″ E	2600	44.4	13.9
Q2	21° 31 0.49″ N	72° 38 48.24″ E	2200	41.9	12.7
Q3	21° 31 11.8″ N	72° 38 41.61″ E	2300	42.9	14.7
Q4	21° 31 15.00″ N	72° 38 49.07″ E	3000	44.0	9.2
Q5	21° 31 26.22″ N	72° 38 46.59″ E	2800	37.3	11.8
Q6	21° 31 25.92″ N	72° 38 53.85″ E	0	0.0	0.0
Q7	21° 31 35.09″ N	72° 38 5.04″ E	2100	42.1	12.2
Q8	21° 3113.63″ N	72° 38 58.43″ E	2400	40.5	12.0
Q9	21° 31 5.94″ N	72°38 53.41″ E	2500	41.2	10.4
Q10	21° 31 41.71″ N	72° 38 34.34″ E	2300	40.0	10.9
Average			**2220.0**	**37**	**--**

4.4. Carbon sequestration potential at Sat Saida Bet

The carbon biomass (Mg/ha) of *A. marina* plantation at Sat Saida bet was 0.076 Mg/ha for plantation with less than 20 cm m height and 0.087 Mg/ha for 60 cm height. The average CO_2 equivalent (dry weight and soil) of *A. marina* plantation at Sat Saida bet was 1.56%.

4.5. Carbon sequestration potential at Nakti creek

At Nakti creek the carbon biomass of *A. marina* plantation varied from 0.041 to 0.202 Mg/ha. Irrespective of the height, the Carbon sequestration potential was more in 100 ha plantation when compared with 50 ha plantation at Nakti creek. The CO_2 equivalent (dry weight and soil) of *A. marina* plantation at Nakti creek was 2.17%. Among the three locations, i.e. Sat Saida bet, Nakti creek and Kantiyajal, the highest Carbon sequestration potential was recorded for Nakti creek.

4.6. Carbon sequestration potential at Kantiyajal

At Kantiyajal carbon biomass of *A. marina* plantation was only carried out which ranged from 0.095 to 0.132 Mg/ha. The CO_2 equivalent (dry weight and soil) for *A. marina* plantation at this site was 1.18%.

5. SUGGESTIONS AND RECOMMENDATIONS

Deendayal port with an area of 999.19 km^2 including 193.19 km^2 of mangroves and 312.9 km^2 of tidal mudflats presents enormous scope for mangrove plantation, restoration and rehabilitation. Based on the present and earlier field surveys and data analysis the following recommendations are suggested for current and future plantation activities.

5.1. Site Selection

By far, site selection within the broader landscape for plantation is the foremost criterion that determines the plantation success. For successful plantation, it is essential that the existing bio-physical conditions of the coastal landscape in a broader and general manner are to be thoroughly understood. Consideration of a set of criteria as given in the Table 12 will enable the planter to conclude the site suitability reliably.

A list of bio-physical parameters such as gradient of the intertidal belt, soil nature, number of days of tidal flushing, presence/absence of natural mangroves in the vicinity and availability of adequate intertidal extent are to be considered and grades should be assigned in a scale of 1 to 10. One major parameter that deserves careful consideration is number of days of tidal flushing which in turn is influenced by the gradient of the intertidal extent; only sites with gentle gradient receiving good tidal flushing for >15 days in a month are to be chosen for plantation activities. The suite of criteria indicated in Table 12 is applicable even for plantation among gaps of natural mangroves, along creek banks and mudflats. Involving local people and fishermen living nearby will render the site selection easier since they are well versed with the local conditions, especially tidal flushing rate. In addition, short term and small-scale feasibility trials could be conducted in order to ascertain the suitability of the site. Several plantation attempts in Kachchh coast and elsewhere have failed due to unsuitable site selection. Hence, it is important that great care be exercised while choosing the plantation site.

Table 12. Criteria for Technically suitable site for Mangrove Plantation

Priority Order	Criteria	Preferred Conditions
1	Site Nature - Open coast/creek/Natural Mangrove formations	Creek systems and river mouths with freshwater input is preferable- In open coast sites gentle gradient is preferred. In enrichment plantation among natural mangroves, adequate gaps with good tidal flushing are to be considered.
2	Intertidal Gradient	Intertidal extent with gentle slope preferred-Steep intertidal gradient and those with convex morphology are to be avoided to prevent water logging.
3	Tidal inundation	Only sites with gentle gradient with minimum of 15 days tidal flushing per month mostly preferred
4	Sediment Texture	Silty-clay or muddy substrate preferred. Though sandy substrate supports some mangrove species such as *A. marina* it has its own drawbacks like shifting sand, sediment deposition on pneumatophores, etc.
5	Water Salinity	Sites close to discharge points of run-off preferred which controls salinity fluctuations -Based on this candidate species are to be selected.
6	Intertidal Extent/Width	Sites with minimum 150-200 m width and gentle gradient close to the waterfront preferred
7	Tidal Currents	Sites with gentle and low velocity currents preferred
8	Mangrove Presence/ Absence in the Vicinity	Presence of natural mangroves in the vicinity is a reliable indication that the site can support good mangroves.
9	Accessibility of the site	Easy accessibility enables increased working hours for labours and easy labour transport
10	Labour Availability	Availability of good labour in nearby villages is a major factor
11	Seed Source	Seed source from nearby mangroves preferable-If new species are to be attempted seeds/propagules are to be acclimatized to higher salinity
12	Pressure-Grazing, Cattle visit, resource gathering etc.	To be avoided through constant vigil- Social fencing by educating villagers and implementing plantation in a community mode and sensitizing villagers not to send their cattle to the plantation.

5.2. Plantation Efforts

In all future plantation activities, the candidate species should be other than *A. marina*. It is suggested to prefer plantation of *R. mucronata*, *C. tagal* and *A.*

corniculatum, they being locally present in DPT environ though in very small numbers as individual plants at Sat Saida bet.

Based on the findings of current evaluation, it is evident that *Otla* bed plantation technique did not yield good survival percentage. Thus, it is recommended that in future plantation activities transplantation of nursery raised saplings and direct seed dibbling should be preferred to raised bed method.

There are several approaches to restore mangroves such as direct planting of saplings, seedlings, and propagules from adjacent mangrove trees; natural recruitment of propagules; hydrologic manipulation resulting in efforts to re-establish hydrologic regimes; and the combination of the aforementioned methods. However, these techniques may befit single species plantation such as *A. marina*. Thus, for plantation of multi-species, a thorough understanding of several crucial factors is quintessential. Certain mangrove species require more precise site conditions unlike others, which may in turn have implications on site selection and species association; *R. mucronata* may prefer seaward side than *A. marina*, which thrives well both in seaward and landward side. Thus, mangrove species may tend to confine themselves to a specific coastal stretch following a zonation pattern. Therefore, it is advised to consider integration of several factors during site selection, which are crucial for the success of mangrove plantation.

Of 193.19 km^2 mangrove formation within the port, dense mangroves are 53.55 km^2 (27.7%) and remaining are sparse/stunted mangroves. Through appropriate restoration measures, these sparse mangroves could be converted into dense patches. Thus, it is suggested to carry out restoration activities along with direct plantation to improve mangrove vegetation cover in Deendayal port area.

Sat Saida Bet could be an ideal site for all future mangrove plantation, restoration and rehabilitation activities with bio-physical amendments such as de-silting existing creeks, joining all the existing minor creeks with one another through new

creek systems. To improve the flow of tidal water in the existing creek systems, the areas with uneven water depths are to be demarcated where de-silting and deepening the creeks will lead to better tidal flushing to mangrove formations gradually converting them to dense and healthy. Increased tidal flooding and hydroperiod will extend the mangrove formation in this location besides converting sparse into dense mangroves in due course of time. This creek re-construction, desilting existing minor creek systems and removing blocks in the natural creeks may be taken up in a phased manner with due budgetary allocation.

5.3. Promoting Natural Regeneration

In the GUIDE (2018) report on the holistic and integrated management of creeks and mangroves, a detailed account is provided on how creek systems and mangroves complement each other. In general, creeks as a bio-physical entity influences natural mangrove formation, regeneration and assist mangroves as a fully functional ecosystem. An elaborate account on how creek systems of Deendayal port promote the process of natural regeneration is given. Physical features of creek systems influence natural regeneration potential of the mangrove formation through their tidal inundation, spreading propagules and assist mangroves in colonizing new intertidal belts. Earlier mangrove vegetation analysis studies at Kandla and Tuna mangroves (GUIDE, 2012 and 2015) have clearly indicated that density and entrance of younger classes is good enough to become mature trees. This also indicates that the recruitment process in the mangrove ecosystem is normal and there is good transformation of younger classes into mature category. Nevertheless, GIS studies carried out on Deendayal port mangroves indicates that out of 193.19 km^2 of mangroves, 72.27% (139.64 km^2) of mangroves are sparse mostly due to inadequate inundation and tidal flushing. Earlier reports (GUIDE, 2012, 2015, and 2018) have clearly outlined the management approaches to promote natural regeneration and conversion of sparse mangroves into dense formation through bio-physical amendments such as desilting natural canals, connecting existing natural canals with each other in order to enhance tidal reach and creation of new canals at micro-levels. It is emphasized

that adapting this bio-physical amendments will enhance natural regeneration process many fold besides converting sparse mangroves into dense formations. To sum up, these measures adapted through sustainable long term management practices will render the Deendayal port mangroves a fully grown and functional ecosystem with enhanced ecological services.

5.4. Assisting Natural Regeneration

In mangrove formations such as Sat Saida Island and in Sara and Pang creeks, extensive mudflats are present which are suitable for plantation activities. In addition to initiating plantation in such mudflats, mangrove formation in Sat Saida Island, Tuna region and Navlakhi creek regions could be classified as sparse, dense, mudflats and salt marshes and appropriate conservation initiatives could be taken for each zone.

Sparse mangroves constitute 72.3% of the total mangroves of the port. This could be restored to dense formation through physical amendment measures *viz*., canal digging, removing blockage in natural canal systems, and by other physical means. Thus, future mangrove plantation efforts could be focused on restoring sparse mangroves into dense formations through biophysical measures.

5.5. Comparison with Earlier Studies

From earlier studies (GUIDE, 2015) and present findings it is apparent that *Otla* bed plantation technique is inapt for good survival percentage. Thus, as recommended in earlier sections, nursery raised transplantation and/or direct seed dibbling techniques may be chosen over *Otla* bed.

Extensive mudflats are an indication of enormous potential the area may hold for restoration and conservation of mangrove ecosystem. According to GUIDE (2018), mudflats and creek systems in Deendayal Port and its surroundings are major ecological entities, with mudflats extending to 312.9 km^2. Therefore, management and conservation measures for mudflats are requisite in Deendayal

port and it's environ. Hence, mangrove restoration efforts in DPT should continue even in the absence of any orders/instructions from MoEF & CC. In view of these specifics, it is recommended that DPT should prepare a long term mangrove restoration, management and monitoring plan in consultation with the experts.

5.6. Mangrove Biodiversity Enhancement

Though mangrove restoration activities in Gujarat are one of the best examples of habitat restoration in the world, the mangrove restoration in Gulf of Kachchh (GoK) is largely single species, comprising of *A. marina*. Given the topography of Gujarat state and in particular Kachchh region, finding continuous fresh water source is atypical. Mangroves require fresh water inundation at certain time intervals for propagation. This, in turn, makes mangroves restoration / plantation work more challenging and uncertain in semi-arid regions. Thus, these factors have contributed to the selection of single hardy species of mangrove i.e. *A. marina* during mangrove plantation in Kachchh coast.

Deendayal port is undertaking mangrove plantation in a massive manner since 2005 and 1300 ha of mangroves have already been planted in Sat Saida Island, Nakti creek and Kantiyajal. However, only *A. marina* is preferred during all the plantation activities due to its environmental plasticity and high salinity tolerance. Nevertheless, within DPT limits, three more mangrove species *viz.*, *R. mucronata*, *C. tagal* and *A. corniculatum* have been sporadically recorded by GUIDE team. Thus, it is recommended that in future mangrove plantation efforts, these additional species which are naturally occurring in this region could be planted extensively. Plantation of these species is expected to create a seed bank in due course of time which would eventually convert single species stand of *A. marina* into multi-species formation.

5.7. Co-Management with the Community

Ideally, mangroves within the DPT jurisdiction should be the object of intense management program with a specific aim to protect them. Such intense

management program is quite feasible in the case of DPT since all the mangrove formations are under its legal control and hence any management program could be implemented without any sectoral conflicts with forest or any other government departments. It was proven in many instances that involving the stakeholder communities in the surrounding villagers will yield better results in mangrove plantation and restoration activities. Though the population in the port surroundings has different livelihood activities, fishermen community could be targeted to involve them in community based mangrove management.

The fishermen communities living in Vera, Khari Rohar and Tuna villages close to the port could be involved in mangrove conservation by forming *Samithies*. The community based organization i.e. *Samithi* roles and responsibilities w.r.t. mangrove conservation in their vicinity should be well defined that would play a seminal role in conserving these mangrove patches. Nevertheless, their resource dependency, perception towards mangroves, level of involvement in such resource management activities, etc. need to be assessed before forming the *Samithi*. It is advised that the *Samithi* may be assigned the task of mangrove plantation/restoration activities, physical protection and other conservation measures. Sustained awareness programs about tangible and intangible benefits the community accrues by conserving mangroves should be strongly conveyed to them. Social structure of the villages in the vicinity could be better understood to see how they could participate in any mangrove centered management programs, preferably a community based resource management.

5.8. Physical Protection

The most common method of conserving mangrove ecosystem is by creation of protected areas. Mangroves of Deendayal port warrant intensive protection as a major means of conservation. Presently, the whole port limit is under the protection of Central Industrial Security Force (CISF). Thus, CISF personnel could be imparted with the ecological significance of mangroves through special awareness program and mangrove patrolling by them can be instituted to enhance

the level of physical protection to mangroves. This could be done by appointing special squads for protecting this patch from incidents like cattle grazing, leaf and wood and other resource collection. Physical protection of natural stand is often the best conservation measure that will fetch positive results.

Employees of Deendayal port need to be made aware with the environmental and ecological significance of mangroves and other coastal resources within the port limits. Licenses for salt works and other port allied industries are awarded by port authorities without understanding the ecological and environmental rules and regulations governing them which often lead to legal and environmental bottleneck at a later stage. Short-term awareness programs to port employees could be conducted by seasoned marine/mangrove ecologists.

5.9. Identification of Stress Factors

It is important that in any conservation efforts, stressors acting on the mangroves are to be identified and removed in order to maintain the ecosystem balance. Mangrove environment will continue to be stable and balanced if there are no external stressors such as change in hydrology, elevation and slope, soil and water salinity and pH, soil texture and wave energy. In addition, human centered stress factors such as resource collection, tree felling and other habitat modification activities will act as major stressors. It would be necessary to find the factors causing stand degradation and scientifically addressing it would remove the stressors allowing mangroves to flourish.

5.10. Change in Hydrology

The most important factors in conserving any mangrove formation include maintaining the original hydrology, original tidal flow including depth, duration of tidal flooding, and frequency of tidal flooding. Understanding the existing mangrove hydrology at micro-level, applying the knowledge to protect mangroves, cost-effective restoration and regeneration, etc. are important. In majority of mangrove degradation instances, it is the modified hydrology and the resultant

reduced tidal flushing and subsequently the critical period of dryness and flushing that determine health of a mangrove forest. Mostly, micro-topography controls the distribution and well-being of mangroves, and physical processes play a dominant role in the formation and functioning of mangrove ecosystem. Even disturbed by human impact, mangrove forest has the ability to self-repair over a period of time provided that the normal tidal hydrology is not disrupted and the availability of water borne seeds are not blocked. Regular monitoring of mangrove hydrology through simple scientific methods will go a long way in maintaining ecosystem balance.

5.11. Regular Mapping through GIS & RS

Mangrove plantation in 1300 ha should be regularly monitored / mapped using GIS and RS facilities as a part of conservation and management efforts. Based on mangrove density, interpolative maps using GIS tools could be prepared which will help in identifying the pockets, which require immediate attention for mangrove restoration. Thus, through a GIS software (Arc-GIS / ERDAS), these layers on yearly basis could be super imposed / overlaid to obtain the difference in mangrove density. This will bridge the gap between decision-making and interventions required for restoring sparse mangrove plantations into dense plantation in due course of time. It could also be used to check mangrove health in terms of canopy cover changes, regeneration potential, and general dynamic nature of mangrove forests. Apart from density, similar interpolative maps for porewater quality could also be prepared.

6. SUMMARY

Mangrove formations in Kachchh coast is predominated by a single species i.e. *A. marina*, with sporadic occurrence of *R. mucronata* and *C. tagal*. The present study was carried out at Sat Saida bet, Nakti creek and Kantiyajal in Kandla vicinity covering eight blocks to evaluate mangrove plantation in 1300 ha during 2005-2017. The major goal of this study was to assess the mangrove plantation survival percentage, assess carbon sequestration potential of planted mangroves, understand the ecological issues, and suggest conservation measures. The mangrove plantation work was carried out in phased out manner i.e. at i) Sat Saida bet: 20 ha during 2005-2006, 200 ha during 2011-2012, 300 ha during 2012-2013, and 330 ha during 2013-2014, ii) Nakti creek: 50 ha during 2008-2009 and 100 ha during 2010-2011, and iii) Kantiyajal: 150 ha during 2015-2016 and another 150 ha during 2016-2017. Due to the prevalence of high salinity in the region, *A. marina* was the preferred species for plantation. Nevertheless, *R. mucronata* and *C. tagal* were also planted in small pockets at Nakti creek. Similarly, *R. mucronata* was attempted at Kantiyajal along with *A. marina*.

The project envisaged three major aspects, i) evaluation of mangrove plantation activities carried out by GEC, and Forest & Environment Department of GoG, ii) investigation of threats being faced by the planted mangroves, iii) assessment of carbon sequestration potential of planted mangroves in the study environ, and iv) suggested conservation and management measures for planted mangroves.

Average density of planted *A. marina* at Sat Saida bet blocks varied from 2031 - 5387 individuals/ha with average height ranging from 39 - 113 cm. In the case of Nakti creek, block-wise average density of *A. marina* varied from 2340 – 2370 individuals/ha with average height from 53 - 84 cm. Nevertheless, the plantation of *R. mucronata* and *C. tagal* at Nakti creek was a failure with very few individuals' existence. *A. marina* average density at two blocks at Kantiyajal was between 1460 and 2220 individuals/ha with an average height between 32 -37 cm. Average density of *R. mucronata* at Kantiyajal was 1280 individuals/ha with an average

height of 30 cm. *R. mucronata* was found mostly as frontline vegetation along the fringes of the block.

Among the locations, maximum density and height was observed at Sat Saida bet. However, of the eight blocks assessed, the survival rate was highest (88.8%) for *A. marina* plantation in 150 ha during 2016-2017 at Kantiyajal followed by *A. marina* plantation in 20 ha at Sat Saida bet (81.6%) during 2005-2006. In rest of the blocks, irrespective of the mangrove species planted, the survival percentage did not reach the minimum expected percentage of 67%. Based on field monitoring and evaluation data it is advised to prefer nursery bed and direct seed sowing methods to *Otla* method since mangrove areas raised through *Otla* method undergo high mortality rate even when initial survival rates are high.

The carbon biomass of *A. marina* plantation varied from 0.041 to 0.202 Mg/ha. The average CO_2 equivalent for all the sites was 1.64%. Among the three locations, i.e. Sat Saida bet, Nakti creek and Kantiyajal, the highest Carbon sequestration potential was recorded for Nakti creek.

The present study indicates that six blocks are most viable for further promotion of mangrove plantation activities, as they have already shown survival failure. Thus, the following conservation measures are suggested for the planted mangroves in order to improve their survival make them a mature mangrove formation over due course of time:

- Appropriate site selection
- Opting for appropriate plantation technique to avoid high mortality
- Regular (in intervals) watering of nursery beds with fresh water
- Regular tidal flushing and inundation
- Manual removal of algal infestation on mangrove recruitment and regeneration classes.
- Monitoring of existing mangrove plantation
- Regular checking of grazing by camels and other livestock

- Containing human activities
- Mangrove plantation involving seed source from nearest area possible
- Restoration of mangroves in sparse areas instead of new plantation sites

Though the mangrove cover in Kachchh coast has reportedly been increasing, the dense mangrove cover has decreased in the region. Thus, to make the mangrove system provide the desired ecosystems services to its fullest, the sparse mangrove patches also need to be made dense through restoration efforts. Appropriate restoration efforts such as deepening and desilting natural canals, removing blocks, etc. are suggested.

Of the several mangrove restoration techniques available, at times they may be suitable for only a single species plantation. Thus, during plantation of multi-species, a thorough understanding of several factors should be considered for the success of mangrove plantation. Involvement of stakeholder communities from the nearby villagers will improve mangrove plantation and restoration activities.

GIS and RS facilities need to be used as a part of mangrove monitoring, conservation and management efforts. Interpolative maps w.r.t. mangrove density, etc. could come handy in identifying the areas that require mangrove restoration.

Above all appropriate awareness and outreach programmes for DPT staff and other stakeholders would strengthen the plantation efforts. The native denizens need to be made aware of the importance of mangroves, the need for their conservation, and the role of relevant authorities. Thus, accordingly these attempts will help in reducing the pressures and/or disturbances on the mangrove plantation efforts in the study area.

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Plate 1. Mangrove Plantation sites in DPT environ

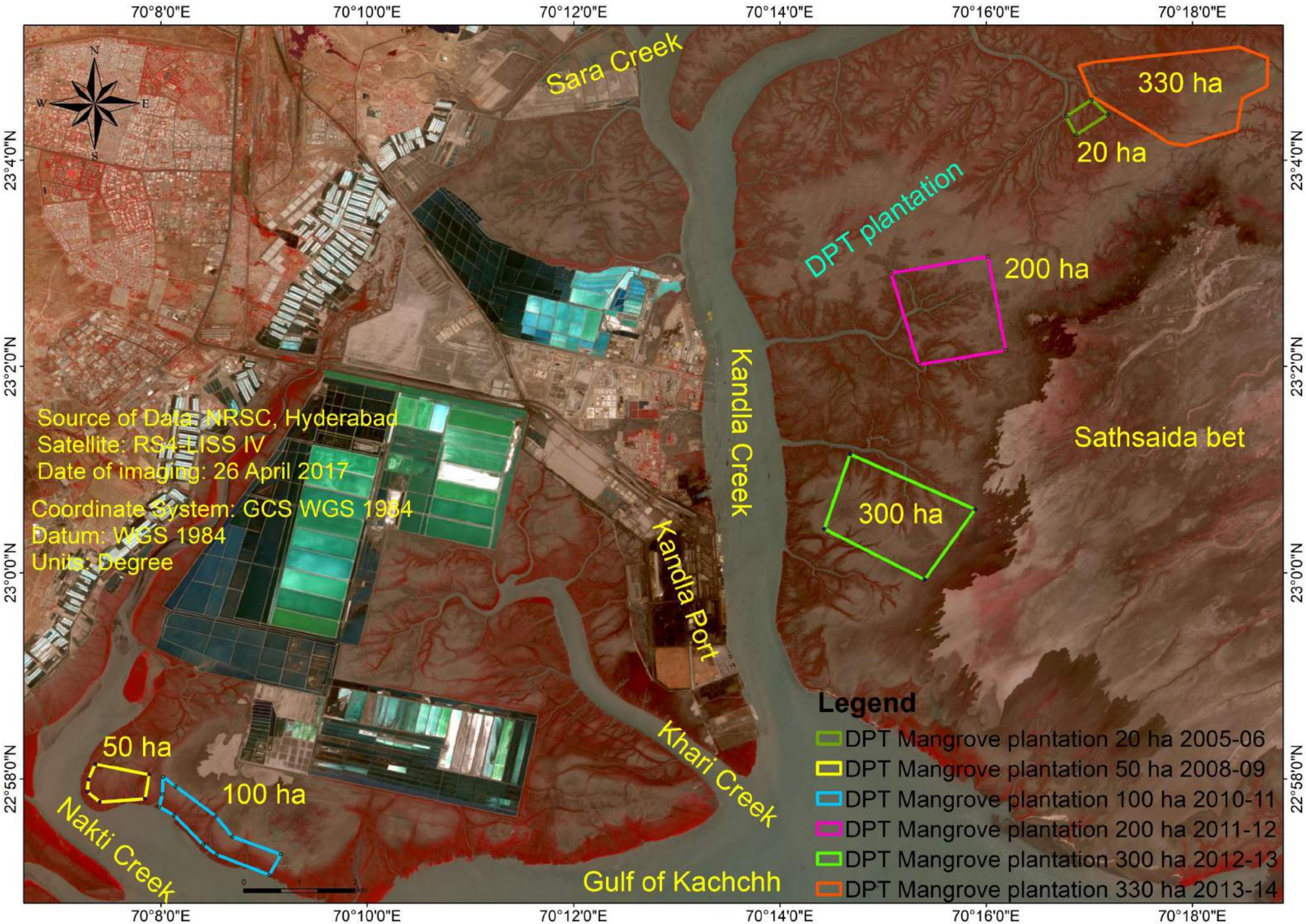

Plate 3. Satellite imageries of 20 ha mangrove plantation at Sat Saida Bet during 2007

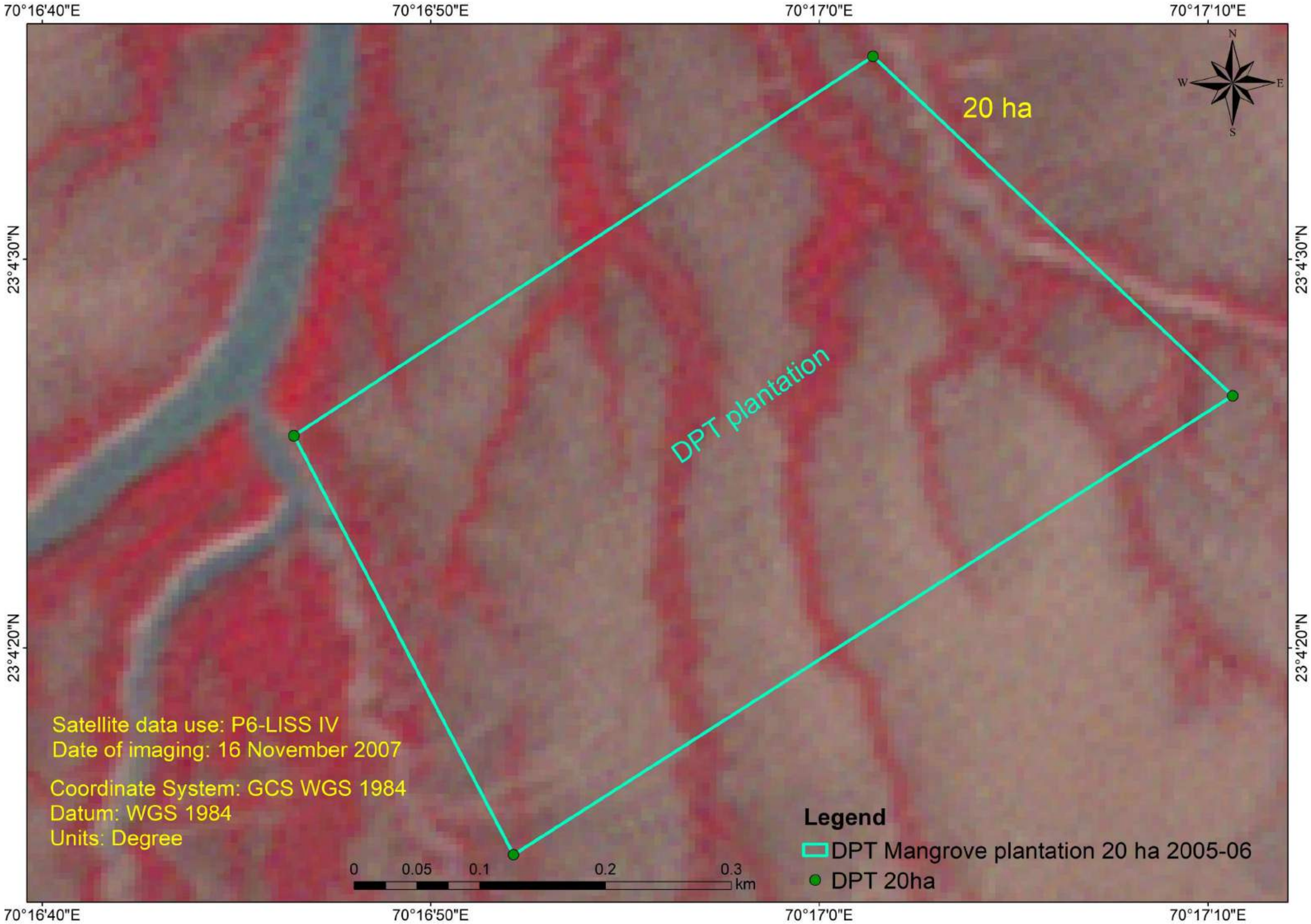

Plate 4. Satellite imageries of 20 ha mangrove plantation at Sat Saida Bet during 2014

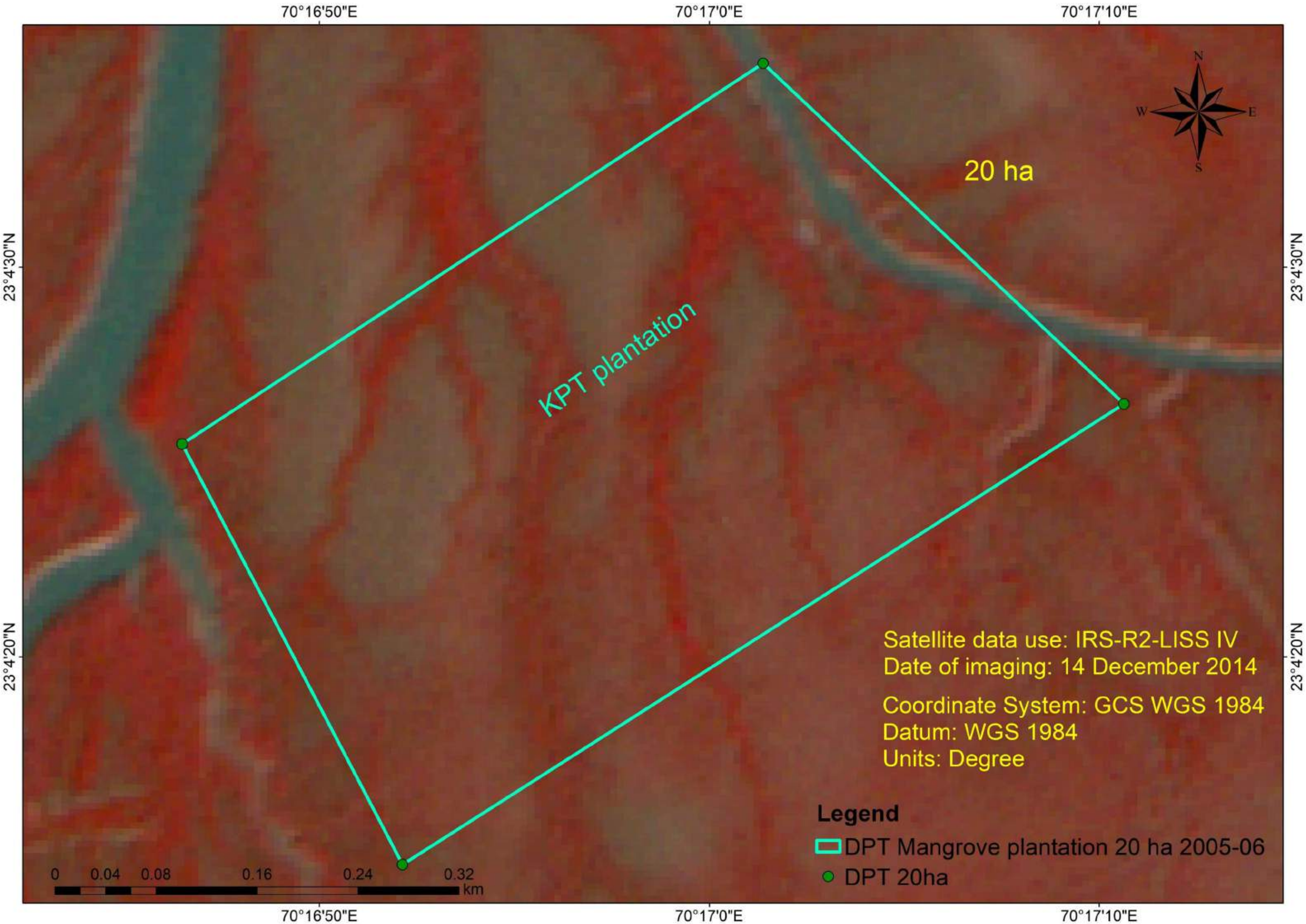

Plate 5. Satellite imageries of 20 ha mangrove plantation at Sat Saida Bet during 2017

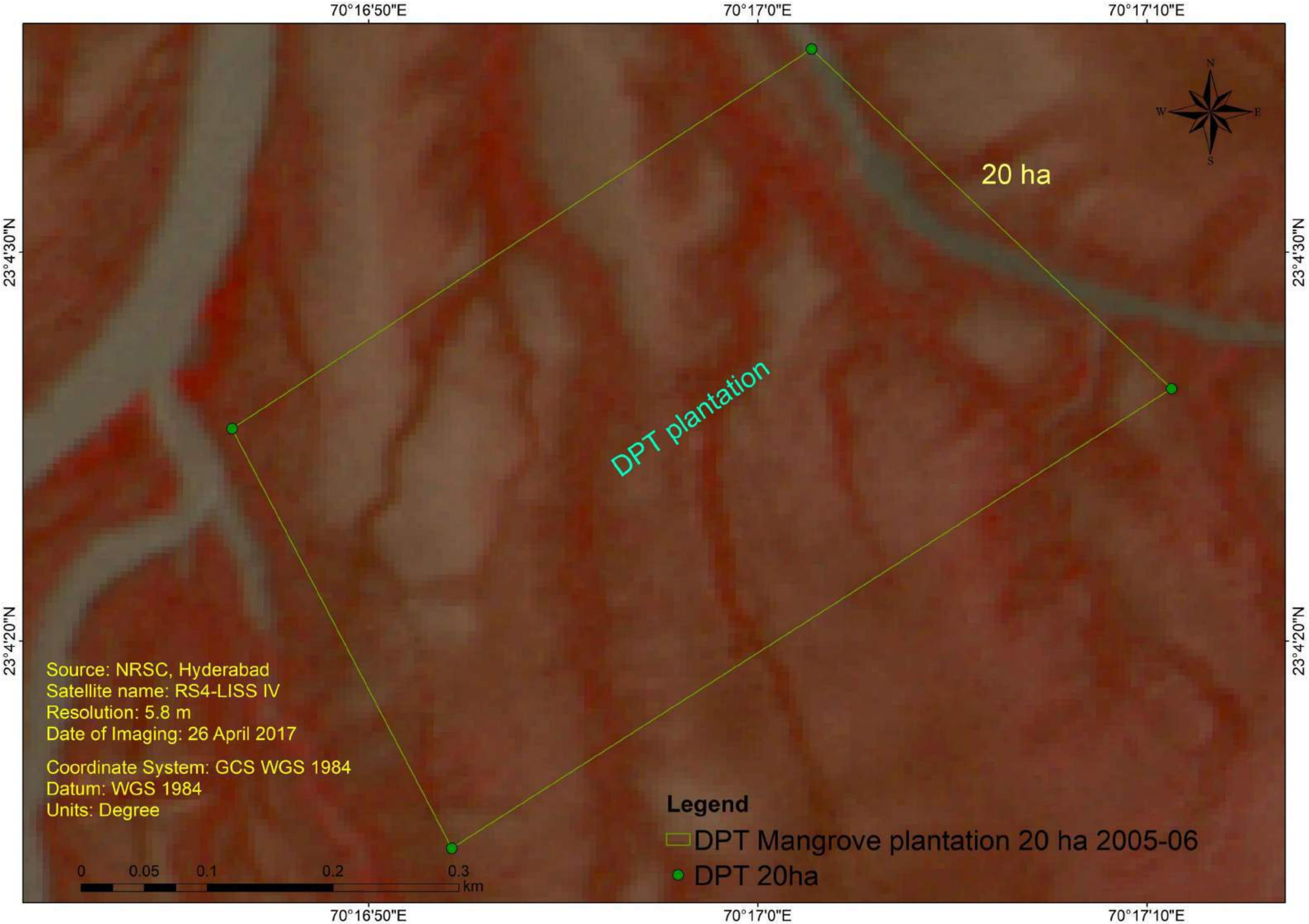

Plate 8. Satellite imageries of 200 ha mangrove plantation at Sat Saida Bet during 2007

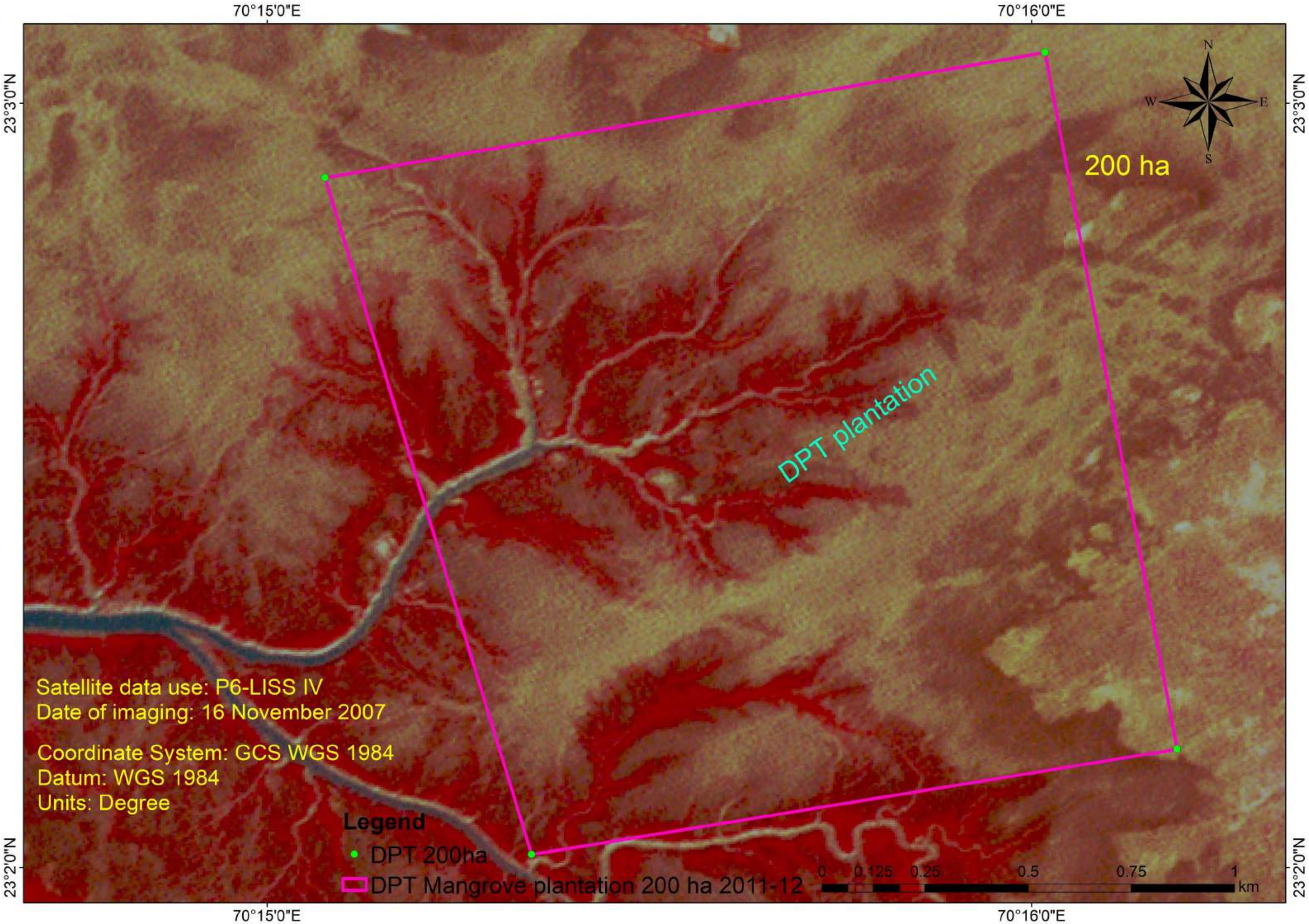

Plate 9. Satellite imageries of 200 ha mangrove plantation at Sat Saida Bet during 2014

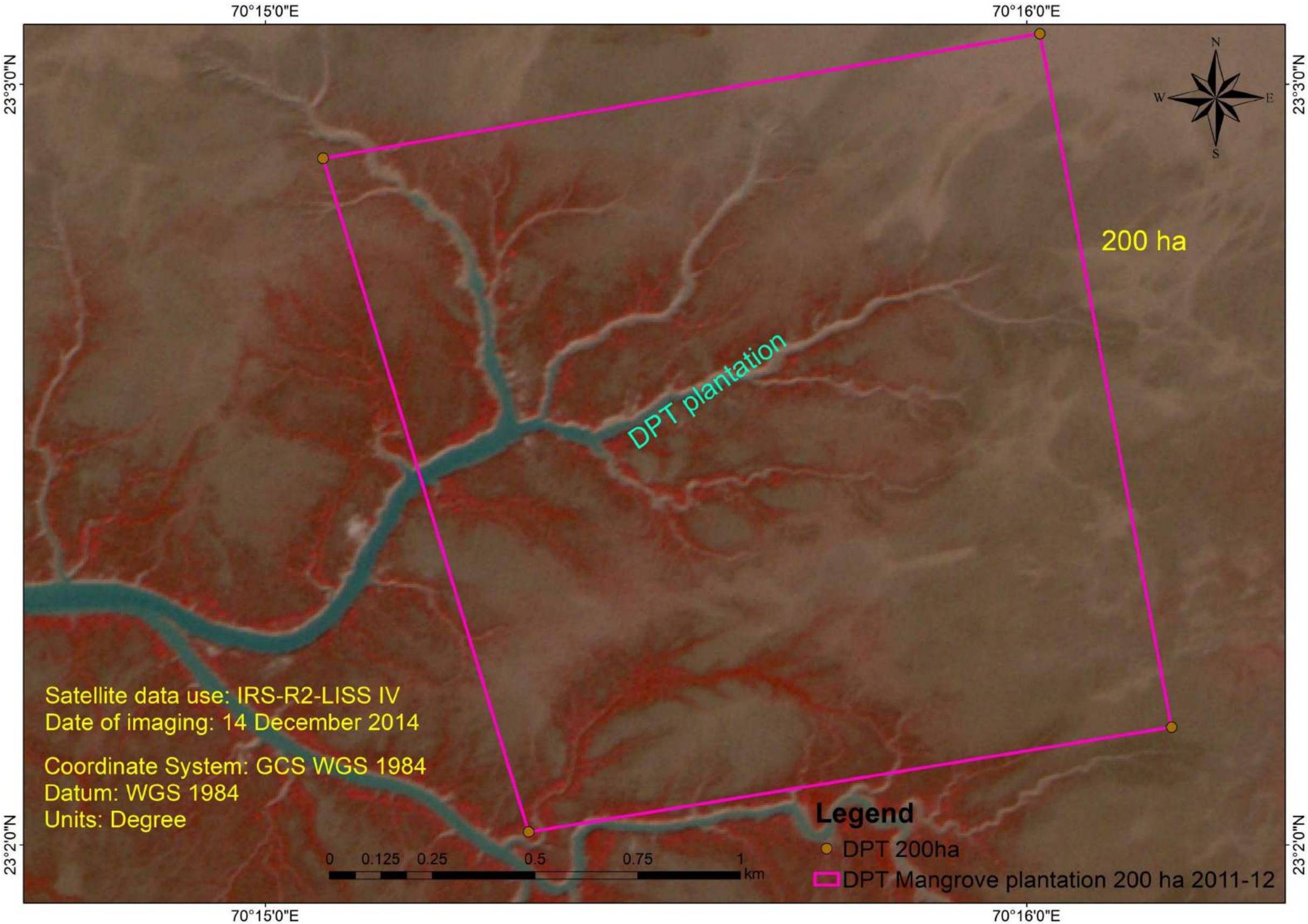

Plate 10. Satellite imageries of 200 ha mangrove plantation at Sat Saida Bet during 2017

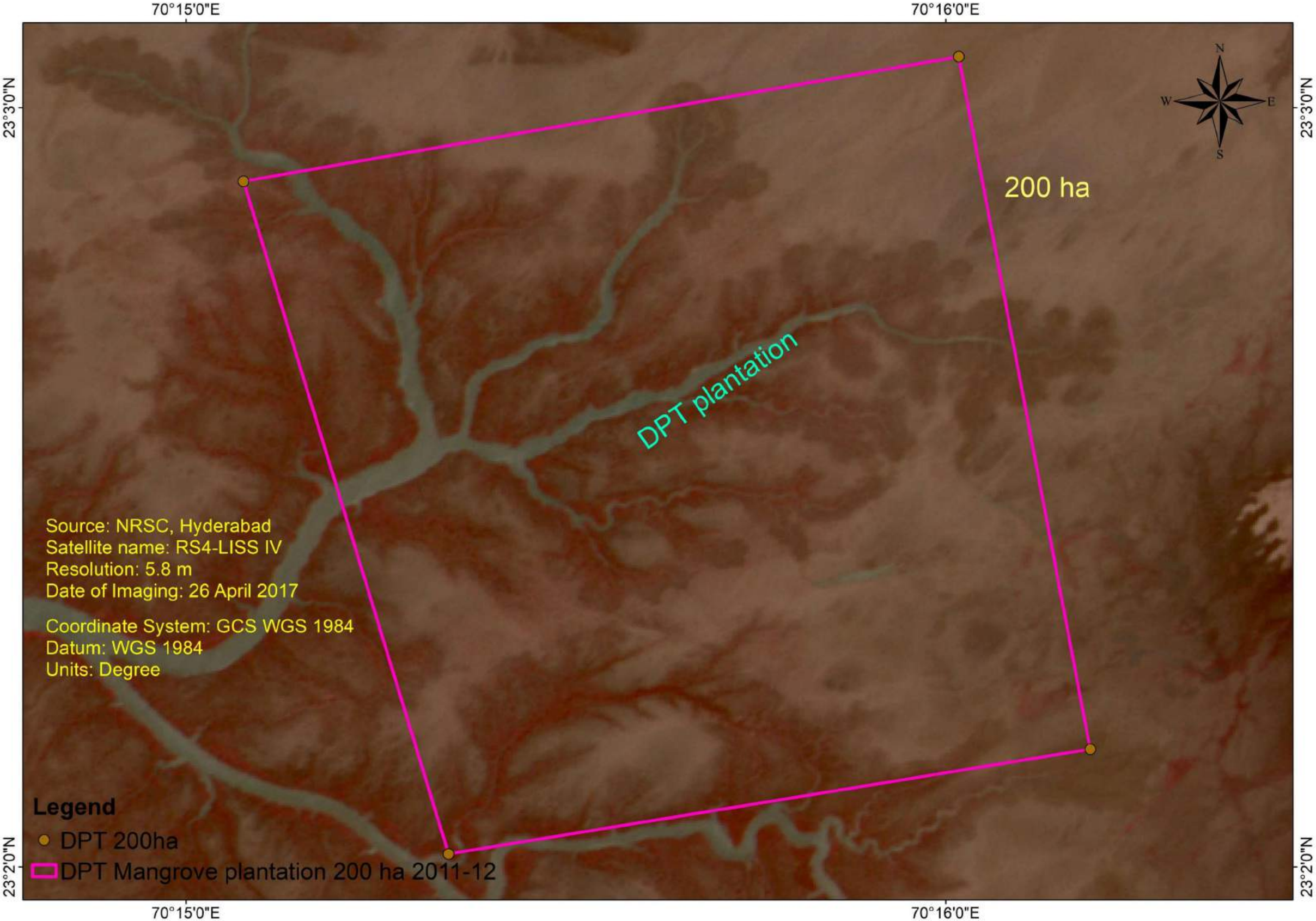

Plate 13. Satellite imageries of 300 ha mangrove plantation at Sat Saida Bet during 2007

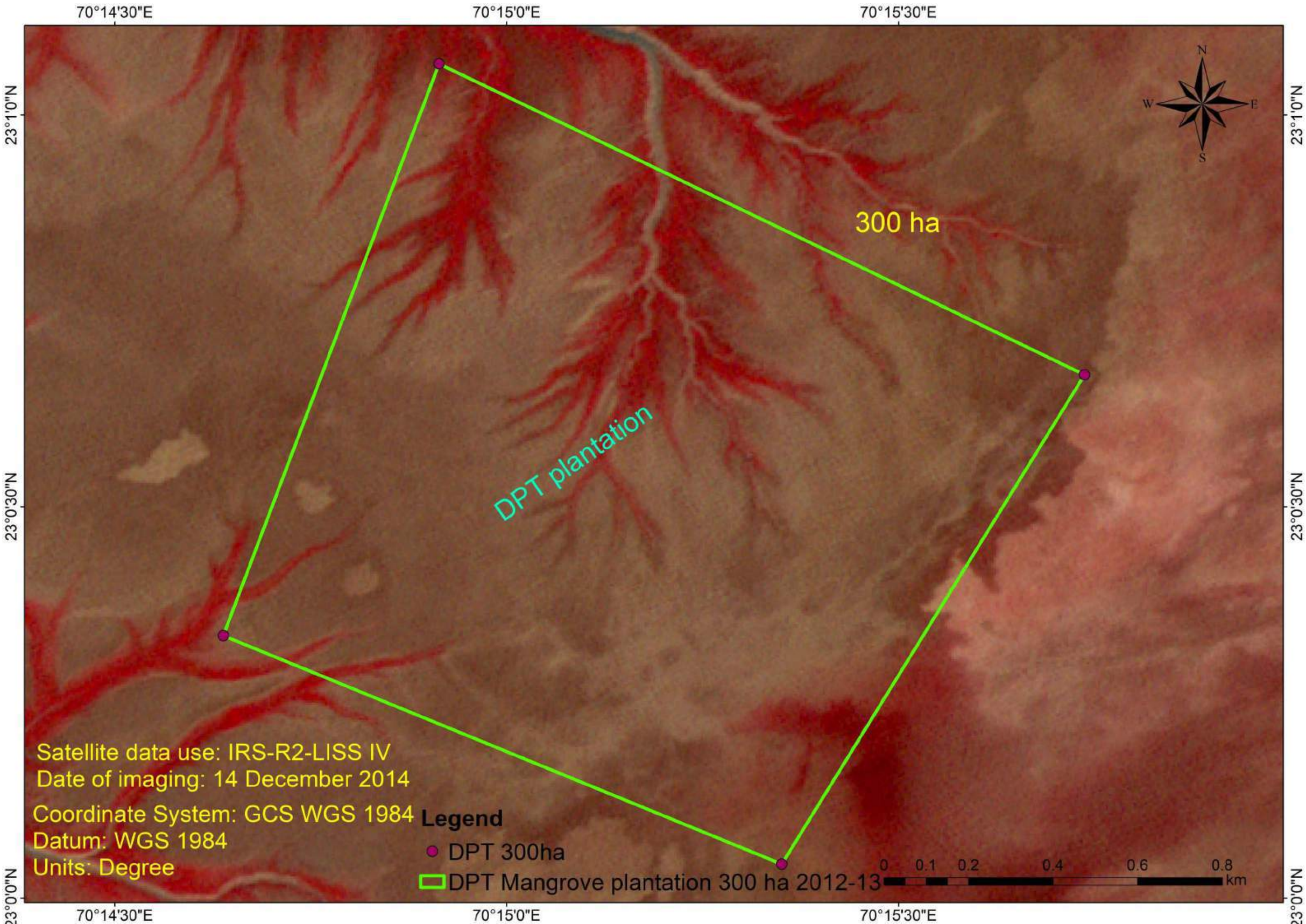

Plate 14. Satellite imageries of 300 ha mangrove plantation at Sat Saida Bet during 2014

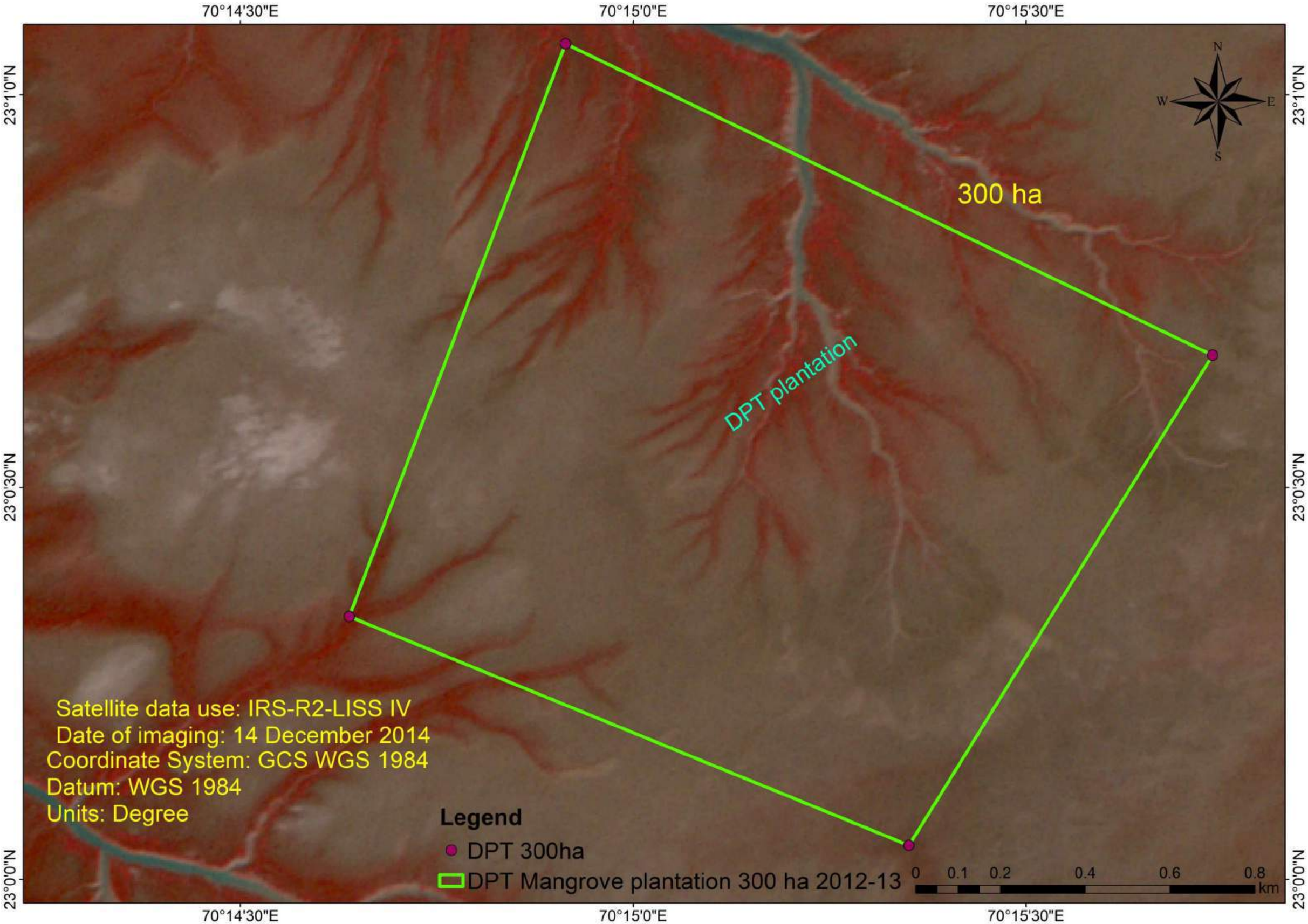

Plate 15. Satellite imageries of 300 ha mangrove plantation at Sat Saida Bet during 2017

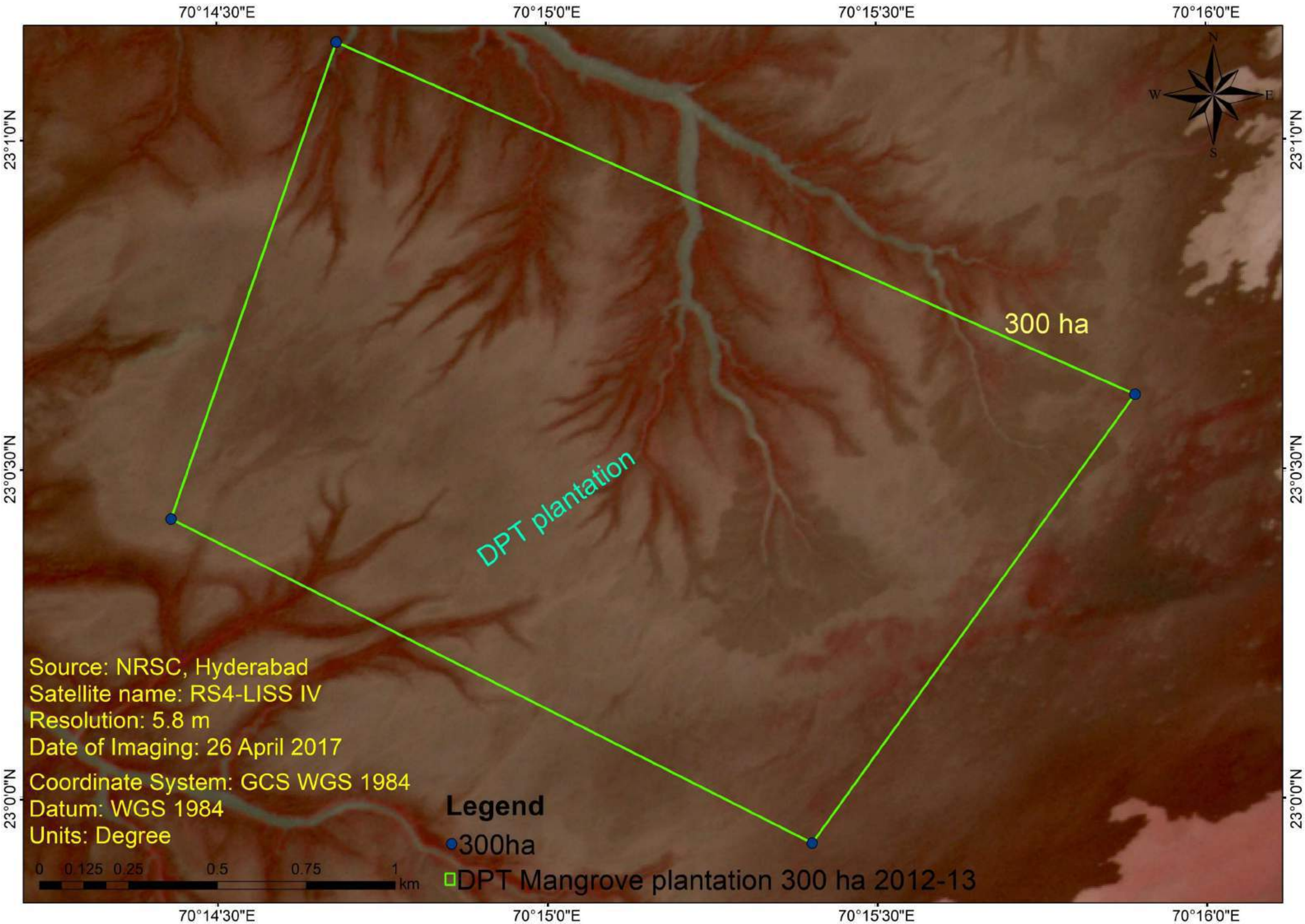

Plate 18. Satellite imageries of 330 ha mangrove plantation at Sat Saida Bet during 2007

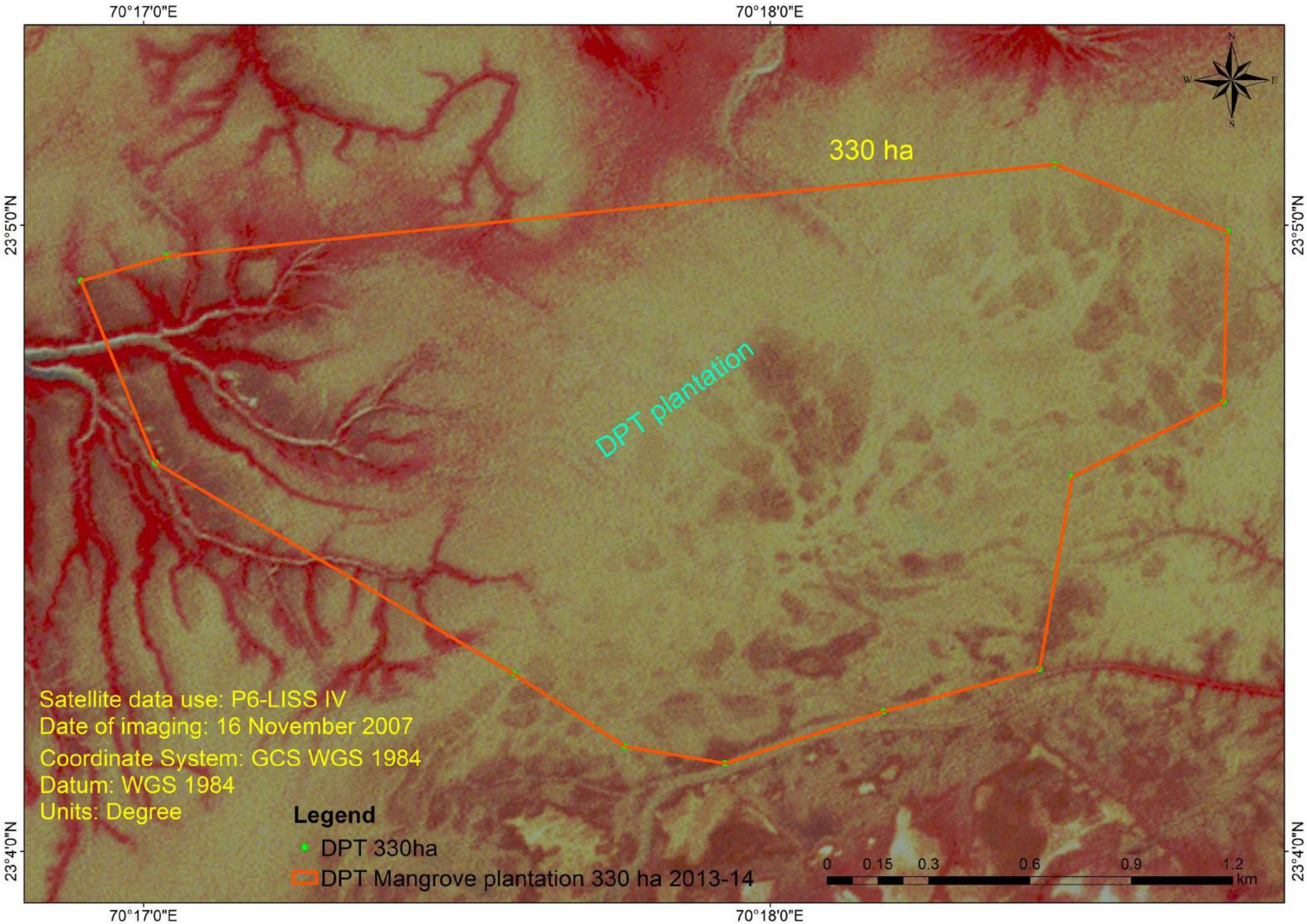

Plate 19. Satellite imageries of 330 ha mangrove plantation at Sat Saida Bet during 2014

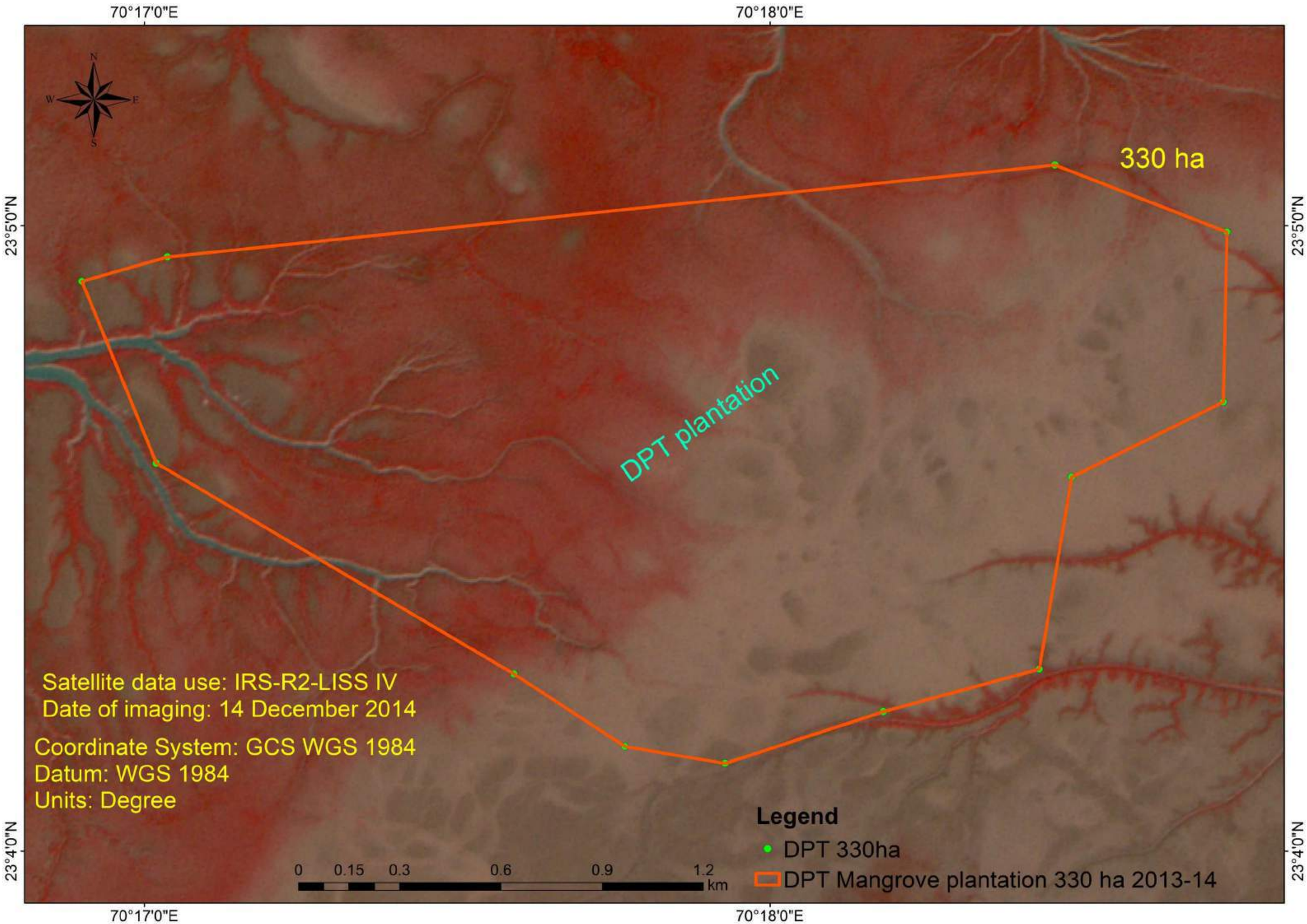

Plate 20. Satellite imageries of 330 ha mangrove plantation at Sat Saida Bet during 2017

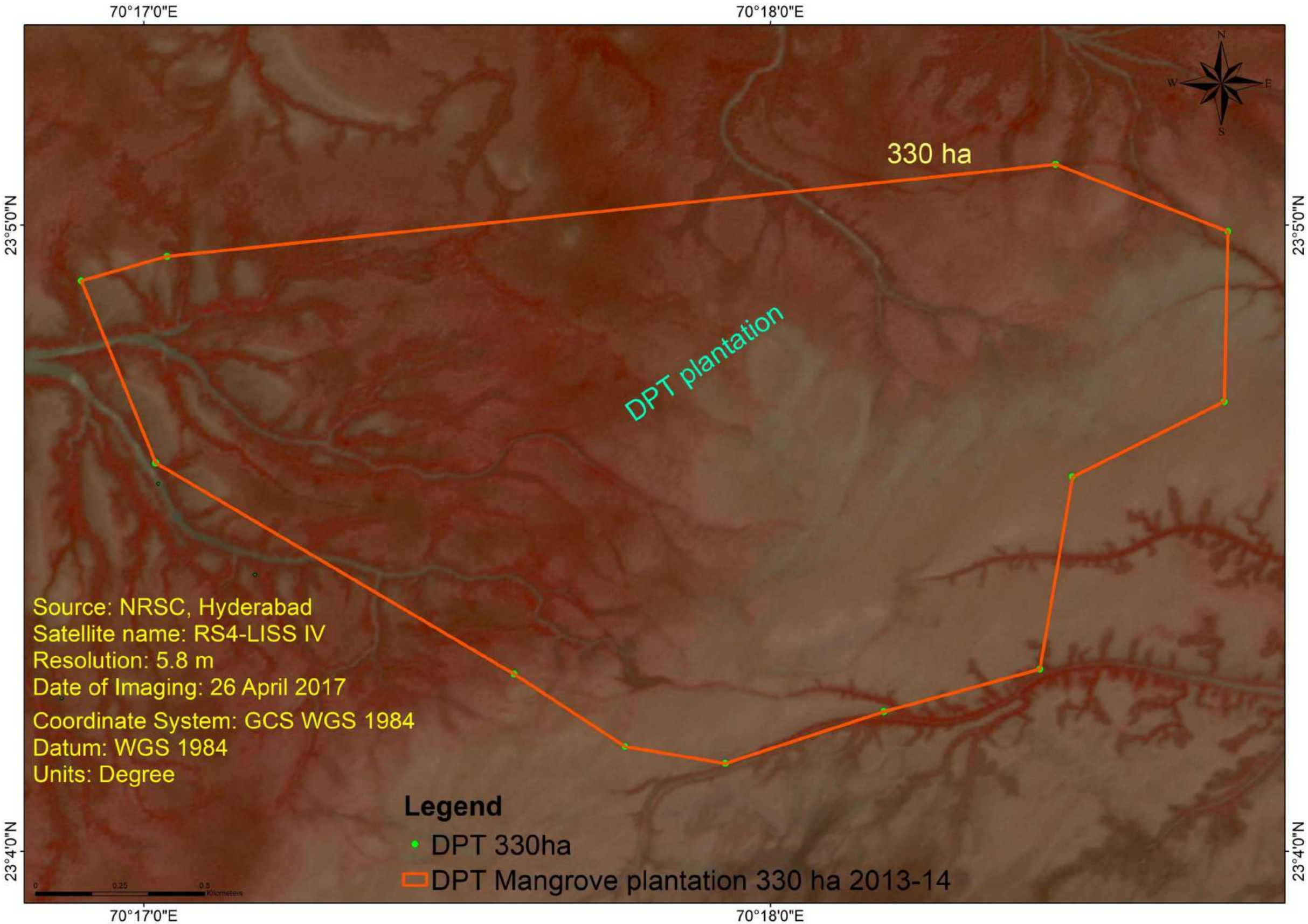

Plate 23. Satellite imageries of 50 ha mangrove plantation at Nakti creek during 2007

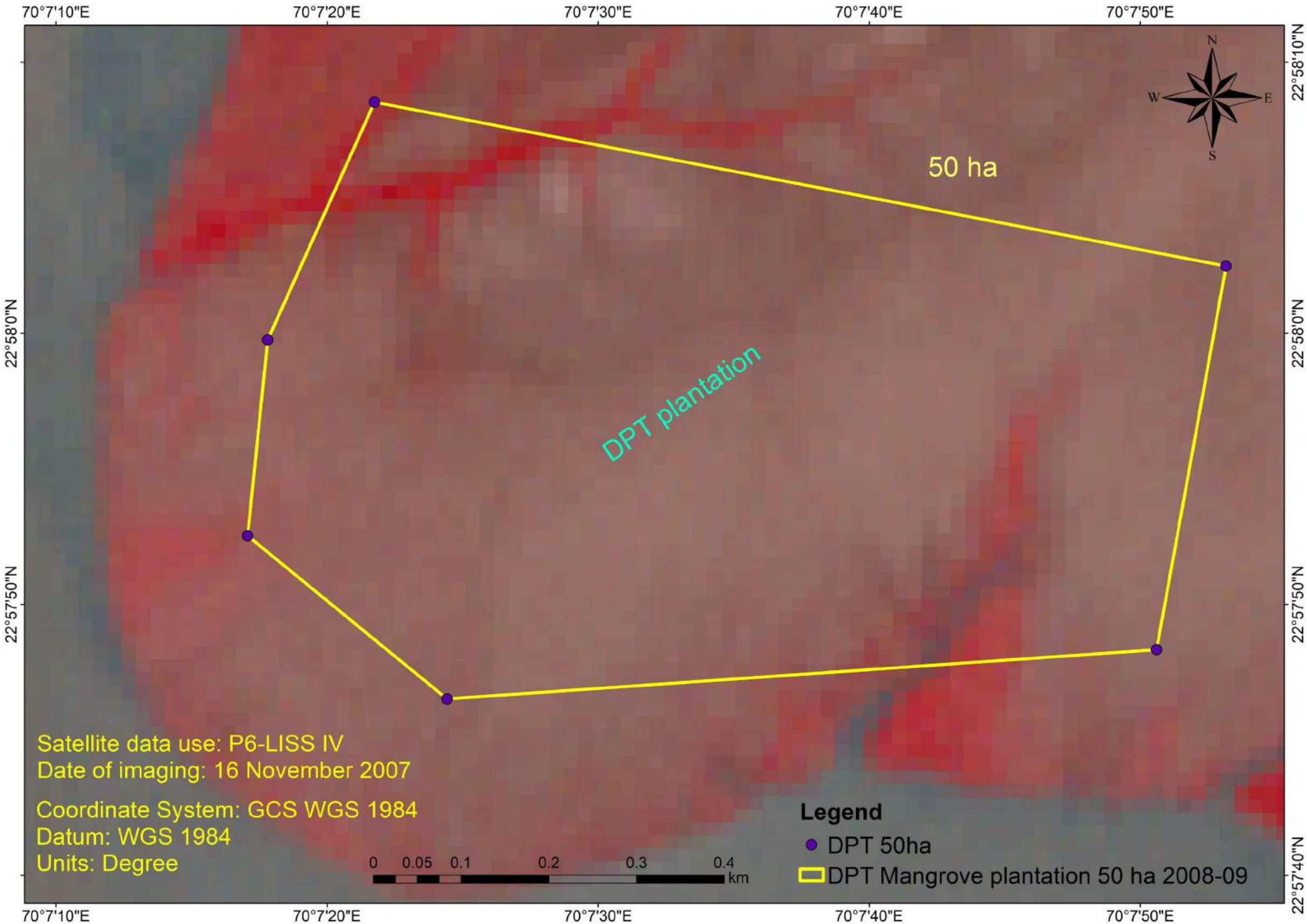

Plate 24. Satellite imageries of 50 ha mangrove plantation at Nakti creek during 2014

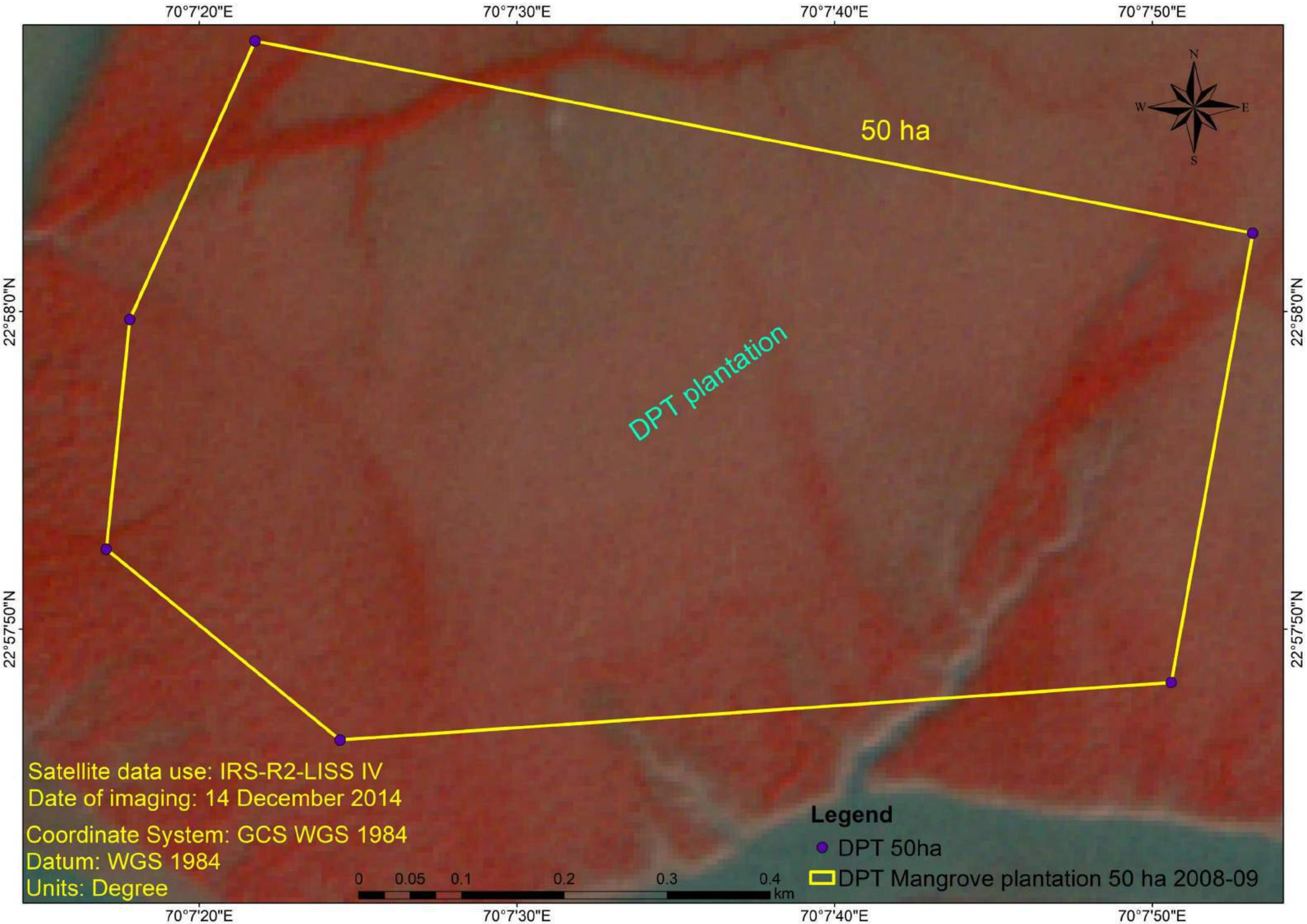

Plate 25. Satellite imageries of 50 ha mangrove plantation at Nakti creek during 2017

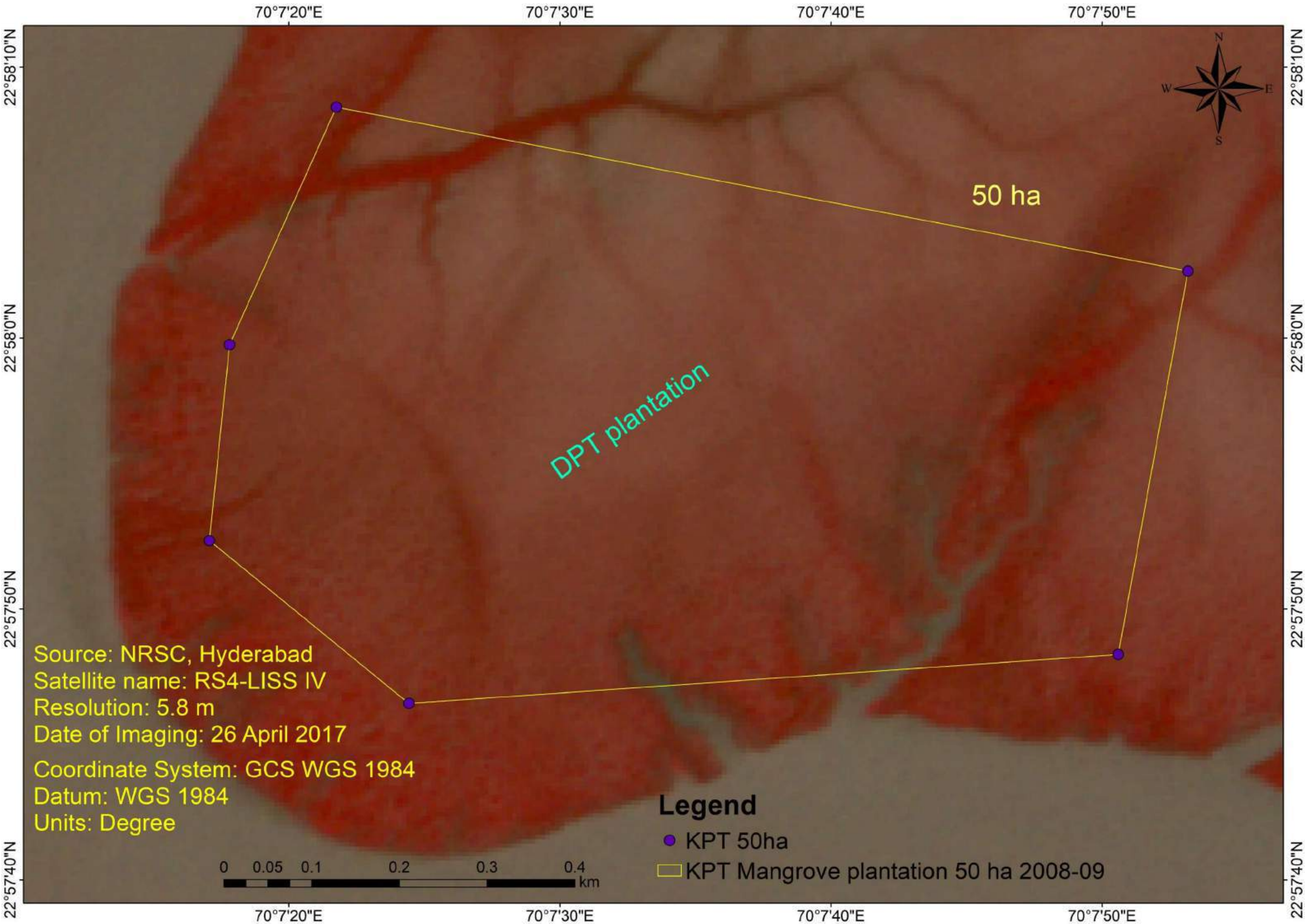

Plate 28. Satellite imageries of 100 ha mangrove plantation at Nakti creek during 2007

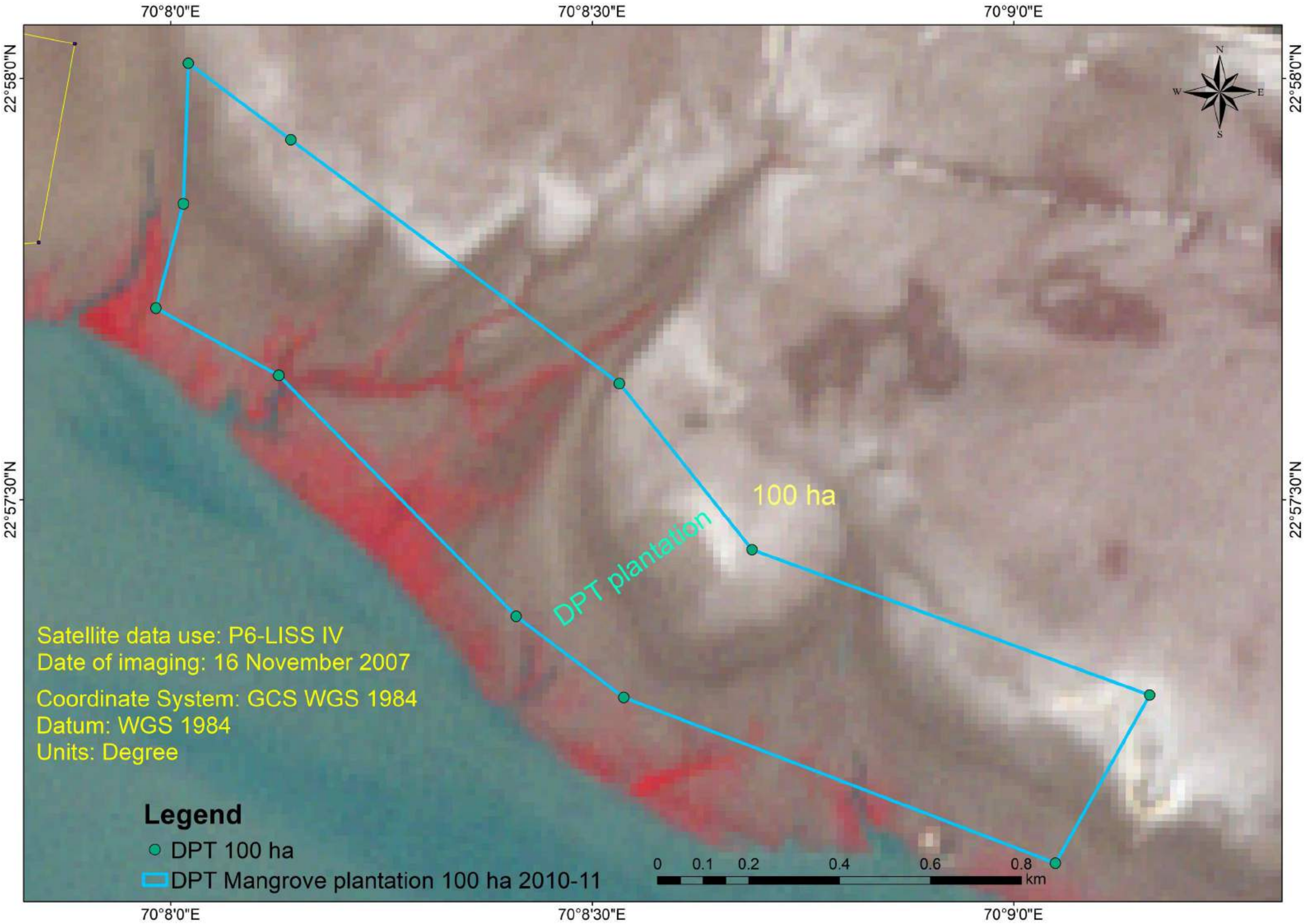

Plate 29. Satellite imageries of 100 ha mangrove plantation at Nakti creek during 2014

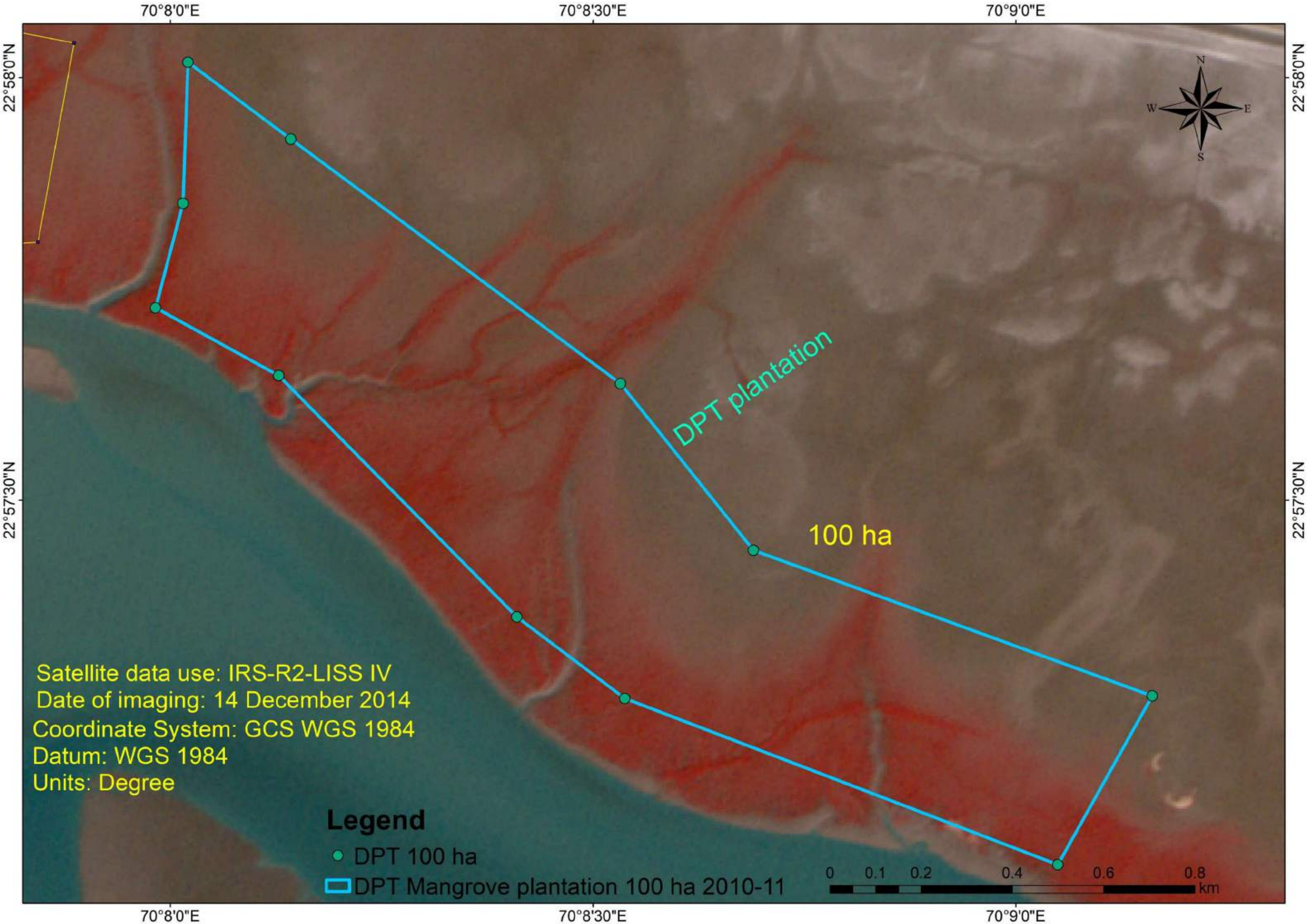

Plate 30. Satellite imageries of 100 ha mangrove plantation at Nakti creek during 2017

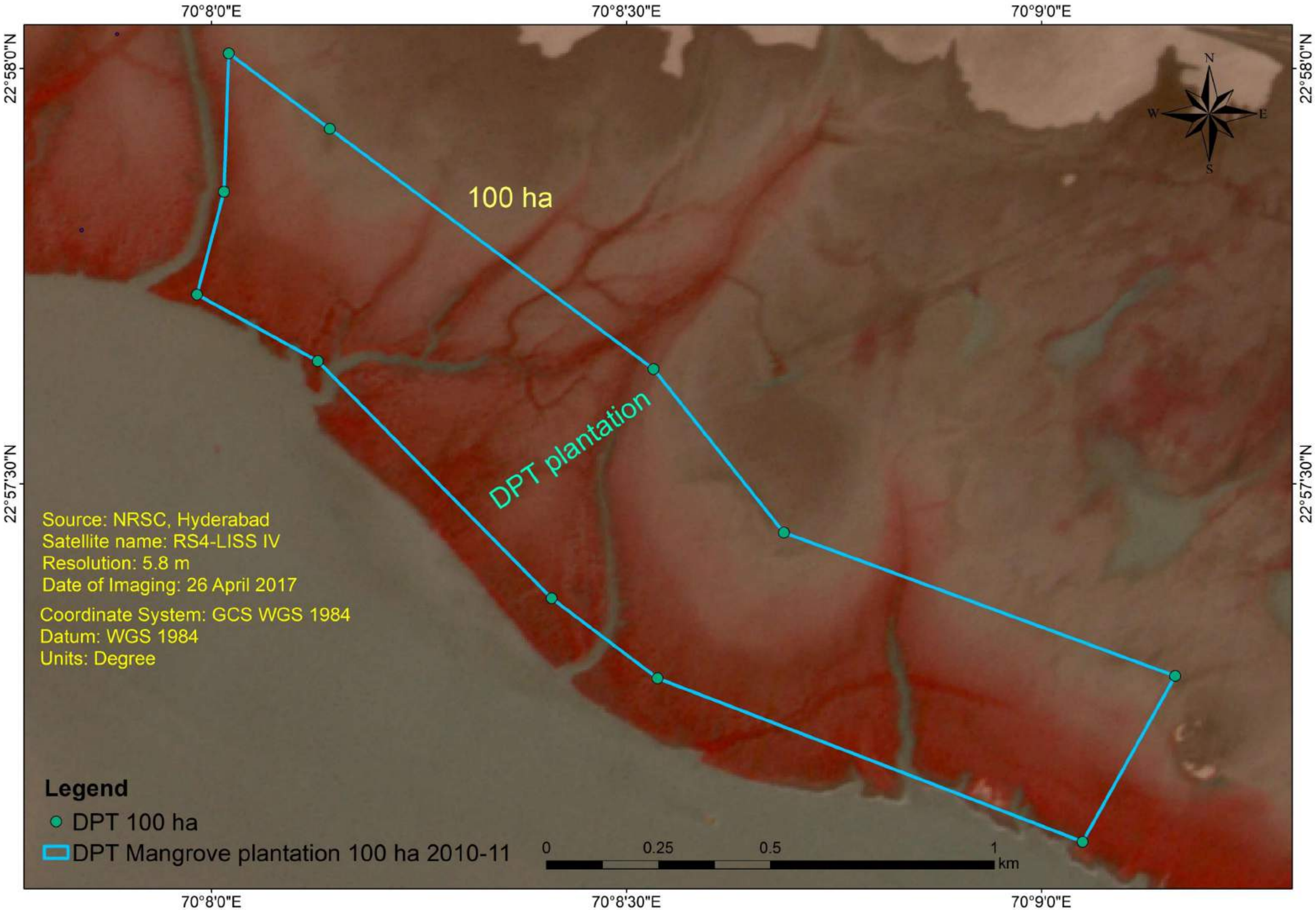

Plate 33. Satellite imageries of 150 ha mangrove plantation at Kantiyajal-block 1 during 2018

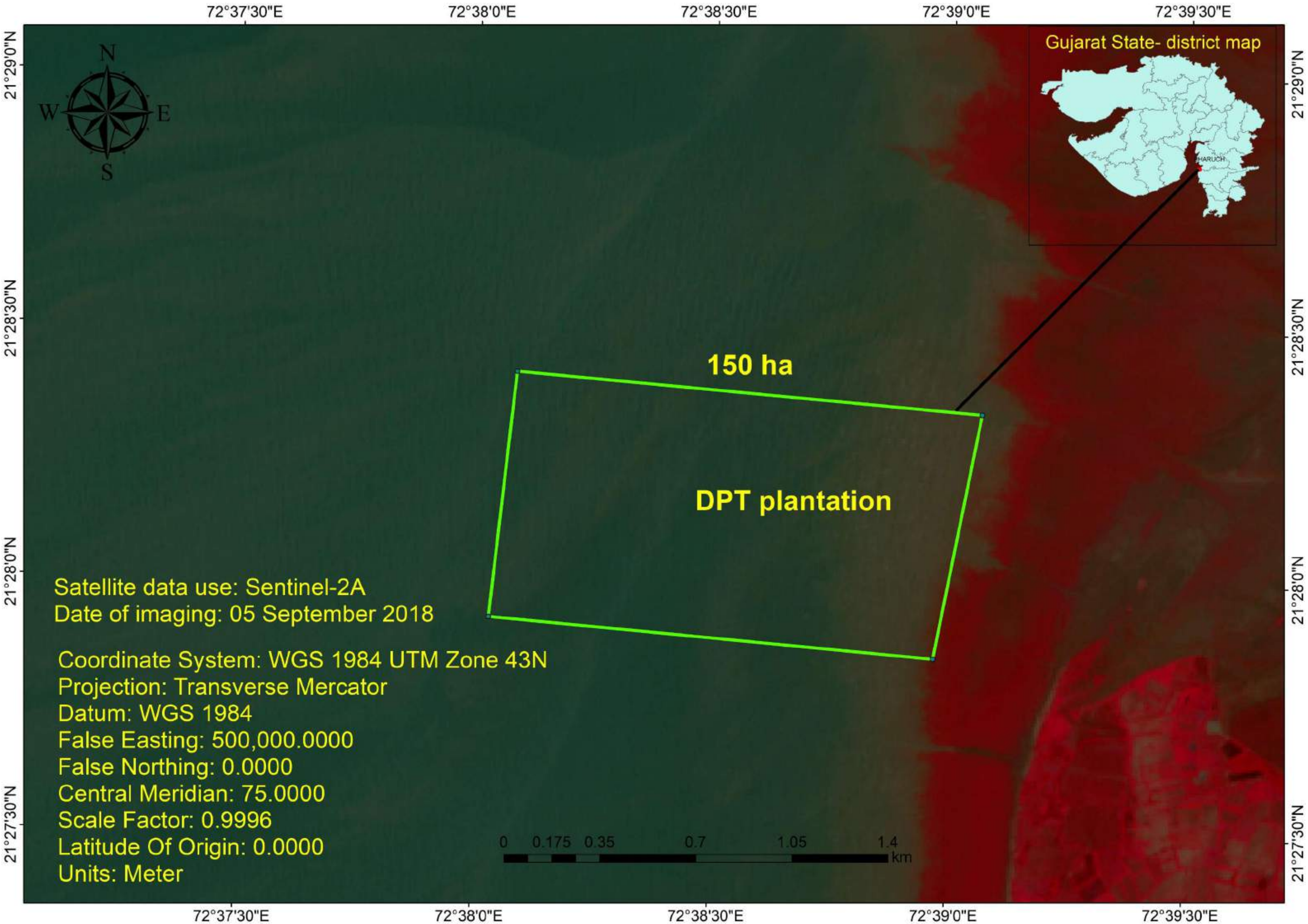

Plate 35. Satellite imageries of 150 ha mangrove plantation at Kantiyajal-block 2 during 2018

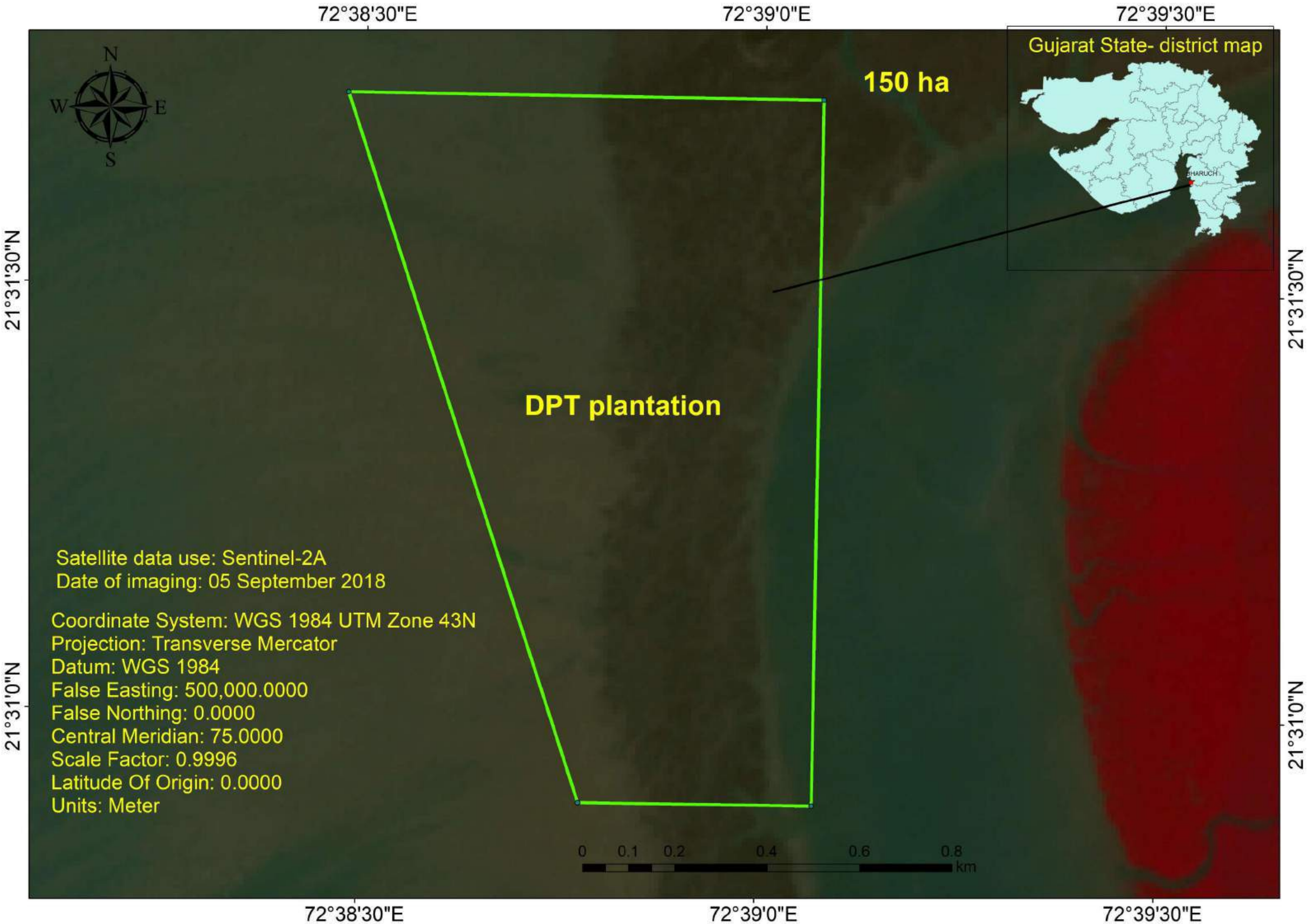

Plate 2. Sampling of soil/sediment for Carbon sequestration studies

Plate 6. 20 ha mangrove plantation at Sat Saida bet during 2005-2006

Plate 7. 20 ha mangrove plantation at Sat Saida bet during 2017-2018

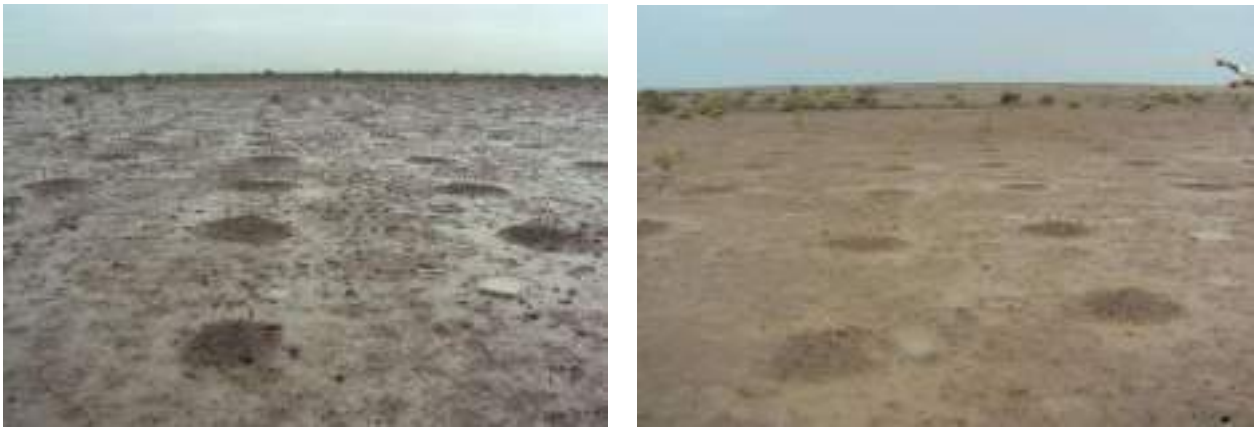

Plate 11. 200 ha mangrove plantation at Sat Saida bet during 2011-2012

Plate 12. 200 ha mangrove plantation at Sat Saida bet during 2017-2018

Plate 16. 300 ha mangrove plantation at Sat Saida bet during 2012-2013

Plate 17. 300 ha mangrove plantation at Sat Saida bet during 2017-2018

Plate 21. 330 ha mangrove plantation at Sat Saida bet during 2013-2014

Plate 22. 330 ha mangrove plantation at Sat Saida bet during 2017-2018

Plate 26. 50 ha mangrove plantation at Nakti creek during 2008-2009

Plate 27. 50 ha mangrove plantation at Nakti creek during 2017-2018

Plate 31. 100 ha mangrove plantation at Nakti creek during 2010-2011

Plate 32. 100 ha mangrove plantation at Nakti creek during 2017-2018

Plate 34. 150 ha mangrove plantation at Kantiyajal-Block 1 during 2018

Plate 36. 150 ha mangrove plantation at Kantiyajal-Block 2 during 2018

ANNEXURE – J

License/Permission to carry out the work of collection and disposal of "Hazardous Waste/Sludge/ Waste Oil" from Vessels calling at Deendayal Port

Regional Office – Kutch (East)
Gujarat Pollution Control Board
Room No. 215-216-217, 2nd Floor,
Kandla Port Trust Administrative Building,
Gandhidham – 370201, Kutch.
Email:- ro-gpcb-kute@gujarat.gov.in

By R.P.A.D.

CONSOLIDATED CONSENT AND AUTHORIZATION (CC & A)
CCA NO: AWH-64725 Appl. Type: CCA-Renewal
NO: GPCB/KUT/RO/CCA- Renewal/ID-38470/

In exercise of the power conferred under Section-25 of the Water (Prevention and Control of Pollution) Act-1974, under Section-21 of the Air (Prevention and Control of Pollution) Act-1981 and Authorization under rule 6(2) of the Hazardous & Other Wastes (Management and Transboundary Movement) Rules-2016, framed under the E(P)Act-1986.

And whereas Board has received consolidated application dated 13/03/2023 and inward no. 274885 for the Renewal of consolidated consent and authorization (CC & A) of this Board under the provisions / rules of the aforesaid Acts. Consolidated Consent & Authorization is hereby granted as under.

CONSOLIDATED CONSENT AND AUTHORISATION:
(Under the provisions / rules of the aforesaid Environmental Acts)

To,
M/s. United Shipping Company,
Plot NO: 46, Mithirohar-GGDC,
Vill: Mithirohar -370240,
Tal: Gandhidham, Dist: Kutch East.

1. **Consent Order No.: AWH-64725, date of Issue 30/06/2023.**
2. The consent under Water Act –1974, Air Act – 1981 and Authorization under Environment (Protection) Act, 1986 **shall be valid up to 13/03/2033** to operate industrial plant to manufacture following product:

Sr. No.	List of Product	Quantity	Unit Per Month	Remarks
1.	Re-Refined Used Oil/ Waste Oil	525.00	MT	--

SPECIFIC CONDITIONS:-

a. No ground water shall be used for the project coming under dark zone without permission of competent authority.
b. Industry shall comply with fresh water from valid source having permission of the competent authority.
c. Industry shall not carry out any activity which may attract the applicability of EIA Notification-2006 & its amendment.
d. Management of Solid Waste generated from industrial activities shall be as per Solid Waste Management Rules-2016 (solid waste as defined in Rule-3(46).
e. As per provision of Rule-18 of Solid Waste Management Rules-2016 all industrial units using fuel and located within 100 km from the refused derived fuel (RDF) plant shall made an arrangement to replace at least five percent of their fuel requirement by refused derived fuel so produced.
f. You shall not receive/ reprocess the used/ spent oil without obtain necessary amendment to authorization under rule-9 of Hazardous and Other Wastes (Management and Transboundary Movement) Rules-2016 from competent Authority.

Outward No. 1610 / 06/05/2023

3. CONDITION UNDER THE WATER ACT:

3.1 Source of water: Tankers.

3.2 The quantity of total water consumption shall not exceed **13 KL/Day** as per below break up as mentioned in form D submitted for consent application under Water Act- 1974.

a) **Industrial: 12 KL/Day.**
b) **Domestic: 1 KL/Day.**

3.3 The quantity of total waste water generation shall not exceed **01 KL/Day** as per below break up as mentioned in form D submitted for consent application under Water Act-1974.

a) **Industrial: 0.5 KL/Day**
b) **Domestic: 0.5 KL/Day**

3.4 Industrial effluent management:

a) Mode of disposal of treated industrial effluent: **ETP.**
b) Description for treated industrial effluent disposal: **There shall be no discharge of industrial effluent. The effluent generated from the manufacturing process and other ancillary industrial operation shall be treated in Effluent Treatment Plant, giving primary treatment and shall be reused back in cooling process, in order to achieve zero liquid discharge.**

3.5 Domestic sewage management:

a) Mode of disposal of treated domestic sewage: **Soak Pit/ Septic Tank.**
b) Description for treated domestic sewage disposal: **Generated domestic waste water shall be disposed into Soak Pit/ Septic Tank.**

3.6 Industry shall provide fixed pipeline with flow meter for reuse of treated effluent in cooling process and maintain its record at site.

3.7 There shall be no discharge of the industrial effluent which will be generated from the manufacturing process and other ancillary industrial operations, Hence the Industry shall strictly adhere to zero liquid discharge (ZLD).

3.8 Disposal system for storm water shall be provided separately. In no circumstances storm water shall be mixed with industrial effluent.

3.9 The Board reserves the right to review and/or revoke the consent and / or make modifications in the conditions which it seems fit in accordance with provisions of Water Act-1974.

4. CONDITIONS UNDER THE AIR ACT:

4.1. Industry shall use fuel as specified in this order and the flue gas emission through stack shall conform to the following standards:

Sr. No.	Stack attached to	Capacity	Name of fuel	Quantity of Fuel	Air Pollution Control Measure (APCM)	Stack Height in Meter (From G.L.)	Parameter & Permissible limit
1.	Thermic Fluid Heater	10 Lac Kcal	Diesel	15 Lit/Hr.	Cyclone Separator	30	PM 150mg/Nm^3 SO_2 100 PPM NOX 50 PPM

4.2. There shall be no process gas emission from the manufacturing process and any other ancillary industrial operation through various stacks/ vent of reactors, process, and vessel from plant premises.

4.3. The concentration of the following parameters in the ambient air within the premises of the Industry shall not exceed the limits specified hereunder as per National Ambient Air Quality Standards issued by MoEF & CC dated 16th November-2009.

Outward No. 10413/30/05/2023

Regional Office – Kutch (East)
Gujarat Pollution Control Board
Room No. 215-216-217, 2nd Floor,
Kandla Port Trust Administrative Building,
Gandhidham – 370201, Kutch.
Email:- ro-gpcb-kute@gujarat.gov.in

Sr. No.	Parameters	Permissible Limit (microgram / m³)	
		Annual	24 Hours Average
1.	Particulate Matter (PM_{10})	60	100
2.	Particulate Matter (PM_{25})	40	60
3.	Oxides of Sulphur (SO_x)	50	80
4.	Oxides of Nitrogen (NO_x)	40	80

- **Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.**
- **24 hourly or 08 hourly or 01 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.**

4.4 Industry shall provide portholes, ladder, platform etc. at chimney(s) for monitoring the air emissions and the same shall be open for inspection to/and for use of Board's staff. The chimney(s) vents attached to various sources of emission shall be designed by numbers such as S-1, S-2, etc. and these shall be painted/displayed to facilitate identification.

4.5 Industry shall take adequate measures for control of noise levels from its own sources within the premises so as to maintain ambient air quality standards in respect of noise to less than 75 dB(A) during day time and 70 dB(A) during night time. Daytime is reckoned in between 6 a.m. and 10 p.m. and nighttime is reckoned between 10 p.m. and 6 a.m.

5. AUTHORISATION FOR THE MANAGEMENT & HANDLING OF HAZARDOUS WASTES Form-2 (See rule 6(2)).

5.1. Number of authorization: **AWH-64725, date of Issue 30/06/2023.**

5.2. **M/s. United Shipping Company**, is hereby granted an authorization to operate facility for following hazardous wastes on the premises situated at **Plot NO: 46, Mithirohar-GGDC, Vill: Mithirohar -370240, Tal: Gandhidham, Dist: Kutch East.**

Sr. No.	Name of Haz. Waste	Category Number	Quantity in MT/Yr.	Facility and Mode of Disposal
1.	Used or Spent Oil	5.1	7200.00	Collection, storage, Transportation and disposal by reuse as lubricant in plant machineries within plant premises.
2.	Discarded Containers/ Barrels/ Liners	33.3	15.00 Nos./Yr.	Collection, storage, Transportation and disposal by giving it to registered recycler.
3.	Oily Sludge/ Emulsion	4.1	30.00	Collection, storage, Transportation and disposal by giving it to registered recycler.
4.	Organic Process Residue	4.4	20.00	Collection, storage, Transportation and disposal to CHWIF.
5.	ETP Sludge	34.3	0.50	Collection, storage, Transportation and disposal to TSDF.
6.	Spent Clay	4.5	30.00	Collection, storage, Transportation and disposal to CHWIF or to actual reuser or for Co-incineration.

Outward No: 16423, 30/06/2023

5.3. The authorization is granted to operate a facility for collection, storage within factory premises, transportation and ultimate disposal of Hazardous wastes as mentioned above.

5.4. The authorization shall be in force for a period as mentioned above.

5.5. The authorization is subject to the conditions stated below and such other conditions as may be specified in the rules from time to time under the Environment (Protection) Act-1986.

5.6. **Terms and conditions of authorization:**

a. The authorized person shall comply with the provisions of the Environment (Protection) Act, 1986, and the rules made there under.

b. The authorization or its renewal shall be produced for inspection at the request of an officer authorized by the Gujarat Pollution Control Board.

c. The person authorized shall not rent, lend, sell, transfer or otherwise transport the hazardous and other wastes except what is permitted through this authorization.

d. Any unauthorized change in personnel, equipment or working conditions as mentioned in the application by the person authorized shall constitute a breach of his authorization.

e. The person authorized shall implement Emergency Response Procedure (ERP) for which this authorization is being granted considering all site specific possible scenarios such as spillages, leakages, fire etc. and their possible impacts and also carry out mock drill in this regard at regular interval of time;

f. The person authorized shall comply with the provisions outlined in the Central Pollution Control Board guidelines on "Implementing Liabilities for Environmental Damages due to Handling and Disposal of Hazardous Waste and Penalty"

g. It is the duty of the authorized person to take prior permission of the Gujarat Pollution Control Board to close down the facility.

h. The imported hazardous and other wastes shall be fully insured for transit as well as for any accidental occurrence and its clean-up operation.

i. The record of consumption and fate of the imported hazardous and other wastes shall be maintained.

j. The hazardous and other waste which gets generated during recycling or reuse or recovery or pre-processing or utilization of imported hazardous or other wastes shall be treated and disposed of as per specific conditions of authorization.

k. The importer or exporter shall bear the cost of import or export and mitigation of damages if any.

l. An application for the renewal of an authorization shall be made as laid down under these Rules.

m. Any other conditions for compliance as per the Guidelines issued by the Ministry of Environment, Forest and Climate Change or Central Pollution Control Board from time to time.

n. Annual return (Form – 4) shall be filed by June 30th for the period ensuring 31st March of the year.

5.7. The industry shall have to manage used or spent oil; empty or discarded barrels / containers / liners contaminated with hazardous chemicals / wastes, process waste as per Hazardous & Other Wastes (Management and Transboundary Movement) Rules-2016, framed under the E(P)Act-1986 and shall apply Authorization for all applicable waste.

5.8. The waste generator shall be totally responsible for (i.e. collection, storage, transportation and ultimate disposal) of the wastes generated.

5.9. In case of any accident, details of the same shall be submitted in Form - 11 to Gujarat Pollution Control Board.

6. GENERAL CONDITION

6.1 In case of change of ownership/ management the name and address of the new ownership/ partners/ directors/ proprietor should immediately be intimate to the Board. Also any change in equipment or working conditions as mentioned in the consent form/ order should immediately be intimated to this Board.

Outward No: 1241-30/06/22

Regional Office – Kutch (East)
Gujarat Pollution Control Board
Room No. 215-216-217, 2nd Floor,
Kandla Port Trust Administrative Building,
Gandhidham – 370201, Kutch.
Email:- ro-gpcb-kute@gujarat.gov.in

6.2 Industry shall put up at the entrance a board displaying the name of the Industry, particulars of the products/ process and the name of proprietor/partners /directors of the Industry and the electricity consumer number as on the record of PGVCL.

6.3 The environmental statements pertaining to the previous year shall be submitting to this State Board latest by 30th June every year.

6.4 Adequate plantation shall be carried out all along the periphery of the industrial premises in such a way that the density of plantation is at least 1000 trees per acre of land and a green belt of 5 meters width is developed.

6.5 The industry shall have to display the relevant information with regard to hazardous waste, waste water & air pollutants as indicated in the Courts Order In W.P. No.657 of 1995 dated 14th October-2003.

6.6 As per "Public Liability Insurance Act – 1991", Industry shall get Insurance Policy, if applicable.

6.7 Applicant shall also comply with the general conditions given in annexure I.

6.8 The waste generator shall be totally responsible for (I.E. Collection, storage, transportation and ultimate disposal) of the wastes generated.

6.9 Records of waste generation, its management and annual return shall be submitted to Gujarat Pollution Control Board in Form - 4 by 31st January of every year

6.10 In case of any accident, details of the same shall be submitted in Form - 5 to Gujarat Pollution Control Board.

6.11 Empty drums and containers of toxic and hazards material shall be treated as per guideline published for management & handling of discarded containers". Records of the same shall be maintained and forwarded to Gujarat Pollution Control Board regularly.

6.12 In no case any kind of hazardous waste shall be imported without prior approval of appropriate authority.

6.13 In case of transport of hazardous waste to a facility for (I.E. Treatment, Storage and disposal) existing in a state other than the state where hazardous waste are generated, the occupier shall obtain "No Objection certificate" from the state pollution Control Board, the Committee of the concerned state or Union territory Administration where the facility exists.

6.14 Unit shall take all concrete measures to show tangible results in waste generation reduction, voidance, reuse and recycle. Action taken in this regards shall be submitted within 03 months and also along with Form 4.

6.15 Industry shall have to display online data outside the main factory gate with regard to quantity and nature of hazardous chemicals being handled in the plant, including wastewater and air emissions and solid hazardous waste generated within the factory premises.

For and on behalf of
GUJARAT POLLUTION CONTROL BOARD

(Rajesh Kumar Parmar)
Regional Officer, Kutch (East)

Outward No: 5413 , 30/06/2023

ISSUED TO,
M/s. United Shipping Company,
Plot NO: 46, Mithirohar-GGDC,
Vill: Mithirohar -370240,
Tal: Gandhidham, Dist: Kutch East.

GPCB ID: 38470, Inward ID: 274885.

Gujarat Pollution Control Board

REGIONAL OFFICE : MEHSANA

GPCB

Plot No.. H/3-A, GIDC Estate, Phase-1, Nr. FCI Godown, Modhera Road, Mehsana-384 002
Phone No.: (02762) 258294, 258106, Web: http/gpcb.gujarat.gov.in

By R.P.A.D

NO: GPCB / MEH / CCA- 46(4)/ ID-18126/ 5403/17805 **Date:08/05/2023**

In exercise of power conferred under Section –25 of the Water (Prevention & Control of Pollution) Act - 1974, under Section - 21 of the Air (Prevention & Control of Pollution) Act - 1981 and Authorization under rule 3 (c) & 5 (5) of the Hazardous Waste (Management & Handling & Trance boundary movement) Rules 2008 framed under the Environmental (Protection) Act 1986.
And Whereas Board has received Consolidated Consent Application letter No. **273092** dated **29/01/2023** for the **Consolidated Consent and Authorization** (C C & A) of this Board under the provision / rules of the aforesaid Acts. Consent & Authorization are hereby granted as under

CONSENT AND AUTHORIZATION:
(Under the provision/ rules of the aforesaid Environmental Acts.)

TO,
M/s. ALICID ORGANIC INDUSTRIES LTD
Plot No. 207, 208.
Village: Hanumant Beduva,
Ta & Dist: Mehsana - 384 002.

1. Consent Order No: **AWH-62807**, Date of issue: **19/04/2023**.
2. The consent shall be valid up to **31/03/2028** for use outlet for the discharge of trade effluent & emission due to operation of industrial plant for manufacture of the following items / products.

SR. No	Product	Quantity
1.	Re cycled Waste Oil (Industrial fuel)	1500 KL/Month
2.	Re-refine used oil	225 KL/Month

SPECIFIC CONDITION:

- **The passbook for Re-Refining of Hazarders waste for "Waste oil @ 18000 KLPD & used oil @ 2700 KLPD" shall be valid up to 31/03/2023.**
- **The unit shall not import any waste without obtaining the clearance as specified in Sch-VII of Haz. Waste Rules-2016.**
- **The unit shall quarterly and annually submit the details of waste procured and processed to the Board.**

3. **CONDITION UNDER THE WATER ACT**

3.1 There shall be no discharge of the industrial effluent from the manufacturing process and other ancillary industrial operations
3.2 The quantity of the industrial discharge shall be **NIL.**
3.3 The quantity of the domestic waste water (sewage) shall not exceed **800 Lits/day.**
3.4 Sewage shall be disposed of through **Septic tank/soak pit** system.

4. **CONDITIONS UNDER AIR ACT 1981:**

4.1 The following shall be used as fuel.

Sr. No	Fuel	Quantity
1.	LDO	65 Lit/ Hr.
2.	Wood	100 Kg/ Hr.
3.	Imported Coal	75 Kg/ Hr.
4.	CNG	175 SCM/ Hr

Clean Gujarat Green Gujarat

ISO - 9001 - 2008 & ISO - 14001 - 2004 Certified Organisation

4.2 The applicant shall install & operate air pollution control system in order to achieve norms prescribed below.
4.3 The flue gas emission through stacks attached to boiler shall conform to the following standards.-

Stack No.	Stack Attached to	Stack Height in Meter	APCM	Parameter	Permissible Limit
1.	Thermic Fluid Heater (02 Lakh Kcal)	30	--	PM SO2 NOx	150 mg/NM3 100 ppm 50 ppm
	Thermic Fluid Heater (02 Lakh Kcal)	30	--		
2.	Thermic Fluid Heater (01 No's) (06 Lakh Kcal)		--		
3.	Thermic Fluid Heater (01 No's) (10 Lakh Kcal)		Dust collector + Bag Filter		

4.4 There shall be no process emission from the manufacturing process and other ancillary operations.
4.5 Ambient air quality within the premises of the industry shall conform to the following standards: -

PARAMETERS	PERMISSIBLE LIMIT	
	Annual	24 Hrs Average
Particulate Matter- 2.5 (PM 2.5)	40 Microgram/M3	60 Microgram/M3
Particulate Matter-10 (PM 10)	60 Microgram/M3	100 Microgram/M3
Sulphur Dioxide (SO2)	50 Microgram/M3	80 Microgram/M3
Nitrogen Dioxide (NOx)	40 Microgram/M3	80 Microgram/M3

4.6 The applicant shall install & operate following Air pollution control equipment very efficiently & continuously so that the emission of particulate matter shall not exceed the concentration mentioned at 4.5 above.
4.7 The consent to operate the industrial plant shall lapse if at any time the parameters of the emission are not within the tolerance limits specified in the condition no-4.5.
4.8 The industry shall take adequate measures for control of noise levels from its own sources within the premises so as to maintain ambient air quality standards in respect of noise to less than 75dB(A) during day time and 70 dB(A) during night time. Day time is reckoned in between 6 a.m. and 10 p.m. and night time is reckoned between 10 p.m. and 6 a.m

5. **AUTHORISATION FOR THE MANAGEMENT & HANDLING OF HAZARDOUS WASTES FORM-2 (See rule 5 (4))**
5.1 Form for grant of authorisation for occupier or operator handling hazardous waste.
5.2 M/S. **ALICID ORGANIC INDUSTRIES LTD** is hereby granted an authorisation to operate facility for following hazardous wastes on the premises situated at **Plot No. 207, 208, Village: Hanumant Heduva, Ta & Dist: Mehsana – 384 002.**

Sr. No.	Type of Waste	Quantity	Category Schedule-1	Facility
1.	Used Oil (Cat. No. 5.1)	2700 KL/Year	5.1	Reception, Collection, Storage & Re-Refining in the premises.
2.	Waste Oil (Cat. No. 5.2)	18000 KL/Year	5.2	Reception, Collection, Storage& Re-cycling in the premises.
3.	Distillation Residues (Cat. No. 20.3)	444 KL/Year	20.3	Collection, Storage, transportation, disposal at Authorized CHWIF
4.	Spent Clay Containing Oil (Cat. No. 4.5)	117 MT/Year	4.5	Collection, Storage, transportation, disposal at Authorized CHWIF
5.	Filter and filtering materials (Cat. No. 36.2)	1.2 MT/Year	33.3	Collection, Storage, Transportation, disposal at Authorized TSDF site

5.3 The authorisation is granted to operate a facility for Collection, Storage, and return back to supplier/ sale to authorized recycler.

5.4 The authorisation shall be valid up to **31/03/2028.**

5.5 The authorisation is subject to the conditions stated below and such other conditions as may be specified in the rules from time to time under the Environment (Protection) Act-1986.

6 GENERAL CONDITION:

6.1 Adequate plantation shall be carried out all along the periphery of the Industrial premises in such a way that the density of plantation is at least 1000 trees per acre of land and a green belt of 05 meters width is developed.

6.2 The applicant shall have to submit the returns in prescribed form regarding water consumption and shall have to make payment of water cess to the board under the Water Cess Act- 1977

6.3 In case of change of ownership/management the name and address of the new owners/partners /directors/proprietor should immediately be intimated to the Board

6.4 The applicant shall however, not without the prior consent of the Board bring into use any new or altered outlet for the discharge of effluent or gaseous emission or sewage waste from the proposed industrial plant. The applicant is required to make applications to this Board for this purpose in the prescribed forms under the provisions of the Water Act-1974, the Air Act-1981 and the Environment (Protection) Act-1986

6.5 Any change in personnel, equipment or working conditions as mentioned in the consents form/ order should immediately be intimated to this Board The Board reserves the right to review and/or revoke the consent and/or make variations in the conditions, which the Board deems fit in accordance with Section 27 of the Act.

6.6 If it is established by any competent authority that the damage is caused due to their industrial activities to any person or his property In that case they are obliged to pay the compensation as determined by the competent authority

6.7 Management of Solid Waste generated from industrial activities shall be as per Solid Waste Management Rules-2016 (solid waste as defined in Rule-3(46).

6.8 As per provision of Rule 18 of Solid Waste Management Rules-2016 all industrial units using fuel and located within 100 km from the refused derived fuel (RDF) plant shall made an arrangement to replace at least five percent of their fuel requirement by refused derived fuel so produced

For and on behalf of
GUJARAT POLLUTION CONTROL BOARD

(D.M.Ratchod)
Regional Officer

GPCB

GUJARAT POLLUTION CONTROL BOARD

REGIONAL OFFICE : AHMEDABAD (RURAL)
1, Daffodils Avenue,
Nr. Zydus Research Center,
Sarkhej-Bavla N.H No-8A, Moraiya-382213
Ta: Sanand, Dist: Ahmedabad.
Website : www.gpcb.gov.in
Email: ID : [redacted]
Ph. No. : [redacted]

NO: GPCB/RO-ABD(RURAL)

DATE:

By: R.P.A.D.

In exercise of the power conferred under section-25 of the Water (Prevention and Control of Pollution) Act-1974, under section-21 of the Air (Prevention and Control of Pollution) Act-1981 and Authorization under rule 6(2) of the Hazardous and other Waste (Management and Transboundary Movement) Rules, 2016, framed under the Environment (Protection) Act-1986.

And whereas Board has received on line consolidated application **Inward No. 159558** dated **19/07/2019** for the Consolidated Consent and Authorization (CC&A) of this Board under the provisions / rules of the aforesaid Acts Consent & Authorization is hereby granted as under.

CONSENT AND AUTHORISATION:
(Under the provisions / rules of the aforesaid environmental acts)

NOTARY
ANWARHUSEN S. TALAT
REGD.No. B669/2011
EXP. DT. 19-09-2026
AHMEDABAD (GUJ. STATE)
GOVERNMENT OF INDIA

To,
M/s. Amar Hydrocarbon Pvt Ltd,
Plote no: 36, S. No. 165/1 to 180, 1+2,
Iyava – 382170,
Tal: Sanand, Dist: Ahmedabad.

1.0 **Consent Order No. : AWH-38235, Date of Issue – 04/09/2019.**

1.1 The consents shall be valid up to **30/06/2024** for the use of outlet for the discharge of trade effluent & emission due to operation of industrial plant for manufacturing of following items/products:

Sr. No	Product	Quantity
1.	Re-Cycled Waste Oil	1500 KL/Month
2.	Re-Refined Used Oil	250 KL/Month
3.	Industrial Fuel Oil	500 KL/Month
4.	Industrial Soft Oil	250 KL/Month
5.	Industrial Specialty Oil	125 KL/Month
6.	Industrial Bottom Oil	125 KL/Month

SUBJECTTO THE FOLLOWING CONDITION:

1. **Unit shall have to obtain the Environmental Clearance from the relevant authority if at any stage project activity is covered under the EIA notification dated 14-09-2006, if applicable.**
2. **Unit shall strictly maintain zero liquid discharge.**
3. **Unit shall comply with guidelines/SOP prescribed by GPCB/CPG for used oil/waste oil.**
4. **Unit shall not extract ground water without getting prior permission from CGWA.**

2.0 CONDITIONS UNDER THE WATER ACT, 1974:

2.1 The total water consumption shall not exceed **5.5 KL/day.**

2.2 The quantity of the industrial effluent to be generated from the manufacturing process and other ancillary industrial operation shall not exceed **3.7 KL/Day.**

2.3 The generated Industrial effluent shall be treated in Effluent Treatment Plant and after treatment treated waste water shall be used **2.7 KL/Day** water in cooling tower and 1 KL/Day evaporated in heat quencher. Thus, unit shall maintain zero liquid discharge.

2.4 The quantity of domestic waste water (sewage) shall not exceed **1.6 KL/day.**

2.5 Domestic effluent shall be disposed off through **Septic tank/Soak pit system.**

3.0 CONDITIONS UNDER THE AIR ACT, 1981:

3.1 The following shall be used as fuel:

Sr. No.	Fuel	Quantity
1	Wood	2 MT/Day
2	LDO/light cut oil	200 lit/day

3.2 The applicant shall install and operate air pollution control system in order to achieve following norms prescribed below:

3.3 The flue gas emission through stack shall conform to the following standards:

Sr. No.	Stack attached to	Stack height in Meter	APCM Details	Parameter	Permissible Limit
1.	Wood fired Furnace	33 Common Stack	Waste Heat Quencher	Particulate matter	150 mg/Nm^3
2.	Thermic Fluid Heater			SO_2	100 ppm
				NO_x	50 ppm

3.4 There shall be no process gas emission from the manufacturing process and other ancillary industrial operations.

3.5 The concentration of the following parameters in the ambient air within the premises of the industry shall not exceed the limits specified hereunder:

Parameters	Permissible Limit Annual	Permissible Limit 24 Hrs Average
Particulate Matter-10 (PM_{10})	60 Microgram/m^3	100 Microgram/m^3
PM 2.5 ($PM_{2.5}$)	40 Microgram/m^3	60 Microgram/m^3
SO_2	50 Microgram/m^3	80 Microgram/m^3
NO_x	40 Microgram/m^3	80 Microgram/m^3

3.6 The applicant shall provide portholes, ladder, platform etc at chimney(s) for monitoring the air emissions and the same shall be open for inspection to/and for use of Board's staff. The chimney(s) vents attached to various sources of emission shall be designed by numbers such as S-1, S-2, etc. and these shall be painted/displayed to facilitate identification.

3.7 The applicant shall operate industrial plant/air pollution control equipment very efficiently and continuously so that the gaseous emission always conforms to the standards specified in condition no. 3.3 and 3.5 above.

3.8 The consent to operate the industrial plant shall lapse if at any time the parameters of gaseous emission are not within the tolerance limits specified in the condition no. 3.3 & 3.5.

3.9 The industry shall take adequate measures for control of noise levels from its own sources within the premises so as to maintain ambient air quality standards in respect of noise to less than 75 dB(A) during day time and 70 dB (A) during night time. Daytime is reckoned in between 6 a.m. and10 p.m. and night-time is reckoned between 10 p.m. and 6 a.m.

3.10 The applicant shall at his own cost get samples of ambient air quality collected & analyzed from an approved laboratory once in for the parameters indicated in condition No. 3.3 & 3.5 and shall submit in duplicate the report there of to the Board by the 10th of the succeeding month.

4.0 GENERAL CONDITIONS:

4.1 Any change in personnel, equipment or working conditions as mentioned in the consents form/order should immediately be intimated to this Board.

4.2 Whenever due to accident or other unforeseen act or ever, such emissions occur or is apprehended to occur in excess of standards laid down such information shall be forthwith reported to Board, concerned Police Station, Office of Directorate of Health Service, Department of Explosives, Inspectorate of Factories and local body. In case of failure of pollution control equipments, the production process connected to it shall be stopped. Remedial actions/measures shall be implemented immediately to bring entire situation normal.

4.3 The Environmental Management unit/cell shall be set up to ensure implementation and monitoring of environmental safeguards and other conditions stipulated by statutory authorities The Environmental Management cell/unit shall directly report to the Chief Executive of the organization and shall work as a focal point for internalizing environmental issues. These cells/units shall also coordinate the exercise of environmental audit of environmental statements.

4.4 The environmental audit shall be carried out yearly, if the unit fall under Schedule-I and Schedule-II of Environment Audit Scheme and the environmental statements pertaining to the activities for the year ending on 31st March shall be submitted to the State Board latest by 30th September every year.

4.5 The Board reserves the right to review and/or revoke the consent and/or make variations in the conditions, which the Board deems, fit in accordance with Section 27 of the Act.

4.6 In case of change of ownership/management the name and address of the new owners/ partners/directors/proprietor should be immediately be intimated to the Board.

5.0. AUTHORISATION FOR THE MANAGEMENT & HANDLING OF HAZARDOUS WASTES Form-2 {See rule 6 (2)}.

5.1 **M/s. Amar Hydrocarbon Pvt Ltd,** is hereby granted an Authorization to operate facility for following hazardous and other wastes on the premises situated at **Plote no: 36, S. No. 165/1 to 180, 1+2, Iyava – 382170, Tal: Sanand, Dist: Ahmedabad.**

Sr. No.	Waste	Category	Quantity	Facility
1.	Waste Oil	5.2	18000 KL/Year	Reception, Collection, Storage and Recycling.
2.	Used Oil	5.1	3600 KL/Year	Reception, Collection, Storage and Recycling.
3.	Distillation residue	20.3	540 KL/Year	Collection, Storage, Transportation, Disposal by incineration at SEPPI Kutch.
4.	Spent clay containing oil	4.5	70 MT/Year	Collection, Storage, Transportation, Disposal by incineration at SEPPI Kutch.
5.	ETP Waste	34.3	240 Kg/Year	Collection, Storage, Transportation, Disposal at TSDF of SEPPI Kutch.
6.	Filters & Filtering materials	35.1	240 Kg/Year	Collection, Storage, Transportation, Disposal at TSDF of SEPPI Kutch.
7.	Discarded barrels	33.3	2400 Nos./Year	Collection, Storage, Transportation, and Sale to registered de-contamination facility.

5.2 The authorization is granted to operate a facility for collection, storage at factory premises and transportation and disposal of hazardous waste as above.

5.3 The **Authorization No. AWH-38235** shall be in force for a period up to **30/06/2024.**

5.4 The authorization is subject to the conditions stated below and such other conditions as may be specified in the rules from time to time under the Environment (Protection) Act-1986.

5.5 The applicant shall have to comply with the provisions of E-Waste (Management) Rules-2016.

be specified in the rules from time to time under the Environment (Protection) Act-1986.

5.5 The applicant shall have to comply with the provisions of E-Waste (Management) Rules-2016

6.0 TERMS AND CONDITIONS OF AUTHORISATION:

6.1 The applicant shall comply with the provisions of the Environment (Protection) Act -1986 and the rules made there under.

6.2 The authorization shall be produced for inspection at the request of an officer authorized by the Gujarat Pollution Control Board.

6.3 The persons authorized shall not rent, lend, sell, and transfer of otherwise transport the hazardous wastes without obtaining prior permission of the Gujarat Pollution Control Board.

6.4 Any unauthorized change in personnel, equipment or working conditions as mentioned in the authorization order by the persons authorized shall constitute a breach of this authorization.

6.5 It is the duty of the authorized person to take prior permission of the Gujarat Pollution Control Board to close down the facility.

6.6 An application for the renewal of an authorization shall be made as laid down in rule 6 (1).

6.7 Industry shall submit annual report within 15 days and sub squinty by 30th June every year.

6.8 Industry shall have to manage waste oil; discarded containers etc as per the Rules 2016 and shall apply Authorization/submit details for all the applicable waste as per the Rules 2016 within 15 days.

7.0 GENERAL CONDITIONS:

7.1 The waste generator shall be totally responsible for (i.e. collection, storage, encapsulation, incineration, treatment, transportation and ultimate disposal) of the wastes generated.

7.2 Records of waste generation, its management and annual return shall be submitted to Gujarat Pollution Control Board in Form – 4 by 30th June of every year.

7.3 In case of any accident, details of the same shall be submitted in Form-11 to Gujarat Pollution Control Board.

7.4 As per "Public Liability Insurance Act - 91 "company shall get insurance Policy, if applicable.

7.5 Empty drums and containers of toxic and hazards material shall be treated as per guideline published for "Management & Handling of discarded containers". Records of the same shall be maintained and forwarded to Gujarat Pollution Control Board regularly.

7.6 In no case any kind of hazardous waste shall be imported without prior approval of appropriate authority.

7.7 In case of transport of hazardous wastes to a facility for (i.e. treatment, storage and disposal) existing in a State other than the State where hazardous wastes are generated, the occupier shall obtain 'No Objection Certificate' from the State Pollution Control Board or Committee of the concerned State or Union territory Administration where the facility exists.

7.8 Unit shall take all concrete measures to show tangible results in waste generation, reduction, avoidance, reuse and recycle. Action taken in this regards shall be submitted within three months and also along with Form-4.

7.9 Industry shall have to display the relevant information with regard to hazardous waste as indicated in the Courts Order in W.P. No.657 of 1995-dated 14th October-2003.

7.10 Industry shall have to display on-line data outside the main factory gate with regard to quantity and nature of hazardous chemicals being handled in the plant, including waste water and air emissions and solid hazardous wastes generated within the factory premises.

For and on behalf of
Gujarat Pollution Control Board

C.A. Shah
Regional Officer

NO: GPCB/RO-A'bad (Rural)/GEN-1201/ID-11702/ 15730 Date: 16/01/2020

Issued To:

M/s. Amar Hydrocarbon Pvt Ltd,
Plote no: 36, S. No. 165/1 to 180, 1+2,
Iyava – 382170, Tal: Sanand, Dist: Ahmedabad.

TRUE COPY
A. S. TALAT
NOTARY
GOVT. OF INDIA

Copy to: (1) The Member Secretary, GPCB, Gandhinagar..... For information please.

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Gujarat Pollution Control Board

REGIONAL OFFICE : MEHSANA

GPCB

Plot No.: H/3-A, GIDC Estate, Phase-1, Nr. FCI Godown, Modhera Road, Mehsana-384 002
Phone No.: (02762) 258294, Fax No.: (02762-258106) Web: gpcb.gov.in

In exercise of power conferred under Section –25 of the Water (Prevention & Control of Pollution) Act – 1974, under Section – 21 of the Air (Prevention & Control of Pollution) Act – 1981 and Authorization under rule 3 (c) & 5 (5) of the Hazardous Waste (Management & Handling & Trance boundary movement) Rules 2008 framed under the Environmental (Protection) Act – 1986. And Whereas Board has received Consolidated Consent Application letter No. **159886** dated **26/06/2019** for the **Consolidated Consent and Authorization** (C C & A) of this Board under the provision / rules of the aforesaid Acts. Consent & Authorization are hereby granted as under:

CONSENT AND AUTHORIZATION:
(Under the provision/ rules of the aforesaid Environmental Acts.)

TO,
M/s. ATLAS ORGANICS P. LTD
Plot No. 14602,
Village:Rajpur-382740,
Ta: Kadi , Dist: Mehsana.

1. Consent Order No: **AWH-37547**, Date of issue: **29/07/2019.**
2. The consent shall be valid up to **31/03/2024** for use outlet for the discharge of trade effluent & emission due to operation of industrial plant for manufacture of the following items / products.

SR. No	Product	Quantity
1	Re-cycled Waste Oil	700 KL/Month
2	Re-refined used Oil	250 KL/Month

SPECIFIC CONDITION:

- **Unit shall obtain necessary CGWA permission in case of ground water withdrawal.**

3 CONDITION UNDER THE WATER ACT

3.1 The quantity of the industrial effluent to be generated from the manufacturing process and other ancillary industrial operations shall be **10.50 KLPD** as generated industrial effluent shall be treated in proposed ETP. Treated waste water shall be reuse back in process.

3.2 The quantity of domestic sewage effluent from the factory shall not exceed **0.2 KLPD.**

3.3 The effluent treatment plant consisting of the following units shall be provided.

Sr.No.	Name of Uint
1.	Collection Tank
2.	Oil & Grease ramoval Tank
3.	Neutralization Tank
4.	Settling Tank
5.	Holding Tank
6.	Sludge Drying Beds

3.4 Domestic effluent shall be disposed of through **Septic tank/soak pit** system.

4 CONDITIONS UNDER AIR ACT 1981:

4.1 The following shall be use as fuel in boiler/furnace/heater respectively.

Sr. No	Fuel	Quantity
1	LDO(for furnace)	500 Lit/ Day
2	LDO	750 Lit/Day
3	Coal	02 MT/Day

4.2 The applicant shall install & operate air pollution control system in order to achieve norms prescribed below.

4.3 The flue gas emission through stacks attached to boiler/furnace/heater shall conform to the following standards:-

Stack No.	Stack Attached to	Stack Height in Meter	APCM	Parameter	Permissible Limit
1	Thermic Fluid Heater & Non IBR Boiler	21	--	PM SO_2 NO_x	150 mg/NM^3 100 ppm 50 ppm
2	Furnace	15	Bag Filter		

NOTARY SHWETA N. RAMNANI Regd. No. 21071420 GUJARAT, INDIA Expiry Date 05/03/2025 GOVT. OF INDIA

26 JUL 2022
TRUE COPY
(SHWETA N. RAMNANI)
ADVOCATE & NOTARY
Gandhidham - Kachchh

TRUE COPY

Gujarat Pollution Control Board

REGIONAL OFFICE : MEHSANA

GPCB

Plot No.: H/3-A, GIDC Estate, Phase-1, Nr. FCI Godown, Modhera Road, Mehsana-384 002
Phone No.: (02762) 258294, Fax No.: (02762-258106) Web: gpcb.gov.in

4.4 There shall be no process emission from the manufacturing process and other ancillary operations.

4.5 Ambient air quality within the premises of the industry shall conform to the following standards: -

PARAMETERS	PERMISSIBLE LIMIT	
	Annual	24 Hrs Average
Particulate Matter- 2.5 ($PM_{2.5}$)	40 Microgram/M^3	60 Microgram/M^3
Particulate Matter-10 (PM_{10})	60 Microgram/M^3	100 Microgram/M^3

4.6 The applicant shall install & operate Air pollution control equipment very efficiently & continuously so that the gaseous emission always conforms to the standards specified in condition no.3.3 above,

4.7 The consent to operate the industrial plant shall lapse if at any time the parameters of the emission are not within the tolerance limits specified in the condition no.3.3 & 3.5 above.

4.8 The applicant shall provide portholes, ladder, platform etc at Chimney(s) for monitoring the air emission and the same shall be open for inspection to/and for use of board's staff. The chimney(s) vents attached to various sources of emission shall be designed by numbers such as S-1,S-2, etc. And these shall be painted/displayed to facilitate identification.

4.9 The industry shall take adequate measures for control of noise levels from its own sources within the premises so as to maintain ambient air quality standards in respect of noise to less than 75dB(A) during day time and 70 dB(A) during night time. Day time is reckoned in between 6 a.m. and 10 p.m. and night time is reckoned between 10 p.m. and 6 a.m.

5. **AUTHORISATION FOR THE MANAGEMENT & HANDLING OF HAZARDOUS WASTES FORM-2 (See rule 5 (4))**

5.1 Form for grant of authorisation for occupier or operator handling hazardous waste.

5.2 **M/s. ATLAS ORGANICS P. LTD** is hereby granted an authorisation to operate facility for following hazardous wastes on the premises situated at **Plot No. 1460/2, Village:Rajpur-382740, Ta: Kadi , Dist: Mehsana.**

Sr. No.	Type of Waste	Quantity	Category Schedule-1	Facility
1	Waste Oil	10080 KL/Year	5.2	Collection, transportation, Storage & Re - cycling
2	Used Oil/Spent Oil	3600 KL/Year	5.1	Collection, transportation, Storage & Re - cycling
3	Empty Barrels/Containers barrels.	500 Nos./year	33.1	Collection, Storage , transportation,& sale to register recycler
4	ETP Sludge	1 MT/Year	34.3	Collection, decontamination s Storage ,& disposal at TSDF
5	Spent clay containing oil	200 MT//Year	4.5	Collection, decontamination s Storage ,& send to co-processor
6	Oily sludge/ Bottom residue	180 KL/Year	4.4	Collection, decontamination s Storage ,& send to co-processor

5.3 The authorisation is granted to operate a facility for Collection, Storage, encapsulation, incineration treatment within the factory premises transportation and ultimate disposal of hazardous waste at NEPL.

5.4 The authorisation is subject to the conditions stated below and such other conditions as may be specified in the rules from time to time under the Environment (Protection) Act-1986.

5.5 The authorisation shall be in force for a period up to **31/03/2024.**

6 **TERMS AND CONDITIONS OF AUTHORISATION**

a) The applicant shall comply with the provisions of the Environment (Protection) Act – 1986 and the rules made there under.

b) The authorisation shall be produced for inspection at the request of an officer authorized by the Gujarat Pollution Control Board.

c) The persons authorized shall not rent, lend, sell, transfer of otherwise transport the hazardous wastes without obtaining prior permission of the Gujarat Pollution Control Board.

d) Any unauthorized change in personnel, equipment or working conditions as mentioned in the authorisation ordered by the persons authorized shall constitute a breach of this authorisation.

e) It is the duty of the authorised person to take prior permission of the Gujarat Pollution Control Board to close down the facility.

NOTARY
GUJARAT
N. RAMNANI
Area-Gadhidham Kutch
Regn. No. 21071/20
GUJARAT-INDIA
Expiry Date
06/03/2025
GOVT. OF INDIA

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Gujarat Pollution Control Board

REGIONAL OFFICE : MEHSANA

GPCB

Plot No.: H/3-A, GIDC Estate, Phase-1, Nr. FCI Godown, Modhera Road, Mehsana-384 002
Phone No.: (02762) 258294, Fax No.: (02762-258106) Web: gpcb.gov.in

f) An application for the renewal of an authorisation shall be made as laid down in rule 5(6)(ii).

g) Industry shall have to manager waste oil, discarded containers etc as per Amended Rules – 2003 and Shall apply authorization/submit details for all applicable waste as per Amended Rules -2003 with 15 days.

h) Industry shall submit annual report within 15 days and subsequently by 31st January every year

GENERAL CONDITION:

1 Adequate plantation shall be carried out all along the periphery of the industrial premises in such a way that the density of plantation is at least 1000 trees per acre of land and a green belt of 05 meters width is developed.

2 The applicant shall have to submit the returns in prescribed form regarding water consumption and shall have to make payment of water cess to the board under the Water Cess Act- 1977.

3 In case of change of ownership management the name and address of the new owners/partners /directors/proprietor should immediately be intimated to the Board.

4 The applicant shall however, not without the prior consent of the Board bring into use any new or altered outlet for the discharge of effluent or gaseous emission or sewage waste from the proposed industrial plant. The applicant is required to make applications to this Board for this purpose in the prescribed forms under the pruvisions of the Water Act-1974, the Air Act-1981 and the Environment (Protection) Act-1986.

5 Any change in personnel, equipment or working conditions as mentioned in the consents form/ order should immediately be intimated to this Board. The Board reserves the right to review and/or revoke the consent and/or make variations in the conditions, which the Board deems, fit in accordance with Section 27 of the Act.

6 If it is established by any competent authority that the damage is caused due to their industrial activities to any person or his property. In that case they are obliged to pay the compensation as determined by the competent authority.

7 Management of Solid Waste generated from industrial activities shall be as per Solid Waste Management Rules-2016 (solid waste as defined in Rule-3(46).

8 As per provision of Rule-18 of Solid Waste Management Rules-2016 all industrial units using fuel and located within 100 km from the refused derived fuel (RDF) plant shall made an arrangement to replace at least five percent of their fuel requirement by refused derived fuel so produced.

NO:GPCB/CCA-MH- 155(3)/ID: 18145/ 1767/15925 Date: 05 AUG 2019

Issued to:
M/s. ATLAS ORGANICS P. LTD
Plot No. 1460/2,
Village:Rajpur-382740,
Ta: Kadi , Dist: Mehsana.

For and on behalf of
GUJARAT POLLUTION CONTROL BOARD

(J.D.Priyadarshi)
Regional Officer

22 JUL 2022
TRUE COPY
(SHWETA N. RAMNANI)
ADVOCATE & NOTARY
Gandhidham - Kachchh

Regional Office – Kutch (East)
Gujarat Pollution Control Board
Room No. 215-216-217, 2nd Floor,
Kandla Port Trust Administrative Building,
Gandhidham – 370201, Kutch.
Email:- ro-gpcb-kute@gujarat.gov.in

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In exercise of the power conferred under section-25 of the Waster (Prevention and Control of Pollution) Act-1974, under section-21 of the Air (Prevention and Control of Pollution) Act-1981 and Authorization under rule 6(2) of the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 framed under the E (P) Act-1986.

And whereas Board has received consolidated application no: 176383, dated 28/06/2020 for the fresh consolidated consent and authorization (CC & A) of this Board under the provision / rules of the aforesaid acts-rules. Consent & Authorization is hereby granted as under.

CONSOLIDATED CONSENT AND AUTHORISATION:
(Under the provision / rules of the aforesaid environmental acts)

NOTARY SAPNA D. DADLANI Area Gandhidham-Kutch Regd. No. 7910/2010 GUJARAT-INDIA Expiry Date 12-05-2025 GOVT. OF INDIA

To,
Aviation Corporation (PCB ID –63724),
PLOT NO: S. No. 67/2/P1,
Shikarpur- 370150
TAL: Bhachau, DIST: Kutch.

1. Consent Order No: AWH -43501; Date of Issue: 21/10/2020.

2. The consent shall be valid up to 27/06/2025 for the use of outlet for the discharge of trade effluent and emission due to operation of industrial plant for manufacture of following items/products at an above-mentioned address.

Sr No	Product	Quantity
1	Used Oil/ Waste Oil Reprocessing	300 MT/Month (Used Oil- 150 MT/Month & Waste Oil- 150 MT/Month)
2	Sodium Silicate	1500 MT/Month

Specific Condition

1. No ground water shall be withdrawn without prior approval from competent authority.
2. You shall not carry out any activity which may attract the applicability of EIA notification-2006 and its amendments.
3. Management of Solid Waste generated from industrial activities shall be as per Solid Waste Management Rules-2016 (solid waste as defined in Rule-3(46).
4. As per provision of Rule-18 of Solid Waste Management Rules-2016 all industrial units using fuel and located within 100 km from the refused derived fuel (ROF) plant shall made an arrangement to replace at least five percent of their fuel requirement by refused derived fuel so produced.
5. Industry shall manage Solid Waste generated from industrial activities as per Solid Waste Management Rules- 2016 (Solid Waste as defined in Rule- 3(46)).
6. Industry shall comply with Plastic Waste Management Rules- 2018 & amended therefore. (if applicable)
7. You shall have to comply with Coal Handling guideline.

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Gujarat Pollution Control Board
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8. You shall have to comply with Fly Ash Notification- 1999 and its amendments.

3	**Condition under the Water Act**
3.1	Source of Water: Tankers
3.2	The quantity of industrial water consumption shall not exceed 07 KL/Day.
3.3	The quantity of Domestic water consumption shall not exceed 02 KL/Day.
3.4	The quantity of industrial waste water generated from manufacturing process & other ancillary operation shall not exceed 2.2 KL/Day.
3.5	The quantity the Domestic waste water (sewage) shall not exceed 1.2 KL/Day.
3.6	Industrial effluent from process plant, washing etc. shall be collected separately & treated into ETP adequately so that treated industrial effluent shall comply with following norms:

PARAMETER	PERMISSIBLE LIMIT
pH	6.5 to 8.5
Temperature	40°C
Color	100 Units
Suspended Solids	100 mg/l
Oil & Grease	10 mg/l
Phenolic Compound	01 mg/l
Amonical Nitrogen	50 mg/l
BOD (03 days At 27° C)	30 mg/l
COD	100 mg/l
Chloride	600 mg/l
Sulphates	1000 mg/l
Total Dissolved Solids	2100 mg/l
Sulphides	02 mg/l
Percent Sodium	60%
Sodium Adsorption Ratio	26

	Treated effluent confirming to the above standards shall be reuse in within plant only.
3.7	Industry shall provide fixed pipeline with flow meter for reuse of treated effluent to achieve Zero Liquid Discharge.
3.5	Sewage shall be disposed of through septic tank / soak pit system.
4	**Conditions under the Air Act**
4.1	The following shall be used as fuel.

Sr No	Fuel	Quantity
1	HSD	20 Lit/Hr.
2	LDO	290 Lit/Day
3	Fire Wood	08 MT/Day
4	Coal	05 MT/Day

4.2 The flue gas emission through stack shall confirm to the following standards.

Stack No	Stack attached to	Stack height in meter	APCM	Parameter	Permissible Limit
1	Boiler (01 TPD)	12	Water Scrubber	PM	150 mg/Nm3

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	2	Vessel (12 TPD)	11	with Cyclone Separator	SO2 NOx	100 PPM 50 PPM
	3	Furnace	30	Alkali Scrubber		
	4	DG Set (80 kVA) Stand by	11	--		

4.3 There shall be no process gas emission from manufacturing activities and other ancillary operations.

4.4 The concentration of the following 11parameters in the ambient air within the premises of the industry shall not exceed the limits specified hereunder as per National Ambient Air Quality Standards issued by MoEF & CC dated 16th November-2009.

Sr. No.	Pollutant	Time Weighted Average	Concentration in Ambient air in microgram/cum
1	Sulphur Dioxide (SO2)	Annual 24 Hours	50 80
2	Nitrogen Dioxide (N02)	Annual 24 Hours	40 80
3	Particulate Matter (PM10)	Annual 24 Hours	60 100
4	Particulate Matter (PM2.5)	Annual 24 Hours	40 60

4.5 The applicant shall provide portholes, ladder, platform etc at chimney(s) for monitoring the air emissions and the same shall be open for inspection to/and for use of Board's staff. The chimney(s) vents attached to various sources of emission shall be designed by numbers such as S-1, S-2, etc. and these shall be painted/ displayed to facilitate identification.

4.6 The industry shall make adequate measures for control of noise levels from its own sources within the premises so as to maintain ambient air quality standards in respect of noise to less than 75dB(a) during day time and70 dB(A)during night time. Daytime is reckoned in between 6 AM to 10 PM and nighttime is reckoned between 10 PM to 6 AM.

4.7 **DG Sets Conditions:**

The D.G. Set shall have acoustic enclosure and shall comply with the standards specified at Sr. no. 95 of Schedule-I of the rule-3 of E.P. Rules -1986 and Noise pollution level.as per the Air Act,1981.

D.G. Sets standards:

The flue gas emission through stack attached to D.G. Sets shall conform to the following standards.

a) The minimum height of stack to be provided with each of the generator set shall be H=h +0.2(KVA) 112, where H=Total stack height in meter, h=height of the building in meters where or by the side of which the generator set is installed.

b) Noise from DG set shall be controlled by providing an acoustic enclosure or by treating the room acoustically, at the user's end

c) The acoustic enclosure or acoustic treatment of the room shall be designed for minimum 25 dB (A) insertion loss or for meeting the ambient noise standards, whichever is on the higher side (if the actual ambient noise is on the higher side, it may not be possible to check the performance of the acoustic enclosure/ acoustic treatment. Such circumstances the performance may be checked for noise reduction up to actual ambient noise level,

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	preferably, in the night time). The measurement for insertion loss may be done at different points at 0.5 m from the acoustic enclosure/room, and the averaged. d) The D.G. Set shall be provided with proper exhaust muffler with insertion loss of minimum 25 dB (A). e) All efforts shall be made to bring down the noise level due to the D.G. Set, outside the premises, within the ambient noise requirements by proper siting and control measures. f) Installation of a D.G. Sets must be strictly in compliance with the recommendations of the D.G. Set manufacturer. g) A proper routine and preventive maintenance procedure for the D.G. Set should be set and followed in consultation with the DG Set manufacture which would help prevent noise levels of the DG Set from deteriorating with use.
5	**Authorization under the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 & amended.**
5.1	**Authorization Number: AWH -43501 Date of Issue: 21/10/2020 and shall valid up to 27/06/2025.**
5.2	**M/s. Aviation Corporation (PCB ID -63724),** is hereby granted an authorization to operate facility for following hazardous wastes on the premises situated PLOT NO. S. No. 67/2/P1, Shikarpur- 370150, TAL: Bhachau, DIST: Kutch.

Sr. No	Waste	Quantity	Schedule-I	Facility
1	Used or spent Oil	1800 MT/yr.	5.1	Receipt, Collection, Storage, Transportation & reused in process.
2	Oily waste	1800 MT/yr.	5.2	Receipt, Collection, Storage, Transportation & reused in process.
2	Sludge from Wet Scrubber	05.0 MT/yr.	37.1	Collection, Storage, Transportation & Disposed to TSDF site.
3	Sludge and filter contaminated with Oil	20.0 MT/yr.	3.3	Collection, Storage, Transportation & Disposed to TSDF site.
4	Empty barrels/ containers/ liners contaminated with hazardous chemicals / wastes	04.00 M/yr.	33.1	Collection, Storage, Transportation & disposed by selling it to registered recycler.

5.3	The authorization is granted to operate a facility for collection, storage within factory premises, transportation and ultimate disposal of Hazardous waste by selling it to registered recyclers.
5.4	Unit shall apply for authorization for other types of hazardous waste referring to the amended Rules.
5.5	The authorization is subject to the conditions stated below and such other conditions as may be specified in the rules from time to time under the Environment (Protection) Act-1986.
5.6	**Terms and conditions of authorization:-**
1.	The authorized person shall comply with the provisions of the Environment (Protection) Act, 1986, and the rules made there under.

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Gujarat Pollution Control Board
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2.	The authorization or its renewal shall be produced for inspection at the request of an officer authorized by the State Pollution Control Board.
3.	The person authorized shall not rent, lend, sell, transfer or otherwise transport the hazardous and other wastes except what is permitted through this authorization.
4.	Any unauthorized change in personnel, equipment or working conditions as mentioned in the application by the person authorized shall constitute a breach of his authorization.
5.	The person authorized shall implement Emergency Response Procedure (ERP) for which this authorization is being granted considering all site specific possible scenarios such as spillages, leakages, fire etc. and their possible impacts and also carry out mock drill in this regard at regular interval of time.
6.	The person authorized shall comply with the provisions outlined in the Central Pollution Control Board guidelines on "Implementing Liabilities for Environmental Damages due to Handling and Disposal of Hazardous Waste and Penalty".
7.	It is the duty of the authorized person to take prior permission of the State Pollution Control Board to close down the facility.
8.	The imported hazardous and other wastes shall be fully insured for transit as well as for any accidental occurrence and its clean-up operation.
9.	The record of consumption and fate of the imported hazardous and other wastes shall be maintained.
10.	The hazardous and other waste which gets generated during recycling or reuse or recovery or pre-processing or utilization of imported hazardous or other wastes shall be treated and disposed of as per specific conditions of authorization.
11.	The importer or exporter shall bear the cost of import or export and mitigation of damages if any.
12.	An application for the renewal of an authorization shall be made as laid down under these Rules.
13.	Any other conditions for compliance as per the Guidelines issued by the Ministry of Environment, Forest and Climate Change or Central Pollution Control Board from time to time.
14.	Annual return shall be filed by June 30th for the period ensuring 31st March of the year.
5.7	**General Conditions**
1	Any change in personnel, equipment or working conditions as mentioned in the consents form/order should immediately be intimated to this Board.
2	Applicant shall also comply with the general conditions given in annexure I.
3	The waste generator shall be totally responsible for (I.E. Collection, storage, transportation and ultimate disposal) of the wastes generated.
4	Records of waste generation, its management and annual return shall be submitted to Gujarat Pollution Control Board in Form - 4 by 31s1 January of every year.
5	In case of any accident, details of the same shall be submitted in Form - 5 to Gujarat Pollution Control Board.
6	As per "Public liability Insurance Act - 91" company shall get Insurance policy, if applicable
7	Empty drums and containers of toxic and hazards material shall be treated as per guideline published for management & handling of discarded containers". Records of the same shall be maintained and forwarded to Gujarat Pollution Control Board regularly.
8	In no case any kind of hazardous waste shall be imported without prior approval of appropriate authority.
9	In case of transport of hazardous waste to a facility for (I.E. Treatment, Storage and disposal) existing in a state other than the state where hazardous waste are generated, the occupier shall obtain "No Objection certificate" from the state pollution Control Board, the Committee of the

Regional Office – Kutch (East)
Gujarat Pollution Control Board
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	concerned state or Union territory Administration where the facility exists.
10	Unit shall take a)) concrete measures to show tangible results in waste generation reduction, voidance, reuse and recycle. Action taken in this regards shall be submitted within 03 months and also along with Form 4.
11	Industry shall have to display the relevant information with regard to hazardous waste as indicated in the Hon Supreme Court's order in W.P. NO.65 of 1995 dated 14th October 2003.
12	Industry shall have to display online data outside the main factory gate with regard to quantity and nature of hazardous chemicals being handled in the plant, including wastewater and air emissions and solid hazardous waste generated within the factory premises.

For and behalf of
Gujarat Pollution Control Board

Regional Officer, Kutch(East)

1 JUN 2022

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(SAPNA D. DADLANI)
ADVOCATE & NOTARY
Gandhidham-Kutch

NOTARY SAPNA D. DADLANI GOVT. OF INDIA

REGIONAL OFFICE
GUJARAT POLLUTION CONTROL BOARD
PLOT NO: 1616-1617, 1st FLOOR, SWASTIC COMPLEX,
NEAR VEER MOKHADAJI CIRCLE, GHOGHA ROAD
BHAVNAGAR- 364001 PHONE: 2566108

No. GPCB/RO-BHV/BHV-1001/ID-15970/ 17384 **Dt:** 15 OCT 2022

To,
M/s. Fine Rifiners Pvt. Ltd. (ID: 15970)
Plot No: 40,
Village-Vartej, GIDC, Vartej
Vartej-364001
Tal: Bhavnagar, Dist: Bhavnagar.

Sub: Extension of validity of Consolidated Consent & Authorization under the Water Act-1974, the Air Act-1981 & the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016.

Ref: 1. Issued Consent order no. **AWH-52604**, Dated: **05/03/2022.**
2. Consent issued vide letter No. **GPCB/RO-BHV/BHV-1001/ID- 15970/ 17255,** Dated: 31/03/2022.

Sir,

In exercise of power conferred under section-27 of the Water (Prevention and Control of Pollution) Act-1974, under Section-21 of the Air (Prevention and Control of Pollution)-1981 & and authorization under Rule 3(3) & 6(2) of The Hazardous and other Wastes (Management and Transboundary Movement) Rules, 2016 and as amended from time to time, framed under The Environmental (Protection) Act-1986, Consent is granted with respect of following condition as under.

- The Validity period of the above referred CCA order is extended up to **30/09/2026,** with following specific condition:
  - Unit shall obtain CTE & CCA Amendment for additional plot.

- All other condition of CCA issued vide letter No. **GPCB/RO-BHV/BHV-1001/ID-15970/17255,** Dated: 31/03/2022. **shall remain unchanged.**

FOR AND BEHALF OF
GUJARAT POLLUTION CONTROL BOARD

(A.J. Rathod)
Regional Officer

FOR, FINE REFINERS PVT. LTD.
DIRECTOR

Dt. 05/05/2023

GUJARAT POLLUTION CONTROL BOARD
REGIONAL OFFICE
Swastik Complex, First Floor, Plot No. 1616/1617,
Near Vir Mokhdaji Circle, Ghogha Road, Bhavnagar - 364 001.
Phone (0278) 2566108 E-mail : ro-gpcb-bhav@gujarat.gov.in XGN site : www.gpcb.gujarat.gov.in

In exercise of the power conferred under section-25 of The Water (Prevention and Control of Pollution) Act-1974, Section-21 of The Air (Prevention and Control of Pollution) Act-1981, and authorization under Rule 3(3) & 6(2) of The Hazardous and Other Solid Wastes (Management & Transboundary Movement) Rules, 2016 and as amended from time to time, framed under The Environmental (Protection) Act-1986.

And whereas Board has received application vide **Inward ID No: 200555 & Inward Dt: 02/09/2021**, for The Consolidated Consent and Authorization (CC&A) of this Board under the provisions/rules of the aforesaid act. Consents & Authorization are hereby grant as under:

CONSENTS & AUTHORISATION
(Under the provisions/rules of aforesaid environmental acts)

TO,

M/s Fine Refiners Pvt. Ltd. (ID: 15970)
Plot No. 40,
GIDC-Vartej,
TAL: Bhavnagar, DIST: Bhavnagar

1 Consolidated Consent and Authorization Order **No: AWH-52604, Date of Issue 05/03/2022.**
2 The validity period of the order shall be up to **30/09/2022**
3 The list of the proposed product to manufacture is as below:

Sr. No	PRODUCT	QUANTITY
1.	Re refined of Used oil	200KL/Month
2.	Re refined of Waste oil	1000KL/Month

Special Condition:

- Unit shall submit the revised presentation including the material mass balance including quantity of raw material including activated clay requirement, product and waste generated, separate corrected flow diagram for used oil and waste oil.
- Unit shall improve the housekeeping and shall carry out plant retrofitting along with painting wherever required and shall submit the photograph.
- Unit shall submit the MOU as per hazardous waste generation of distillation residue and membership certificate for other waste disposal as per material balance quantity.
- Unit shall submit hazardous waste annual returns regularly.
- Unit shall adopt and regularly use the online manifest system for procurement & disposal of hazardous waste.

4 **CONDITIONS UNDER THE WATER ACT:**

4.1 The quantity of trade effluent from the manufacturing process and other ancillary operations shall not exceed **0.3 KL/Day.**

4.2 The applicant shall provide adequate effluent treatment system in order to achieve the quality of the treated effluent as per GPCB norms mentioned below:

Parameter	Permissible Limit
pH	6.5-8.5
Temperature	40 °C

FOR, FINE REFINERS PVT. LTD.
DIRECTOR
Dt. 05/05/2023

Color (Pt. Co Scale)	100 units
Suspended Solids	100 mg/l
Oil & Grease	10 mg/L
Ammonical Nitrogen	50 mg/L
BOD (5 days at 20 deg C)	30 mg/L
COD	100 mg/L
Chlorides	600 mg/L
Sulphates	1000 mg/L
TDS	2100 mg/L
% Na	60%.
Sodium Absorption Ratio	26

(All efforts shall be made to remove color and Unpleasant odor as far as practicable)

4.3 The Final treated effluent confirming to above shall be utilized on land within the factory premises and on land of farmer with whom agreement is made, for gardening & plantation purpose.

4.4 The quantity of sewage effluent from the factory shall not exceed **0.8 KL/Day**.

4.5 Domestic effluent shall be disposed off through septic tank/soak pit system.

5 CONDITIONS UNDER THE AIR ACT:

5.1 The following shall be used as fuel in the Boiler (Hot Water Generation):

Sr No.	Fuel	Quantity
1	Wood	50 Kg/Hr
2	LDO	15 Lit/Hr

5.2 The flue gas emission through stack shall conform to the following standards:

Sr.	Stack attached to	Stack height in meters	APCM	Parameters	Permissible Limit
1	Dehydration Furnace	Common Stack 33	Water Scrubber	Particulate Matter SO_2 NOx	150 mg/NM^3 100 ppm 50 ppm
2	Distillation Furnace				
3	Bleaching Furnace				
4	Incinerator				

5.3 There shall be no any process emission from the manufacturing process and other ancillary industrial operations.

5.4 The concentration of the following parameters in the ambient air within the premises of the industry and a distance of 10 meters from the source other than the stack/vent shall not exceed the following levels:

Sr. No.	Pollution Parameters	Time weighted Average	Concentration Ambient Air
1.	Sulphur dioxide (SO2), µg/M^3	Annual 24 Hours	50 80
2.	Nitrogen dioxide (NO2), µg/M^3	Annual 24 Hours	40 80
3.	Particulate Matter (Size less than 10µm)OR PM 10 µg/M^3	Annual 24 Hours	60 100
4.	Particulate Matter (Size less than 2.5m) OR PM2.5 µg/M^3	Annual 24 Hours	40 60

FOR, FINE REFINERS PVT. LTD.

DIRECTOR

Dt. 05/05/2023

5.5 Stack monitoring facilities like port hole, platform/ladder etc shall be provided with stack/vents chimney in order to facilitate sampling of gases being emitted in to the atmosphere.

5.6 The applicant shall provide proper ventilation and exhaust facilities to maintain healthy working atmosphere within the factory premises.

6 CONDITIONS UNDER HAZARDOUS WASTE:

6.1 Number of Authorization: **AWH- -52604**, Date of issue: **05/03/2022**

6.2 **M/s Fine Refiners Pvt. Ltd.** is hereby granted an authorization to operate facility for following hazardous wastes on the premises situated at **Plot No. 40,GIDC-Vartej, TAL: Bhavnagar, DIST: Bhavnagar.**

Sr. No.	Waste	Quantity	Category	Facility
1	Wastes or residues containing oil	9000 (MT/Year)	1-5.2	Collection, Storage, Recycle, Transport
2	Chemical sludge from waste water treatment	0.600 (MT/Year)	1-35.3	Collection, Storage, Reuse as lubricant within plant
3	Used or Spent Oil	1800 (MT/Year)	1-5.1	Collection, Storage, Recycle, Transport
4	Ash from incineration and flue gas cleaning residue	294.00 (MT/Year)	1-37.2	Collection, Storage, Reuse as lubricant within plant
5	Spend Clay Containing Oil	300.0 (MT/Year)	1-4.5	Collection, Storage, Transportation Disposal at TSDF site
6	Empty barrels/ containers/liners contaminated with hazardous chemicals/wastes	12.00 (MT/Year)	1-33.1	Collection, Storage, Reuse
7	Organic Residues From Process	130.600 (MT/Year)	1-4.4	Collection, Storage, Disposal at Incinerator.
8	Contaminated cotton rags or other cleaning materials	0.600 (MT/Year)	1-33.2	Collection, Storage, Disposal at Incinerator.

6.3 The authorization shall be valid up to **30/09/2022.**

6.4 The applicant shall obtain membership of common Hazardous Waste incinerator for disposal of incinerable waste, whenever applicable.

6.5 The applicant shall provide temporary storage facilities for each type of Hazardous Waste as per Hazardous and other solid waste (Management & Transboundary Movement) Rules-2016 as amended from time to time.

7 GENERAL CONDITION:

7.1 Unit shall develop green belt within premise as per the CPCB guidelines. However, if the adequate land is not available within premises, the unit shall tie up with local agencies like gram panchayat, school, and social forestry office etc. for the plantation at suitable open land in nearby locality and submit an action plan of plantation for next three years to GPCB.

7.2 Adequate plantation shall be carried out all along the periphery of premises in such a way that the density of plantation is at least 1000 tree per acre of land and a green belt of 10 meters width is developed.

7.3 The applicant shall have to submit the returns in prescribe form regarding water consumption and shall have to make payment of water cess to the Board under The Water Act-1977.

7.4 In case of change of ownership/management, the name and address of the new Owners/partners/directors/proprietor shall immediately intimate to the Board.

FOR, FINE REFINERS PVT. LTD.

DIRECTOR

Dt. 05/05/2023

7.5 The applicant shall however, not without the prior consent of the Board bring into use any new or altered outlet for the discharge of effluent or gaseous emission or swage waste from the proposed industrial plant. The applicant is required to make application to this Board for this purpose in the prescribed forms under the provisions of the Water Act-1974, the Air Act-1981 and the Environment (Protection) Act-1986.

7.6 The overall noise level in and around the plant area shall be kept well within the standard by providing noise control measure including engineering control like acoustic insulation hood, silencers, enclosures etc on all source of noise generation. The ambient noise level shall conform to the standards prescribed under the Environment (Protection) Act-1986& Rules.

7.7 The concentration of noise in ambient air within the premises of industrial unit shall not exceed following levels:

Between 6A.M. and 10P.M.: 75dB (A)
Between 10P.M. and 6A.M.: 70dB (A)

7.8 Applicant is required to comply with the manufacturing, Storage and Import of Hazardous Chemicals Rules-1989 Framed under the Environment (Protection) Act-1986.

7.9 If it is, establish by any competent authority that the damage is caused due to their industrial activities to any Person or his property; in that case they are obliged to pay the compensation as determined by the competent authority.

7.10 Applicant shall have to comply with the guidelines/directive issued/being issued by MoEF & CC/CPCB/DoEF from Time to time.

7.11 Applicant shall not use/withdraw ground water either during construction and/or operation phase.

7.12 Environmental cell shall be step and shall be responsible for the total Environmental management.

7.13 Monitoring in respect to Air, Water, and Noise level shall carry out regularly and results shall submit to this Board.

FOR AND BEHALF OF
GUJARAT POLLUTION CONTROL BOARD

31-3-2022

(A.G. Oza)
Regional Officer, Bhavnagar

No. GPCB/RO/BHV-1001/ID-15970/17255

Dt: 31 MAR 2022

M/s Fine Refiners Pvt. Ltd. (ID: 15970)
Plot No. 40,
GIDC-Vartej,
TAL: Bhavnagar, DIST: Bhavnagar

submit to this Board.

FOR, FINE REFINERS PVT. LTD.
DIRECTOR

Dt 05/05/2023

GPCB

GUJARAT POLLUTION CONTROL BOARD

PARYAVARAN BHAVAN
Sector-10-A, Gandhinagar-382 010
Phone : (079) 23226295
Fax : (079) 23232156
Website : www.gpcb.gov.in

BY R.P.A.D

"Consent to Establish"
(CTE-110273)

NO: GPCB/CCA-KUTCH-1742/ ID-78079 /57 HH 22 Date: 05-12-2020

To,
M/s. Mahalaxmi Asphalt Pvt. Ltd.,
Survey no.: 343,
Village: Bandhadi ,
Tal: Bhachau
Dist: Kutch – 370 140,

Sub Consent to Establish (NOC)-Amendment under Section 25 of Water Act 1974 and Section 21 of Air Act 1981

Ref: Your application for CTE no. **179791** received dated **22/09/2020.**

Without prejudice to the powers of this Board under the Water (Prevention and Control of Pollution) Act-1974, the Air Act-1981 and the Environment (Protection) Act-1986 and without reducing your responsibilities under the said Acts in any way, this is to inform you that this Board grants Consent to Establish to set up an industrial plant located at Survey 343, Village. Bandhadi Tal Bhachau, Dist: Kutch

1. The validity of this order will be up to 21/09/2027.
2. The list of the products to be manufacture is as below:

Sr. No.	Product	Quantity
1.	Re-refined waste oil	500 KL/Month
2	Bitumen Melting	200 MT/Month

SUBJECT TO THE FOLLOWING CONDITIONS:

1. Industry shall not carry out any activity which attracts provision of EIA notification 2016 & its amendment.
2. Industry shall not withdrawal ground water without prior NOC of CGWA as per order of Hon National Green Tribunal.
3. Unit shall obtain Rule 9 permission as per Hazardous & Other Waste Management Rule-2016 for refining of waste oil.
4. Industry shall use environmentally sound technologies for refining of used oil/ waste oil as per Hazardous Rules.
5. Industry shall carry out only melting of solid bitumen in bitumen melting plant.
6. Unit shall obtain fresh water from valid source have permission of the complete authority
7. Industry shall take adequate measures to control fugitive emission due to storage, handling and transportation of raw materials and products.

3. **CONDITIONS UNDER WATER ACT 1974:**

3.1 Water Source: - Tankers

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For, MAHALAXMIASPHALT PVT. LTD
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(U. K. JOSHI)
NOTARY
DIST. KUTCH- (GUJARAT)
Reg. No.5848

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3.2 The quantity of fresh water consumption for Industrial purpose shall not exceed 4 KL/Day.

3.3 The quantity of fresh water consumption for Domestic purpose shall not exceed 2 KL/Day.

3.4 There shall be no generation of effluent asphalt mixer plant industrial waste water from waste oil refine plant after necessary treatment, shall be reused in cooling tower. In order to achieve ZLD.

3.5 Industry shall provide fixed pipeline with flow meter for reuse of treated industrial waste water & maintain its record.

3.6 The quantity of Domestic waste water generation shall not exceed 1.6 KL/Day.

3.7 The sewage shall be disposed through septic tank / soak pit system.

3.8 Disposal system for storm water shall be provided separately. In no circumstances storm water shall be mixed with the industrial effluent.

4. CONDITIONS UNDER AIR ACT 1981:

4.1 The following shall be used as fuel in the Furnaces, TFH & D.G Set respectively.

Sr. No.	Utility	Fuel	Quantity
1.	Furnaces (2 nos.)	Diesel	40 liter/hr
2.	TFH	Diesel	45 liter/hr
3	D.G set	Diesel	05 liter/hr

4.2 The applicant shall install & operate comprehensive air pollution control system in order to achieve flue gas emission norms as prescribed below.

4.3 The flue gases emission from stack attached to Furnaces, THF & D.G Set respectively:

Sr. No	Stack attached to	Stack height in Meters	APCM	Parameter	Permissible limit
1.	Furnaces (2 nos.) (waste oil plant)	33	Heat Quencher	PM SO_2 NO_x	150 mg/NM^3 100 ppm 50 ppm
2.	TFH (6 lakh K cal) (Bitumen melting plant)	11	–	PM SO_2 NO_x	150 mg/NM^3 100 ppm 50 ppm
3.	D.G. set (cap –165 KVA) Standby facility	–	–	PM SO_2 NO_x	150 mg/NM^3 100 ppm 50 ppm

4.4 There shall be no process gas emission from manufacturing process and other ancillary operations

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4.5 The concentration of the following parameters in the ambient air within the premises of the industry and a distance of 10 meters from the sources (other than the stack/vent) shall not exceed the following levels.

Sr. NO.	Pollutant	Time Weighted Average	Concentration in Ambient air in $\mu g/m^3$
1.	Sulphur Dioxide (SO_2)	Annual 24 Hours	50 80
2.	Nitrogen Dioxide (NO_2)	Annual 24 Hours	40 80
3.	Particulate Matter (Size less than 10 µm) or PM_{10}	Annual 24 Hours	60 100
4.	Particulate Matter (Size less than 2.5 µm) or $PM_{2.5}$	Annual 24 Hours	40 60

4.6 The level of Noise in ambient air within the premises of industrial unit shall not exceed following levels:

Between 6 am to 10 pm : 75 dB(A)
Between 10 pm to 6 am : 70 dB(A)

4.7 <u>D.G. Sets Conditions</u>

The D.G. Set shall have acoustic enclosure and shall comply sith the standards specified at Sr. no. 95 of Schedule-I of the rule-3 of E.P. Rules -1986 and Noise pollution level as per the Air Act-1981.

D.G. Sets standards: -

The flue gas emission through stack attached to D.G. Sets shall conform to the following standards.

a) The minimum height of stack to be provided with each of the generator set shall be H=h + 0.2 (KVA) 1/2, where H= Total stack height in meter, h= height of the building in meters where or by the side of which the generator set is installed.

b) Noise from DG set shall be controlled by providing an acoustic enclosure or by reating the room acoustically, at the users end.

c) The acoustic enclosure or acoustic treatment of the room shall be designed for minimum 25 dB (A) insertion loss or for meeting the ambient noise standards, whichever is on the higher side (if the actual ambient noise is on the higher side, it may not be possible to check the performance of the acoustic enclosure/ acoustic treatment. Such circumstances the performance may be checked for noise reduction up to actual ambient noise level, preferably, in the night time). The measurement for insertion loss may be done at different points at 0.5 m from the acoustic enclosure/room, and the averaged.

d) The D.G. Set shall be provided with proper exhaust muffler with insertion loss of minimum 25 dB (A).

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e) All efforts shall be made to bring down the noise level due to the D.G. Set, outside the premises, within the ambient noise requirements by proper siting and control measures Installation of a D.G. Sets must be strictly in compliance with the recommendations of the D.G. Set manufacturer.

f) A proper routine and preventive maintenance procedure for the D.G. Set should be set and followed in consultation with the DG Set manufacture which would help prevent noise levels of the DG Set from deteriorating with use

5. CONDITIONS UNDER HAZARDOUS & OTHER WASTE RULES 2016:

5.1 The applicant shall have to comply with provisions of Hazardous and other Waste (Management and Trans Boundary Movement) Rules 2016.

5.2 The applicant shall obtain membership of common TSDF site for disposal of Hazardous waste as categorized in Hazardous and other Waste (Management and Trans Boundary Movement) Rules 2016.

5.3 The applicant shall obtain membership of common Hazardous Waste incinerator for disposal of incinerable waste.

5.4 The applicant shall provide temporary storage facilities for each type of Hazardous Waste as per Hazardous and other Waste (Management and Trans Boundary Movement) Rules 2016.

5.5 The applicant shall obtain registration/authorization for recycling/reprocessing any hazardous waste before procuring material/starting production as per HW Rules 2016.

5.6 The applicant shall obtain authorization for recovery/reuses of any hazardous waste material as per HW Rules 2016.

6. GENERAL CONDITION:

6.1 Adequate plantation shall be carried out all along the periphery of the industrial premises in such a way that the density of plantation is atleast 1000 trees per acre of land and a green belt of 03 meters' width is developed.

6.2 In case of change of ownership/management the name and address of the new owners /partners/ directors/ proprietor should immediately be intimated to the Board.

6.3 The applicant shall however, not without the prior consent of the Board bring into use any new or altered outlet for the discharge of effluent or gaseous emission or sewage waste from the proposed industrial plant. The applicant is required to make applications to this Board for this purpose in the prescribed forms under the provisions of the Water Act-1974, the Air Act-1981 and the Environment (Protection) Act-1986.

6.4 The concentration of Noise in ambient air within the premises of Industrial unit shall not exceed following levels:

Between 6 A.M. and 10 P M 75 dB(A)
Between 10 P M and 6 A.M. : 70 dB(A)

NOTARY UMED K. JOSHI Area- Dist. Kutch Reg. No.5449 Gujarat State (INDIA) GOVT. OF INDIA

For, MAHALAXMIASPHALT PVT. LTD.

MAHALAXMIASPHALT PVT. LTD.

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6.5 Applicant is required to comply with the manufacturing, Storage and Import of Hazardous Chemicals Rules-1989 framed under the Environment (Protection) Act-1986.

6.6 If it is established by any competent authority that the damage is caused due to their industrial activities to any person or his property .in that case, they are obliged to pay the compensation as determined by the competent authority.

For and on behalf of
GUJARAT POLLUTION CONTROL BOARD

(Smt U.K. Upadhyay)
Environment Engineer

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NOTARY
DIST. KUTCH- (GUJARAT)
Reg. No.5848

MAHALAXMIASPHALT PVT. LTD.

For, MAHALAXMIASPHALT PVT. LTD.

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BY-RPAD

In exercise of the power conferred under section-25 of the Water (Prevention and Control of Pollution) Act-1974, under section-21 of the Air (Prevention and Control of Pollution) Act-1981 and Authorization under rule 6(2) of the Hazardous & other Waste (Management, Handling and Tran boundary Movement) Rules, 2016 framed under the E (P) Act-1986.

And whereas Board has received consolidated application Inward **ID No.154661, dated 01/04/2019** for the consolidated consent and authorization (CC&A) of this Board under the provisions / rules of the aforesaid acts, Consent & Authorization is hereby granted as under.

CONSENTS AND AUTHORISATION:
(Under the provisions /rules of the aforesaid environmental acts)

NOTARY SAPNA D. DADLANI Area Gandhidham-Kutch Regd. No. 7916/2018 GUJARAT-INDIA Expiry Date 12-05-2025 GOVT. OF INDIA

TO,
M/S. PRIYANSI CORPORATION,
SHED NO.,CI-804 TO 808,
GIDC,BAMANBORE-363520,
TA:CHOTILA, DIST: SURENDRANAGAR

1. **Consent Order No.: AWH – 101211 date of Issue: 22/04/2019.**
2. The consents shall be valid up to **21/04/2024** for operation of industrial plant for manufacture of the following items/products:

Sr. No.	Product	Quantity
1	Recycle Waste Oil	150 KL/Month
2	Re Refine Used Oil	200 Kl/Month

Specific Condition: Unit shall have to comply with all the conditions stipulated in registration certificate for re-refining /recycling of Hazardous waste.

3. **CONDITIONS UNDER THE WATER ACT:**

3.1. There shall be no generation of industrial effluent from the manufacturing process and other ancillary industrial operations. But waste water generated from Dehydration process , unit has provided collection cum Neutralization Tank for the same.

3.2. The quantity of sewage wastewater from the factory shall not exceed **1000 Lit/day.**

3.3 Unit shall provide flow meter on water intake line of raw water and maintain record of use of water & made available for inspection.

3.4. Sewage wastewater shall be disposed off through septic tank / soak pit system.

4. **CONDITIONS UNDER THE AIR ACT:**

4.1 The following shall be used as fuel.

Sr. No.	Fuel	Quantity
1	Wood	1.5 MT/Day
2	Light out Oil	10 Lit/Hrs

4.2 The applicant shall install & operate air pollution control system in order to achieve norms prescribed below.

4.2.1 The flue gas emission through stack attached shall conform to the following standards:

Stack No.	Stack attached to	Stack height in Meter	Air Pollution Control Measures	Parameter	Permissible Limit
1.	Furnace-3 Nos (Heating vessel)	33	---	Particulate Matter SO_2 NO_x	150 mg/NM^3 100 ppm 50 Ppm

4.2.2 The process emission through various stack/vent of reactors, process, vessel shall conform to the following standards.

Outward No:508/42/2/06/2019

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4.2.3 The concentration of the following parameters in the ambient air within the premises of the industry shall not exceed the limits specified hereunder.

PARAMETER	PERMISSIBLE LIMIT ANNUAL	PERMISSIBLE LIMIT 24 HRS. AVERAGE
Particulate matter-10[PM10]	60 Microgram /NM^3	100 Microgram /NM^3
Particulate matter-2.5[PM2.5]	40 Microgram /NM^3	60 Microgram /NM^3
Oxides of Sulphur	50 Microgram /NM^3	80 Microgram /NM^3
Oxides of Nitrogen	40 Microgram /NM^3	80 Microgram /NM^3

4.3. The applicant shall provide portholes, ladder, platform etc at chimney(s) for monitoring the air emissions and the same shall be open for inspection to/and for use of Board's staff. The chimney(s) vents attached to various sources of emission shall be designed by numbers such as S-1, S-2, etc. and these shall be painted/ displayed to facilitate identification.

4.4. The industry shall take adequate measures for control of noise levels from its own sources within the premises so as to maintain ambient air quality standards in respect of noise to less than 75 dB(A) during day time and 70 dB (A) during night time. Daytime is reckoned in between 6 a.m. and10 p.m. and night time is reckoned between 10 p.m. and 6 a.m.

Authorization for the Management & Handling of Hazardous Wastes Form-2 (See rule 6(2) Form for grant of authorization for occupier or operator handling hazardous waste.

M/s PRIYANSI CORPORATION, is hereby granted an authorization to operate facility for following hazardous wastes on the premises situated at **SHED NO.,CI-804 TO 808,GIDC,BAMANBORE-363520,TA:CHOTILA, DIST: SURENDRANAGAR.**

No.	Waste	Quantity	Schedule / I	Facility
1.	Used oil	2880 Kl/Year	IV-20	Reception, Storage,Transportation& disposal by used as raw material.
2	Waste Oil	2400 KL/Year	IV-20	Reception, Storage,Transportation& disposal by used as raw material.
3	Organic Residue from process	300 Kl/year	4.4	Collection,Storage,Transportation & disposal by incineration at CHWIF of SEPPL, Kutch.
4	Spent Clay containing Oil	78 MT/Year	4.5	Collection,Storage,Transportation & disposal by incineration at CHWIF of SEPPL, Kutch.
5	ETP Waste	600 KG/Year	35.3	Collection,Storage,Transportation & disposal by incineration at CHWIF of SEPPL, Kutch.
6	Discarded drums /Barrels	12,000 Nos/Year	33.1	Collection,Storage,Transportation & disposal by sale to registered recyclers.

5.2 The authorization shall be in force up to **21/04/2024**.

5.3 The authorization is subject to the conditions stated below and such other conditions as may be specified in the rules from time to time under the Environment (Protection) Act-1986.

Outward No:508942, 07/06/2019

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5.4 TERMS AND CONDITIONS OF AUTHORISATION:

a) The applicant shall comply with the provisions of the Environment (Protection) Act - 1986 and the rules made there under.
b) The authorisation shall be produced for inspection at the request of an officer authorized by the Gujarat Pollution Control Board.
c) The persons authorized shall not rent, lend, sell, and transfer of otherwise transport the hazardous wastes without obtaining prior permission of the Gujarat Pollution Control Board.
d) Any unauthorized change in personnel, equipment or working conditions as mentioned in the authorisation order by the persons authorized shall constitute a breach of this authorisation.
e) It is the duty of the authorised person to take prior permission of the Gujarat Pollution Control Board to close down the facility.
f) An application for the renewal of an authorisation shall be made as laid down in rule 5 (6) (ii).
g) Industry shall submit annual report within 15 days and subsequently by 30th June of every year.

6. GENERAL CONDITIONS: -

6.1 Any change in personnel, equipment or working conditions as mentioned in the consents form/order should immediately be intimated to this Board.
6.2 Applicant shall also comply with the general conditions given in annexure I.
6.3 The waste generator shall be totally responsible for (I.E. Collection, storage, transportation and ultimate disposal) of the wastes generated.
6.4 Records of waste generation, its management and annual return shall be submitted to Gujarat Pollution Control Board in Form – 4 by 30th June of every year.
6.5 In case of any accident, details of the same shall be submitted in Form – 5 to Gujarat Pollution Control Board.
6.6 As per "Public liability Insurance Act – 91" company shall get insurance policy, if applicable.
6.7 Empty drums and containers of toxic and hazards material shall be treated as per guideline published for "management & handling of discarded containers". Records of the same shall be maintained and forwarded to Gujarat Pollution Control Board regularly.
6.8 In no case any kind of hazardous waste shall be imported without prior approval of appropriate authority.
6.9 In case of transport of hazardous waste to a facility for (I.E. Treatment, Storage and disposal) existing in a state other than the state where hazardous waste are generated, the occupier shall obtain "No Objection certificate" from the state pollution Control Board, the Committee of the concerned state or Union territory Administration where the facility exists.
6.10 Unit shall take all concrete measures to show tangible results in waste generation reduction, voidance, reuse and recycle. Action taken in this regards shall be submitted within three months and also along with Form – 4.
6.11 Industry shall have to display the relevant information with regard to hazardous waste as indicated in the Hon Supreme Court's order in W.P. No.657 of 1995 dated 14th October 2003.
6.12 Industry shall have to display on-line data outside the main factory gate with regard to quantity and nature of hazardous chemicals being handled in the plant, including wastewater and air emissions and solid hazardous waste generated within the factory premises.

Outward No:508942, 03/0

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ISO - 9001 - 2008 & ISO - 14001 - 2004 Certified Organisation

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6.13 The applicant shall provide proper collection system for storage of solid waste generated from plant and Effluent treatment plant & disposed of the same in environmentally mentally sound manner.

For and on behalf of
Gujarat Pollution Control Board

D.M. Thaker 21/5/19
(D.M.THAKER)
Environmental Engineer

NO: GPCB/ CCA/SN-199/ ID- 34506/

ISSUED TO:
M/S. PRIYANSI CORPORATION,
SHED NO.,CI-804 TO 808,
GIDC, BAMANBORE-363520,
TA: CHOTILA, DIST: SURENDRANAGAR

-3 DEC 2022
TRUE COPY
(SAPNA D. DADLANI)
ADVOCATE & NOTARY
Gandhidham-Kutch

NOTARY
SAPNA
D. DADLANI
Area Gandhidham-Kutch
Regd. No. 7916/2010
GUJARAT-INDIA
Expiry Date
12-05-2025
GOVT. OF INDIA

Outward No:508942,03/06/2019

Regional Office – Kutch (East)
Gujarat Pollution Control Board
Room No. 215-216-217, 2nd Floor,
Kandla Port Trust Administrative Building,
Gandhidham – 370201, Kutch.
Email:- rogpcb.eastkutch@gmail.com

In exercise of the power conferred under section-25 of the Waster (Prevention and Control of Pollution) Act-1974, under section-21 of the Air (Prevention and Control of Pollution) Act-1981 and Authorization under rule 6(2) of the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 framed under the E (P) Act-1986.

And whereas Board has received consolidated application no: **168422**, dated 17/12/2019 for the fresh consolidated consent and authorization (CC & A) of this Board under the provision / rules of the aforesaid acts-rules. Consent & Authorization is hereby granted as under.

CONSOLIDATED CONSENT AND AUTHORISATION:
(Under the provision / rules of the aforesaid environmental acts)

To,
Revolution Petrochem LLP. (PCB ID -59793),
PLOT NO: 187, Mithi Rohar (GGDC) Industrial Estate,
Mithi Rohar-370201
TAL: Gandhidham, DIST: Kutch.

1. Consent Order No,: AWH -40354; Date of Issue: 24/01/2020

2. The consent shall be valid up to 16/12/2024 for the use of outlet for the discharge of trade effluent and emission due to operation of industrial plant for manufacture of following items/products at an above-mentioned address.

Sr No	Product	Quantity
1	Recycled Waste Oil (Industrial Fuel)	1200 KL/Month
2	Re-Refined Used Oil	300 KL/Month

Specific Condition	
	1. No ground water shall be withdrawn without prior approval from competent authority. 2. You shall not carry out any activity which may attract the applicability of EIA notification-2006 and its amendments. 3. Management of Solid Waste generated from industrial activities shall be as per Solid Waste Management Rules-2016 (solid waste as defined in Rule-3(46). 4. As per provision of Rule-18 of Solid Waste Management Rules-2016 all industrial units using fuel and located within 100 km from the refused derived fuel (ROF) plant shall made an arrangement to replace at least five percent of their fuel requirement by refused derived fuel so produced.
3	**Condition under the Water Act**
3.1	The quantity of industrial effluent shall not exceed 5.4 KL/Day.
3.2	The quantity the Domestic waste water (sewage) shall not exceed 1.0 KL/Day.
3.3	The quality of industrial effluent shall confirm to following standards.

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Reg. No.5848

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Kandla Port Trust Administrative Building,
Gandhidham – 370201, Kutch.
Email:- rogpcb.eastkutch@gmail.com

PARAMETER	PERMISSIBLE LIMIT
pH	6.5 to 8.5
Temperature	40°C
Color	100 Units
Suspended Solids	100 mg/l
Oil & Grease	10 mg/l
Phenolic Compound	01 mg/l
Ammoniacal Nitrogen	50 mg/l
BOD (03 days At 27° C)	30 mg/l
COD	100 mg/l
Chloride	600 mg/l
Sulphates	1000 mg/l
Total Dissolved Solids	2100 mg/l
Sulphides	02 mg/l

All efforts shall be made to remove color & unpleasant odor as far as practicable.

3.4 The treated waste water confirming to the above standards, where 4.2 KL/Day treated waste water shall be recirculated in cooling tower & remaining 1.2 KL/Day shall be evaporated in heat quencher & evaporation.

3.5 Sewage shall be disposed of through septic tank / soak pit system.

4 **Conditions under the Air Act**

4.1 The following shall be used as fuel.

Sr No	Fuel	Quantity
1	Diesel	125 L/Hr.

4.2 The flue gas emission through stack shall confirm to the following standards.

Stack No	Stack attached to	Stack height in meter	Parameter	Permissible Limit
1	Boiler + TFH (06 L K Cal/Hr.)	11	PM SO2 NOx	150 mg/Nm3 100 PPM 50 PPM
2	Furnace	33		
3	Furnace	33		
4	DG Set (165 kVA)	11	NO_x+ HC CO PM Smoke Limit (Light Absorption Co-efficient)	≤ 7.5 g/kW-hr ≤ 3.5 g/kW-hr ≤ 0.3 g/kW-hr ≤ 0.7 m^{-1}

4.3 There shall be no process gas emission from manufacturing activities and other ancillary operations.

4.4 The concentration of the following 11parameters in the ambient air within the premises of the industry shall not exceed the limits specified hereunder as per National Ambient Air Quality Standards issued by MoEF & CC dated 16th November-2009.

Outward No: 22/04/2020

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Reg. No.5848

NOTARY
GOVT. OF INDIA
UMED K. JOSHI
Area: Dist Kutch
Regd. No. 5848
GUJARAT STATE
(INDIA)

Regional Office – Kutch (East)
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Gandhidham – 370201, Kutch.
Email:- rogpcb.eastkutch@gmail.com

Sr. No.	Pollutant	Time Weighted Average	Concentration in Ambient air in microgram/cum
1	Sulphur Dioxide (SO.)	Annual 24 Hours	50 80
2	Nitrogen Dioxide (N02)	Annual 24 Hours	40 80
3	Particulate Matter (PM10)	Annual 24 Hours	60 100
4	Particulate Matter (PM2.5)	Annual 24 Hours	40 60

4.5 The applicant shall provide portholes, ladder, platform etc at chimney(s) for monitoring the air emissions and the same shall be open for inspection to/and tor use of Board's staff. The chimney(s) vents attached to various sources of emission shall be designed by numbers such as S-1, S-2, etc. and these shall be painted/ displayed to facilitate identification.

4.6 The industry shall make adequate measures for control of noise levels from its own sources within the premises so as to maintain ambient air quality standards in respect of noise to less than 75dB(a) during day time and70 dB(A)during night time. Daytime is reckoned in between 6 AM to 10 PM and nighttime is reckoned between 10 PM to 6 AM.

5 **Authorization under the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 & amended.**

5.1 **Authorization Number: AWH -40354 Date of Issue: 21/01/2020 and shall valid up to 16/12/2024.**

5.2 **Revolution Petrochem LLP. (PCB ID -59793),** is hereby granted an authorization to operate facility for following hazardous wastes on the premises situated PLOT NO: 187, Mithi Rohar (GGDC) Industrial Estate, Mithi Rohar- 370201, TAL: Gandhidham, DIST: Kutch.

Sr. No	Waste	Quantity	Schedule-1	Facility
1	Used or spent Oil	4321.0 MT/yr.	5.1	Receipt, Collection, Storage, Transportation & reused in process.
2	Distillation Residues	170.0 MT/yr.	20.3	Collection, Storage, Transportation & Disposed to TSDF site.
3	Chemical sludge from waste water treatment	2.40 MT/yr.	35.3	Collection, Storage, Transportation & Disposed to TSDF site.
4	Empty barrels/containers/liners contaminated with hazardous chemicals /wastes	5.00 M/yr.	33.1	Collection, Storage, Transportation & disposed by selling it to registered recycler.
5	Spent clay containing oil	105.0 MT/yr.	4.5	Collection, Storage, Transportation & Disposed to TSDF site.

Outward No: 15... 2020

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(U. K. JOSHI)
NOTARY
DIST. KUTCH- (GUJARAT)
Reg. No.5848

NOTARY
GOVT. OF INDIA
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(INDIA)

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Gujarat Pollution Control Board
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Gandhidham – 370201, Kutch.
Email:- rogpcb.eastkutch@gmail.com

	6	Wastes as residues containing oil	17280.0 MT/yr.	5.2	Collection, Storage, Transportation & disposed by selling it to registered recycler.

5.3	The authorization is granted to operate a facility for collection, storage within factory premises, transportation and ultimate disposal of Hazardous waste by selling it to registered recyclers.
5.4	Unit shall apply for authorization for other types of hazardous waste referring to the amended Rules.
5.5	The authorization is subject to the conditions stated below and such other conditions as may be specified in the rules from time to time under the Environment (Protection) Act-1986.
5.6	**Terms and conditions of authorization:-**
1.	The authorized person shall comply with the provisions of the Environment (Protection) Act, 1986, and the rules made there under.
2.	The authorization or its renewal shall be produced for inspection at the request of an officer authorized by the State Pollution Control Board.
3.	The person authorized shall not rent, lend, sell, transfer or otherwise transport the hazardous and other wastes except what is permitted through this authorization.
4.	Any unauthorized change in personnel, equipment or working conditions as mentioned in the application by the person authorized shall constitute a breach of his authorization.
5.	The person authorized shall implement Emergency Response Procedure (ERP) for which this authorization is being granted considering all site specific possible scenarios such as spillages, leakages, fire etc. and their possible impacts and also carry out mock drill in this regard at regular interval of time.
6.	The person authorized shall comply with the provisions outlined in the Central Pollution Control Board guidelines on "Implementing Liabilities for Environmental Damages due to Handling and Disposal of Hazardous Waste and Penalty".
7.	It is the duty of the authorized person to take prior permission of the State Pollution Control Board to close down the facility.
8.	The imported hazardous and other wastes shall be fully insured for transit as well as for any accidental occurrence and its clean-up operation.
9.	The record of consumption and fate of the imported hazardous and other wastes shall be maintained.
10.	The hazardous and other waste which gets generated during recycling or reuse or recovery or pre-processing or utilization of imported hazardous or other wastes shall be treated and disposed of as per specific conditions of authorization.
11.	The importer or exporter shall bear the cost of import or export and mitigation of damages if any.
12.	An application for the renewal of an authorization shall be made as laid down under these Rules.
13.	Any other conditions for compliance as per the Guidelines issued by the Ministry of Environment, Forest and Climate Change or Central Pollution Control Board from time to time.
14.	Annual return shall be filed by June 30th for the period ensuring 31st March of the year.
5.7	**General Conditions**
1	Any change in personnel, equipment or working conditions as mentioned in the consents form/order should immediately be intimated to this Board.
2	Applicant shall also comply with the general conditions given in annexure I.
3	The waste generator shall be totally responsible for (I.E. Collection, storage, transportation and ultimate disposal) of the wastes generated.

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Reg. No.5848

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Adv. Dist. Kutch
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Regional Office – Kutch (East)
Gujarat Pollution Control Board
Room No. 215-216-217, 2nd Floor,
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Gandhidham – 370201, Kutch.
Email:- rogpcb.eastkutch@gmail.com

4	Records of waste generation, its management and annual return shall be submitted to Gujarat Pollution Control Board in Form - 4 by 31s1 January of every year.
5	In case of any accident, details of the same shall be submitted in Form - 5 to Gujarat Pollution Control Board.
6	As per "Public liability Insurance Act - 91" company shall get Insurance policy, if applicable.
7	Empty drums and containers of toxic and hazards material shall be treated as per guideline published for management & handling of discarded containers". Records of the same shall be maintained and forwarded to Gujarat Pollution Control Board regularly.
8	In no case any kind of hazardous waste shall be imported without prior approval of appropriate authority.
9	In case of transport of hazardous waste to a facility for (I.E. Treatment, Storage and disposal) existing in a state other than the state where hazardous waste are generated, the occupier shall obtain "No Objection certificate" from the state pollution Control Board, the Committee of the concerned state or Union territory Administration where the facility exists.
10	Unit shall take a)) concrete measures to show tangible results in waste generation reduction, voidance, reuse and recycle. Action taken in this regards shall be submitted within 03 months and also along with Form 4.
11	Industry shall have to display the relevant information with regard to hazardous waste as indicated in the Hon Supreme Court's order in W.P. NO.65 of 1995 dated 14th October 2003.
12	Industry shall have to display online data outside the main factory gate with regard to quantity and nature of hazardous chemicals being handled in the plant, including wastewater and air emissions and solid hazardous waste generated within the factory premises.

NO. GPCB/RO- Kutch (East)/CCA-Fresh/Kutch-/PCB ID: 59793/ Date: -

For and behalf of
Gujarat Pollution Control Board

Regional Officer, Kutch(East)

Outward No:15594,22/04/2020

TRUE COPY
(U. K. JOSHI)
NOTARY
DIST. KUTCH-(GUJARAT)
Reg. No.5848

NOTARY
UMESH K. JOSHI
Area: Dist Kutch
Regd. No. 5848
GUJARAT STATE
(INDIA)
GOVT. OF INDIA

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GUJARAT POLLUTION CONTROL BOARD
REGIONAL OFFICE-AHMEDABAD (CITY)

2nd floor, Gujarat Pollution Control Board (Old Building), Paryavaran Bhavan, Sector-10-A, Gandhinagar-382010. Phone: 079-23222096 E-Mail – ID: ro-gpcb-ahmc@gujarat.gov.in

In exercise of the power conferred under section-25 of the Water (Prevention and Control of Pollution) Act-1974, under section-21 of the Air (Prevention and Control of Pollution) Act-1981 and Authorization under rule 5(4) of the Hazardous and Other Wastes (Management and Transboundry Movement) Rules, 2016, framed under the Environment (Protection) Act-1986.

And whereas Board has received consolidated consent application **NO. 164983** dated **16/10/2019** for the Consolidated Consent and Authorization (CC & A) of this Board under the provisions/rules of the aforesaid acts. Consents & Authorization are hereby granted as under:

CONSENTS AND AUTHORISATION:
(Under the provisions /rules of the aforesaid environmental acts)

NOTARY SHWETA N. RAMNANI Area-Gadhidham Kutch Regd. No. 21871/20 GUJARAT-INDIA Expiry Date 04/03/2025 GOVT. OF INDIA

To,
M/s. Shana Oil Process
Nr Good Luck Market,
Chandola Lake,
Ahmedabad-380028

1. **Consent Order No.: AWH–39520, Date of issue: 27/11/2019.**
2. The consents shall be valid up to **30/09/2024** for use of outlet for the discharge of trade effluent & emission due to operation of industrial plant for following products.

Sr. No	Product	Quantity
1	Re-Refining of Used Oil	24.25 KL/Month
2	Recycled Waste Oil (Industrial Fuel)	40 KL/Month

SPECIFIC CONDITIONS

- **Unit shall obtain CTE/CCA Amendment on receipt of CCA Renewal.**
- **Unit shall not to procure waste oil or used oil more than consented quantity and comply with undertaking dated 10/10/2019.**
- **Unit shall not operate plant in night hours during winter season and comply with the winter action plan and air action plan of Ahmedabad city.**
- **The applicant shall receive/transport/sell any hazardous waste in global Positioning system enabled (GPS enabled) dedicated tankers/trucks only and shall have to adopt online manifest system of GPCB-Xtended green node (XGN) invariably.**

3. CONDITIONS UNDER WATER ACT 1974

3.1 Domestic water consumption shall not exceed **1.0 KLPD** and the quantity of the domestic waste water (sewage) shall not exceed **0.8 KLPD**. Sewage shall be discharge in to AMC drain.

3.2 Industrial water consumption shall not exceed **3.25 KLPD** which shall be treated in ETP and partly reuse in cooling tower make up & partly evaporated in evaporator, so there shall be no discharge of any kind of industrial effluent from the manufacturing process and other ancillary operations.

3.3 The directives issued by the board from time to time in view of direction issued by the Honorable High Court of Gujarat in the matter of S.C.A. 770/95 and any other shall have to be complies with.

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4. **CONDITIONS UNDER THE AIR ACT :**

4.1 The following shall be used as fuel in furnaces.

Sr. No.	Fuel	Quantity
1	LDO	0.03 KL/Hr

4.2 The applicant shall install & operate the Air pollution control system in order to achieve norms prescribed below.

Stack No.	Stack attached to	Stack height in Meter	Parameter	Permissible Limit
1	Furnaces (2 nos)	11	Particulate Matter SO_2 NO_x	150 mg/NM^3 100 PPM 50 PPM

4.3 Stack monitoring facility like port hole, platform / ladder, etc. shall be provided with stack/vents chimney in order to facilitate sampling of gases being emitted into the atmosphere.

4.4 There shall be no process gas emission.

4.4 Ambient air quality within the premises of the industry shall conform to the following standards:

Pollutant	PERMISSIBLE LIMIT Annual	PERMISSIBLE LIMIT 24 Hrs Average
Particulate Matter 10 (PM10)	60 Microgram/M^3	100 Microgram/M^3
PM 2.5 (PM 2.5)	40 Microgram/M^3	60 Microgram/M^3
SO_2	50 Microgram/M^3	80 Microgram/M^3
NO_x	40 Microgram/M^3	80 Microgram/M^3

The industry shall take adequate measures for control of noise levels from its own sources within the permission so as to maintain ambient air quality standards in respect of noise to less than 75 dB(A) during day time and 70 dB(A) during night time. Daytime is reckoned in between 6 a.m. and 10 a.m. and nighttime is reckoned between 10 p.m. and 6 a.m.

4.6 The applicant shall provide proper ventilation and exhaust facilities so as to maintain healthy working atmosphere within the factory premises.

5. **Authorization for the Management & Handling of Hazardous Wastes Form-2 (See rule 3 (c) & 5 (4) Form for grant of authorization for occupier or operator handling hazardous waste.**

5.1 **Number of authorization: AWH-39520, Date of issue: 27/11/2019.**

Shana Oil Process is hereby granted an authorization to operate facility for following hazardous wastes on the premises situated at **Nr Good Luck Market, Chandola Lake, Ahmedabad-380028.**

Sr. No	Waste	Quantity per year	Schedule / category	Facility
1	Used or Spent Oil	300 MT	5.1	Collection, Storage, Reception, Reprocess within premises

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2	Waste or Residues containing Oil	610 MT	5.2	Collection, Storage, Reception, Reprocess within premises
3	Distillation Residues	56 MT	20.3	Collection, Storage, Transportation to common hazardous waste incineration facility for final disposal by incineration at approved CHWIF
4	Spent Clay Containing Oil	98 MT	4.5	Collection, Storage, Transportation to common hazardous waste incineration facility for final disposal by incineration at approved CHWIF
5	Chemical Sludge from Waste Water Treatment	0.72 MT	35.3	Collection, Storage, Transportation to common hazardous waste treatment facility for final disposal by land filling at approved CHWTF
	Empty Barrels/Containers/Liners Contaminated with Haz Chemicals/ Wastes	100 MT	33.1	Collection, Storage, Decontamination, Transportation, Sell to Registered Recyclers

5.2 The authorization is granted to operate a facility for collection, storage, Reuse within factory premises and ultimate disposal of generated hazardous waste at CHWTF site of M/s. SEPPL, Bhachau.

5.3 The authorization shall be in force for a period up to **30/09/2024.**

5.4 The authorization is subject to the conditions stated below and such other conditions as may be specified in the rules from time to time under the Environment (Protection) Act-1986.

5.5 Terms and conditions of Authorization:

a) The Applicant shall comply with the provisions of the environment (protection) Act – 1986 and the rules made there under.

b) The Authorization shall be produced for inspection at the request of an officer authorized by the Gujarat Pollution Control Board.

c) The persons authorized shall not rent, land, sell, transfer of otherwise transport the hazardous waste without obtaining prior permission of the Gujarat Pollution Control Board.

d) Any authorized change in personnel, equipment or working conditions as mentioned in the Authorization order by the persons authorized shall constitute a breach of this authorization.

e) It is the duty of the authorized person to take prior permission of the Gujarat Pollution Control Board to close down the facility.

f) An Application for the renewal of an Authorization shall be made as laid down in rule 5 (6) (ii).

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g) Industry shall manage waste as per amended rules 2016 and shall applied authorization for all applicable waste as per amended rules 2016 within 15 days.
h) Industry shall submit annual report within 15 days and subsequently by 30 June every year.

6. **GENERAL CONDITIONS: -**

6.1 Any change in personnel, equipment or working conditions as mentioned in the consents form/order should immediately be intimated to this Board.

6.2 In case of any accident, details of the same shall be submitted in Form – 14 to Gujarat Pollution Control Board.

6.3 In no case any kind of hazardous waste shall be imported without prior approval of appropriate authority.

6.4 Unit shall take all concrete measures to show tangible results in waste generation reduction, voidance, reuse and recycle. Action taken in this regards shall be submitted within three months and also along with Form – 4.

6.5 In case of transport of hazardous waste to a facility for (i.e. Treatment, Storage and disposal) existing in a state other than the state where hazardous waste are generated, the occupier shall obtain "No Objection certificate" from the state pollution Control Board, the Committee of the concerned state or Union territory Administration where the facility exists.

6.6 Industry shall have to display the relevant information with regard to hazardous waste as indicated in the Hon Supreme Court's order in W.P. No.657 of 1995 dated 14th October 2003.

6.7 As per "Public liability Insurance Act – 91" company shall get insurance policy, if applicable.

6.8 Industry shall have to display on-line data outside the main factory gate with regard to quantity and nature of hazardous chemicals being handled in the plant, including wastewater and air emissions and solid hazardous waste generated within the factory premises.

NOTARY SHWETA N. RAMNANI Area-Gandhidham Kutch Regd. No. 21071/20 GUJARAT-INDIA Expiry Date 05/03/2025 GOVT. OF INDIA

For and on behalf of
Gujarat Pollution Control Board

N.D. Ajmera
I/C Regional Officer

5 DEC 2019

NO: GPCB/RO-ABD/AWC-[illegible]/ID-13711/ 18670

30 MAY 2022
TRUE COPY
(SHWETA N. RAMNANI)
ADVOCATE & NOTARY
Gandhidham - Kachchh

ISSUED TO:
M/s. Shana Oil Process
Nr Good Luck Market,
Chandola Lake,
Ahmedabad-380028

COPY TO:
1. THE MEMBER SECRETARY, G.P.C.BOARD. GANDHINAGAR.
2. OFFICE COPY CONCERNED INDUSTRIES FILE.

ANNEXURE – K

Oil Spill Contingency Plan

ANNEXURE-XIV

(Oil Spill Contingency Plan)

Annexure-H

MEMORANDUM OF UNDERSTANDING

BETWEEN

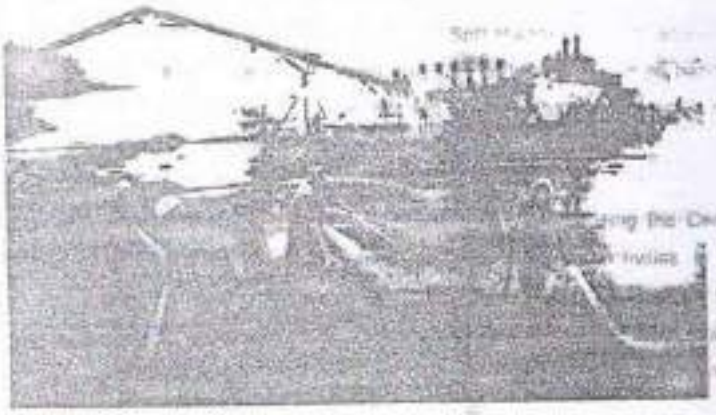
KANDLA PORT TRUST

AND

OIL COMPANIES

ON

SETTING UP OF TIER-I FACILITY FOR COMBATING OIL SPILL AT KANDLA



THE MEMORANDUM OF UNDERSTANDING
AMONGST KPT, BPCL, IOCL, HPCL
ON SETTING UP OF TIER-I FACILITY
FOR COMBATING OIL SPILL AT KANDLA

This Memorandum of Understanding made on this 14th day of June 2011 amongst -

1. Kandla Port Trust having its administrative office at Gandhidham, Kutch District, Gujarat State (hereinafter referred to as KPT).
2. Bharat Petroleum Corporation Limited having its registered office at Bharat Bhavan, 4&6 Currimbhoy Road, Ballard Estate, Mumbai – 400 001 (hereinafter referred to as BPCL),
3. Indian Oil Corporation Limited having its registered office at G-9, Allyavar Jung Marg, Bandra (East), Mumbai (hereinafter referred to as IOCL),
4. Hindustan Petroleum Corporation Limited having its registered office at 17-Jamshedji Tata Road, Mumbai – 400 020 (hereinafter referred to as HPCL),

BPCL, IOCL and HPCL are hereinafter collectively referred to as Oil Companies wherever the context so requires. KPT and Oil Companies are hereafter collectively referred as parties whenever the context so requires.

WHEREAS in recent times the risk of Oil Spill at various Port locations has gone up rapidly due to increased quantum and frequency in oil handling and recognizing the importance, it is felt essential that oil companies shall participate in the efforts to combat oil spill.

AND WHEREAS the Director General, Coast Guard being the Central Coordinating Authority for marine oil spill response activities in the maritime zones in India has prepared and published the National Oil Spill Disaster Contingency Plan (NOSDCP) to combat oil spill, which delineates the duties and responsibilities of each participating agency. To meet the

14/6/11

requirement of providing a Tier-I facility to combat oil spill at Kandla, based on the discussions held at various levels amongst KPT and Oil companies operating at Kandla, the parties herein agree to deduce the same into writing by this Memorandum of Understanding (MOU).

NOW, THEREFORE, THE PARTIES HEREIN MUTUALLY AGREE AND WITNESSETH AS FOLLOWS:

1.0 Objective

The objective of this MOU is to strengthen the Oil spill combating Tier-I facilities available at Kandla so as to meet the requirements as mentioned above.

2.0 Scheme for setting up of Tier-I facility for combating oil spill

2.1 KPT and Oil Companies hereto have mutually agreed to and shall participate in this scheme for combating the oil spill as mentioned herein.

2.2 Oil Companies jointly agree to make an one time payment of Rs. 500 lakhs (Rupees Five Hundred Lakhs) to KPT and KPT agrees for setting up of Tier-I facilities at Oil Spill Response Centre (OSRC) at Kandla by December 2011. Thereafter, KPT shall develop, operate and maintain these facilities to combat oil spill as required in 1.0 above.

KPT further agrees that the above mentioned payment of Rs. 500 lakhs will only be used for setting up of Tier-I facilities for combating oil spill. Further, Oil Companies shall not be asked for any payments towards purchase of equipments under Tier-II/III facilities. The Oil Companies shall not be responsible for the maintenance of these

facilities and day to day operating and maintenance costs shall be borne by KPT only.

The payment by Oil Companies to KPT will be proportionate to the throughput of each Oil Company as mentioned in 2.3. The amount of Rs. 500 lakhs is based on the estimates as per the enclosed list of equipment. However, the overall payment shall be made based on actual progressive expenditure.

2.3 Oil Companies agree that the payment to be made by individual oil company to KPT shall be shared amongst them, on the basis of the volume of the oil handled by the Oil Companies during 2009-10, in the following manner:

Oil Co.	Volume Handled (In MTs) during 2009-10	% Share
IOCL	2017761	77.33
HPCL	291796	11.18
BPCL	299704	11.49
TOTAL	2609261	100.00

The payments by the Oil Companies to KPT shall be made as per the advice of the KPT which will be based on actual expenditure with details of accounts as certified by KPT and Oil Companies shall have access to such documents.

2.4 KPT will provide the necessary dedicated sea worthy vessel for installing all the OSRC equipment and it will be kept ready for efficient OSRC activities.

14/2/11 14/2/11 14/2/11

KPT shall be responsible for taking necessary statutory and other approvals for operation, maintenance and purchase of equipments/facilities and for other obligations as per this MOU. All approvals (tendering process etc.) shall be carried out by KPT.

2.5 A separate fund (sinking fund) for expenses for operations, maintenance and replacement of equipments (oil spill combat equipments) including insurance cover of the same, would be created by KPT. The co-ordination/monitoring committee shall monitor the fund management.

In order to implement the model and make it self-sustainable for timely maintenance and replacement of equipments as and when required, KPT to approach TAMP for levying some kind of fee/surcharge on all vessels berthed at Kandla Port, other than participating Oil Companies.

All the ships coming to Kandla Port carry POL as bunker fuel and hence tariff for each vessel to be finalized by KPT and the fund to be put in the sinking fund. The tariff will be 'nil' for participating companies.

2.6 Some other private companies may be rare users of Port facilities in handling and their volumes of hydro carbons are less . However, if they cause any pollution, they will be charged by KPT for recovery of the oil spill, apart from the other statutory fines. Further, if participating Oil Companies cause any leak/ pollution, no recoveries of any expenses or penalties shall be levied against them.

As regards recovery from non-participating port users identified as the polluter, KPT shall issue a public notice to bring to their knowledge about the recovery of expenditure @ 300 % of actual plus

supervision and overhead charges (@7 %) towards combating oil spill from non-participating port users identified by KPT as the

polluter. KPT shall co-ordinate for such recovery from the polluter who are non-participating port users. The amount so recovered shall be ploughed back to meet the normal operation & maintenance and manning & crewing of OSRC set up.

For any new entrant, proportionate sharing of costs shall be recovered by KPT. This amount will be part of the sinking fund and available to the Co-ordination committee for appropriate use.

2.7 KPT shall make use of the expertise of the Coast Guard while preparing the specifications of the oil spill combating facilities.

2.8 KPT shall be obliged to provide accounts of expenditures and allow access to such documents as may be asked by Oil Companies and also shall provide necessary documents to Oil Companies to claim rebate on income tax/service tax, as applicable.

3.0 Oil Spill Contingency Plan

KPT has prepared its action plan for setting up the oil spill combating facilities along with target dates, in consultation with Oil Companies.

This plan shall be updated every year. The Action Plan, attached hereto, shall form a part of the MoU. As per the action plan, the oil spill combating facilities shall be fully functional by December 2011. KPT shall maintain and operate these facilities as per the norms prescribed by Original Equipment Manufacturers (OEMs), the Coast Guard, statutory bodies, and Government agencies. KPT shall also

keep proper record and Oil Companies shall in no way be held responsible for the same.

4.0 Geographical coverage

KPT shall normally operate the oil spill combating facilities within the limits of the Kandla Port. However, KPT will extend the said facilities beyond the limits of Kandla Port, on specific requests from Oil Companies and other Government agencies, on mutually agreeable terms.

5.0 Mock Drill

KPT shall organize at least one mock drill every six months. The date of the mock drill will be communicated to the Coast Guard and Oil Companies well in advance. The Oil Spill Contingency Plan will be modified and updated, if required , to take care of the observations made during the mock drill.

6.0 Co-ordination Committee

For effective coordination and smooth working of the Plan, a Committee, with representative of KPT as Chairman, and representative of the Coast Guard and Oil Companies as Members will be formed to monitor the functioning of the oil spill combating facilities. The decision may be considered to be taken by majority of member committee. The committee shall meet as and when required, but at least four meetings shall be held in a year (one in each quarter).

The committee shall oversee the following

a. Cash flow requirement : This will be based on the actual expenses towards procurement of equipment (inclusive of all taxes) ... This will be based on the PO placed by KPT

b. Progress Review : Every quarter the progress shall be reviewed and the Committee shall advise on the adequate funds required for next quarter or six months, so as to ensure smooth execution of all activities.

7.0 Notices

All notices, requests, demands and other communications required or provided for under this MoU shall be forwarded to the following respective addresses of the parties hereto :

1. The Deputy Conservator,
   Kandla Port Trust, Admin Office
   Gandhidham – (Dist-Kutchh)

2. Senior Manager Operations (Retail),
   Bharat Petroleum Corporation Ltd.,
   Khan Rohar Road
   Kandla (Dist. Kutchh)

3. Senior Installation Manager,
   Hindustan Petroleum Corporation Ltd.,
   Khan Rohar Road,
   Kandla (Dist. Kutchh)

4. Sr Terminal Manager,
   Indian Oil Corporation Ltd.,
   Fore Shore Terminal, K K Road,
   Kandla (Dist. Kutchh)

5. Sr Terminal Manager,
Indian Oil Corporation Ltd.,
Main Terminal,
Kharirohar Road,
Kandla (Dist. Kutchh)

8.0 General

8.1 This MoU supersedes all provisions or undertakings arrived at between all the parties herein regarding the subject of these presents, whether in writings or otherwise prior to the date of execution of these presents.

8.2 This MoU shall not be amended, varied or modified in any manner except by an instrument in writing and signed by all the parties herein.

8.3 Any dispute or difference of any nature whatsoever between any of the parties hereto arising out of or in relation to this MOU shall be referred to the sole Arbitration as detailed in the Arbitration Clause in the Annexure attached hereto.

8.4 This MoU shall be made in five copies and each party to the MoU shall have one copy each.

8.5 To ensure the compliance by the non-participating Port users, KPT shall issue a Public Notice, which shall be binding on the non-participating users at the time of the incidence.

14/6/11 14/6 14/6/11

IN WITNESS THEREOF THE PARTIES HERE TO HAVE SET THEIR HANDS SIGNED AND DELIVERED THIS M.O.U ON THE DATE ABOVE WRITTEN.

14/6/11
KPT
Dr. Chairperson
CAPT H K SIBAL

14/6/11
BPCL
Sr Manager Installation (R) Kandla
(R.G. DEKATE)

14/6/11
IOCL
Sr Terminal Manager, FST, Kandla
(B. ROUT)

14/6/11
IOCL
Sr Terminal Manager, Main, Kandla
D.V. SARANGIA

14/6/11
(J.M. NAIK) BPCL
Sr Installation Manager, Kandla

ARBITRATION CLAUSE

(a) All disputes or differences of any nature whatsoever any claim, counter-claim or set off of the _____ against the _____ or regarding any right, liability, act, omission or account of any of the parties hereto arising out of or in relation to this MOU shall be referred to the sole Arbitration of the Director(Marketing) of [redacted] Oil Company or of some officer of the Oil Company who may be nominated by the Director (Marketing). The _____ will not be entitled to raise any objection to any such arbitrator on the ground that the arbitrator is an officer of the Oil Company or that he has dealt with the matters to which the contract relates or that in the course of his duties as an officer of the Oil Company he had expressed views on and on any other matters in dispute or difference. In the event of the arbitrator to whom the matter is originally referred being transferred or vacating his office or being unable to act for any reason, the Director(Marketing) as aforesaid at the time of such transfer, vacation of office or inability to act may in the discretion of the Director(Marketing) designate another person to act as arbitrator in accordance with the terms of the MOU to the end and intent that the original arbitrator shall be entitled to continue the arbitration proceedings notwithstanding his transfer or vacation of office as an officer of Oil Company if the director (Marketing) does not designate another person to act as arbitrator on such transfer, vacation of office or inability of original arbitrator. Such persons shall be entitled to proceed with the reference from the point at which it was left by his predecessor. It is also a term of this contract that no person other than the director (Marketing) or a person nominated by such Director (marketing) of Oil Company as aforesaid shall act as arbitrator hereunder. The award of the arbitrator so appointed shall be final conclusive and binding on all parties to the MOU subject to the provisions of the Arbitration Act, 1996 or any statutory modification or re-enactment thereof and the rules made thereunder for the time being in force shall apply to the arbitration proceedings under this clause.

(b) The award shall be made in writing and published by the arbitrator within two years after entering upon the reference or within such extended time not exceeding further twelve months as the sole arbitrator shall by a writing under his own hands appoint. The parties hereto shall be deemed to have irrevocably given their consent to the arbitrator to make and publish the award within the period referred to hereinabove and shall not be entitled to raise any objection or protest thereto under any circumstances whatsoever.

(c) The arbitrator shall have power to order and direct either of the parties to abide by, observe and perform all such directions as the arbitrator may think fit having regard to the matters in difference i.e dispute before him. The arbitrator shall have all summary powers and may take such evidence oral and/or documentary, as the arbitrator in his absolute discretion thinks fit and shall be entitled to exercise all powers under the Indian Arbitration Act, 1996 including admission of any affidavit as evidence concerning the matter in difference i.e dispute before him.

1/2

(d) The parties against whom the arbitration proceedings have been entitled, that is to say, the respondents in the proceeding, shall be entitled to prefer a cross-claim or set off before the arbitrator in respect of any matter in issue arising out of or in relation to MOU without seeking a formal reference of arbitration to the Director (Marketing) for such counter-claim, cross-claim, or set off and the arbitrator shall be entitled to consider and deal with the same as if the matters arising therefrom has been referred to him originally and deemed to form part of the reference made by the Director(Marketing).

(e) The arbitrator shall be at liberty to appoint, if necessary any accountant or engineering or other technical person to assist him, and to act by the opinion so taken.

(f) The arbitrator shall have power to make on or more awards whether interim or otherwise in respect of the dispute and difference and in particular will be entitled to make separate awards in respect of claims or cross-claims of the parties.

(g) The arbitrator shall be entitled to direct any one of the parties to pay the costs of the other party in such manner and to such extent as the arbitrator may in his discretion determine and shall also be entitled to require one or both the parties to deposit funds in such proportion to meet the arbitrators expenses whenever called upon to do so.

The parties hereby agree that the courts in the city of Gandhidham alone shall have jurisdiction to entertain any application or other proceedings in respect of anything arising under this MOU and any award or awards made by the sole arbitrator hereunder shall be filled in the concerned courts in the city of Gandhidham only.

2/2

14/6/11
KPT
Dy. Conservator
CAPT. H.K. SIBAL

14.06.11
BPCL
Sr Manager Operations (R) Kandla
(H. G. DEKATE)

14/6/11
IOCL
Sr Terminal Manager, FST, Kandla
(B. ROUT)

14/6/11
IOCL
Sr Terminal Manager, Main, Kandla
D.V. SARANGLA

(J.M. NAT K) 14/6/11
BPCL
Sr Installation Manager, Kandla

Annexure - H

KANDLA PORT TRUST

LOCAL OIL SPILL - DISASTER CONTINGENCY PLAN.

(KPT - LOS - DCP)

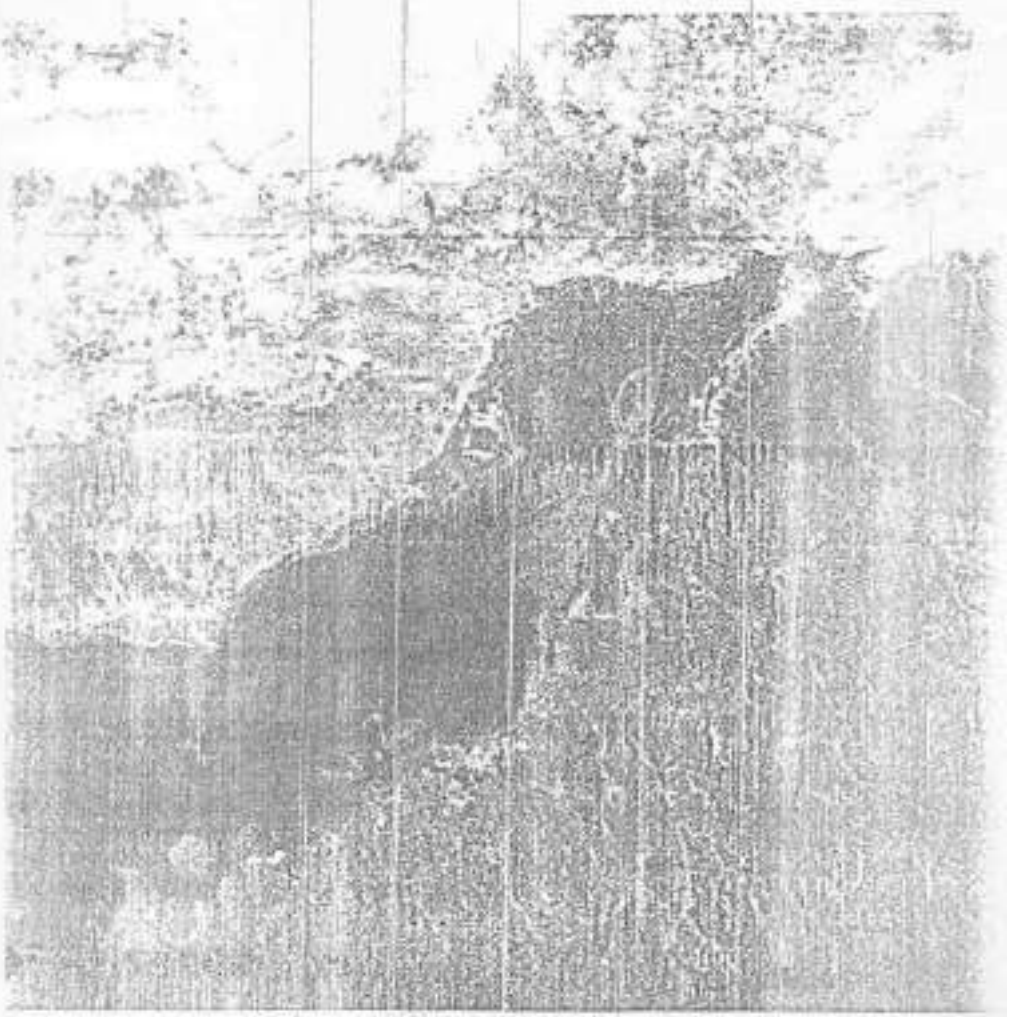
AUGUST 2000

MARINE DEPARTMENT, KANDLA PORT TRUST, P O BOX - 50, GANDHIDHAM, KUTCH, GUJARAT - 370 240.
Tel: 02836-20336, FAX: 02836-20882, SATELLITE PHONE: 00 873 762042 777.

KANDLA PORT TRUST

LOCAL OIL SPILL - DISASTER CONTINGENCY PLAN.

(KPT - LOS - DCP)



AUGUST 2000

MARINE DEPARTMENT, KANDLA PORT TRUST, P.O. BOX - 50, GANDHIDHAM, KUTCH, GUJARAT - 370 201.
Tel: [illegible], FAX: [illegible], SATELLITE PHONE: [illegible]

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1 Introduction

2 KPT - LOS - DCP, Jurisdiction and description of the plan area

- 2.1 Oil spill threat perception
- 2.2 Port facilities
- 2.3 Port activities
- 2.4 Local environmental conditions

3 Existing oil spill response system at Kandla port

- 3.1 Communication system and Reporting procedures
- 3.2 Oil spill response team setup
- ~~3.3 Communication systems~~
- 3.4 Oil spill response equipment and accomplishments
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KANDLA PORT TRUST

LOCAL OIL SPILL – DISASTER CONTINGENCY PLAN

(LOS-DCP)

INTRODUCTION

The Indian Coast Guard (ICG) has been designated as the nodal agency to deal with all contingencies associated with OIL SPILL DISASTERS in the coastal and marine environs of the Nation. The ICG in this regard had prepared a NATIONAL OIL SPILL – DISASTER CONTINGENCY PLAN popularly known as the NOS-DCP. The NOS-DCP identifies the Major Ports as among the RESOURCE AGENCIES of ICG. Further the plan details co-ordination procedures for the resource agencies to inter act with the nodal agency.

Under the guidelines of the NOS-DCP it is obligatory for the resource agencies to develop a local oil spill disaster contingency plan and link it up with the NOS-DCP. This plan is an effort of KANDLA PORT TRUST to link up its updated LOS-DCP with the NOS-DCP.

Kandla Port is located towards the extreme eastern margin of the GULF OF KUTCH (GOK). Ships calling at Kandla port therefore have to traverse across the GOK, which had been identified as a highly sensitive coastal zone of the maritime state of GUJARAT, owing to the rich bio-diversity persisting along its southern coast line. The GOK is also significant in maritime culture with the existence of three port complexes viz. KANDLA – VADINAR Major port complex, RELAINCE PETRO-CHEMICALS Ltd.- Marine Terminal complex and the up coming GUJARAT ADANI PORT Ltd. complex. In view of the above ships plying in the GOK and the maritime community associated with them are required to exercise utmost caution particularly with regard to prevention of oil pollution by ships.

KPT - LOS - DCP, Jurisdiction and description of the plan area

The plan jurisdiction encompasses the Port limits in general. Fig 1 illustrates the Port limits as defined by the Govt. of India Notification no. 256(E), published in the gazette of India, part II section 5, subsection (I) dated 1st May 1978.

2.1 Oil Spill threat Perception

Oil spill can be broadly categorized into three categories depending upon the volume and area of oil spill, which has taken place. These three categories of oil spill are generally classified as Tier 1, 2 & 3 and each tier will require response strategies suitable to magnitude and manifestations as mentioned below:

Tier – 1: This would be a spill of a magnitude the local resources could respond to successfully without assistance from other agencies.

Tier – 2: This would be a spill of a magnitude that would outstrip the local resources & would require assistance on a regional basis. This would either come from local/central Government or local Industries Mutual Aid arrangement.

Tier – 3: This would be a spill of a magnitude that would surpass the capabilities of tier one and tier- 2. Additional resources would be required on a national and international level.

Tier level	Volume
One	$<10\ m^3$
Two	$10m^3 - 100m^3$
Three	$>100m^3$

The Oil spill threat perception in Kandla Port has taken into consideration various Port facilities, type of port operations in conjunction with local conditions and record of recurrences of oil spill events. A review of the above aspects reveals the following points :-

- SBM operations at Vadinar are susceptible for probable oil spills.
- In the entire history of Kandla port, there had been no record of Tier 2 & 3 level oil spills. However, minor occurrence of tier level-1, oil spills are on record. Oil spill on 31st May 1998, which occurred due to failure of sub-marine hose which, resulted in oil spill of 2000 litres of Bombay High Crude while the second event of oil spill was noticed during the aftermath period of Cyclone of June 1998. The spill was of minor nature and the source of spill was from a badly damaged and grounded ship, which was subsequently salvaged and was berthed, in a cold move. The third occurrence of the oil spill of an uncertain source was established during November 1999. The quantity of oil spilled was also undetermined. This oil spill was established based on the evidences observed on the shoreline in the vicinity of Vadinar.
- The mitigative action taken in the above accidents was deployment of dispercent chemicals.
- Owing to the local conditions, any occurrence of the oil spill in the plan area are likely to spread and travel faster, thereby bringing down the available response time to very short duration.
- Owing to the short duration of the response time available, the danger of oil spill striking the coastline at Vadinar is highly probable.
- The existence of Coral reeves in the vicinity of Vadinar Port area sensitizes port operations at Vadinar.
- Use of chemical dispercents, deployment of offshore oil spill containment booms and complimentary skimmers are strongly recommended for SBM operations at Vadinar.
- The above mentioned oil spill response equipment needs to be kept in readiness at all times.
- The threat perception in the Kandla scenario is not as much as at Vadinar owing to the decline in POL traffic at Kandla.

In view of above the plan area is classified in to the following zones in the order of importance based on oil spill threat perception:

OIL SPILL THREAT PERCEPTION ZONE	APPROPRIATE OIL SPILL RESPONSE SYSTEM SUGGESTED IN ORDER OF PERFERENCE
Vadinar SBM operational area	Immediate deployment of containment booms system, followed by skimming by MV sagarika and, in the event of inclement weather attempt use of chemical dispercents.
Vadinar Anchorage	Immediate deployment of containment boom system, followed by skimming by MV sagarika and in the event of inclement weather attempt use of chemical dispercents.
Old Kandla Oil Jetty complex	Press in MV Karishma for skimming in case of inclement weather attempt spraying chemical dispercents.
Vadinar port craft jetty	Press in MV Sagarika for skimming, secondly attempt spraying chemical dispercents to disperse the oil slick.
New Kandla general cargo berths and harbor area	Press in MV Karishma for skimming in case of inclement weather attempt spraying chemical dispercents.
Kandla creek including inner anchorage and moorings	Press in MV Karishma for skimming in case of inclement weather attempt spraying chemical dispercents.
Kandla outer anchorage (OTB area)	Press in MV Karishma for skimming in case of inclement weather attempt spraying chemical dispercents.
Kandla creek system and area within Port limits other than the above.	Press in MV Karishma for skimming in case of inclement weather attempt spraying chemical dispercents.

2.2 Port facilities

Within the Plan area, the following operational port facilities exist:

KANDLA

- Five 'T' shaped Oil Jetties for handling liquid cargo inclusive of one jetty, which is equipped with LPG handling facilities.

- One Steel Floating Dry Dock for dry docking Port crafts.

- A Rectangular shape basin for handling barges
- A 90 m. long "L" shaped Berthing Jetty for the use of Port crafts.
- 2280 m. long wharf to accommodate 10 to 12 ships in a straight line for handling general cargoes.
- Three pre-designated Inner Anchorage points and three mid stream anchorage points.
- Shipping tugs, Harbor tugs, Mooring Crafts, General Service Launches, Fire Boat, Pilot launches, Buoy laying dumb barge and one Survey Launch equipped with modern automated hydrographic equipment.
- One Buoy laying dumb barge equipped with 20 tonne winch
- Two units of land based Fire Brigade System (One located at Oil Jetties Complex and another within the General Cargo Berths complex).
- One Multi-purpose anti pollution vessel.
- One Tank lorry to receive oily waste from ships along side berths.

VADINAR

- Two Single Buoy Moorings (SBM) installed at a depth of 33 mtrs. Off Salaya Creek at Vadinar. The two SBMs are inter-connected with sub-marine pipeline, which ultimately leads to the tank farms located on the Nirara bet.
- Two Nos. Pull Back / Shipping Tugs.
- Two Nos. Mooring tenders and a harbor tug.
- One Multi-purpose / Oil pollution vessel.

In addition to the above mentioned Port facilities, well developed infrastructural facilities such as adequate power supply units, adequate water supply units, residential complexes, sewage & drainage system and rail and road net work also exist. While at Vadinar, the Crude Oil discharge facilities is directly connected by inter state across the country pipeline from the IOC tank terminal at Narora bet to Koyali, Mathura and Panipat Refineries with branching at Viramgam and Mathura.

2.3 Port activities

The significant Port activities with particular reference to vulnerability to probable oil spills are as follows:-

Vadinar –

- Waiting of ships at Outer Anchorage at Vadinar
- Crude Oil discharge operations from SBM No.1 & 2 at Vadinar.
- Port craft maintenance operations at Vadinar Port Craft Jetty.
- Ships running aground due to loss of engine control or adverse Weather
- Ship to ship collision due to engine control failure or poor visibility associated with malfunctioning of navigational aids like Radar/ARPA system.

Kandla –

- Waiting of ships at outer anchorage at Kandla.
- Discharge of liquid chemicals and POL through pipelines from Old Kandla Oil Jetty complex to various tank farm complexes belonging to PSU Oil Companies and private sector liquid chemical storage complexes.

- Loading and discharge of dry bulk/break bulk cargoes at the General Cargo Berths.
- Maintenance operations of Port crafts at Steel Floating Dry Dock and at the Port craft Berthing Jetty.
- Ships running aground due to loss of engine control or inclement weather.
- Ship to ship collision due to engine control failure or poor visibility associated with malfunctioning of navigational aids like Radar/ARPA system.

2.4 Local environmental conditions

The local environmental conditions at Kandla Port attract significant consideration with respect to Oil spill prevention, response and mitigation activities owing to the mega tidal domain and the meteorological parameters. In the event of any oil spill, the slick dimensions and the direction of its progradation are dependent on sea surface winds and surface currents. In order to make onsite assessment, the meteorological data recorded at Kandla Observatory is placed at Annexure-I.

Tides and currents – Consequent to the large tidal range, the Port experiences high magnitude tide currents both during ebb and flow (of the order of 3.0 to 3.6 meters per second). Annexure-II illustrates detailed information of tide levels and tidal streams observed at Kandla and Vadinar.

Waves – Kandla Port area being located on the West Bank of Kandla creek which, emerges from the extreme eastern margin of the Gulf of Kutch is well protected from wave action. The significant wave height measures 2.20 mtrs. However, occasionally due to prevailing winds, wind generated waves and associated swells can reach maximum height of 3.5 mtrs.

Wind – The plan area experiences predominantly WSW winds for over
months in the year and NE winds are experienced during October
December. The WSW winds tend to push the berthed vessels away from th
berths whereas the NE winds tend to push the vessels on to the berth thereb
causing probable damages to the ship's side or the port structure.

Turbidity – Due to very high background value of SPM, the waters
Kandla are turbid round the year. Presence of SPM in the creek wate
enables any event of oil spill to coagulate faster and act as a natural disperce
This aspect protects the Kandla creek system from ecological perturbanc
naturally.

Rainfall – Precipitation in the region of plan area is generally categoriz
under "Scanty rain fall". The major source of rainfall for this region is from
residual southwesterly monsoon clouds. The average rain fall in the regi
measures 400 mm. Per annum.

3. Existing Oil Spill Contingency System at Kandla Port

3.1 Communication system and Reporting procedures –

Communication System

Kandla Port Trust Had established 3 Emergency Response Centre (ERC) which are equipped with a state of art Communication systems. These are located at Administrative Office Building at Gandhidham, Port & Customs Building at Kandla and at Vadinar Port Office. The three ERCs are provided with uninterrupted power supply and are designed for round the clock and round the year operations. The communication system installed in these units include the following:-

- VHF communication system
- P & T Telephones
- Fax facility
- Intercom connection
- Planet – 1 satellite telephone system
- Multimedia P.C. with Internet
- UHF communication system
- Mobile phone (to the officers In-charge of the ERC units & above.)

In addition to the above mentioned communication systems, the Kandla ERC is equipped with Cyclone Warning Dissemination System (CWDS) of IMD. Xerox, transistor Radio and television sets are also provided at all the three ERCs. Details of the above mentioned communication system together with the contact numbers of the resource personnel of the OSRT is placed at Annexure-III & IV.

Reporting procedures

The port operational areas are extensively traversed by Port cra henceforth, the field staff and officers particularly Pilots, Tug Masters Marine Engineers are instructed to report any occurrence of oil spill to nearest ERC in the format shown at Annexure-V. The ERC in turn, convey particulars of oil spill event to the Oil Spill Response Team (OSRT), which immediately attempt to reach the site of spill occurrence and commen response and mitigative action. The response activities basically include :-

- Detecting the spill and establishment of its current location
- Estimation of the extent and assessment of the oil spill in terms of quantity
- Assessment of the probable direction of slick's progradation
- Selection of appropriate interception mechanism/ mitigative measures
- Mobilization of resources and execution of actual cleanup operation
- Investigation and report generation.

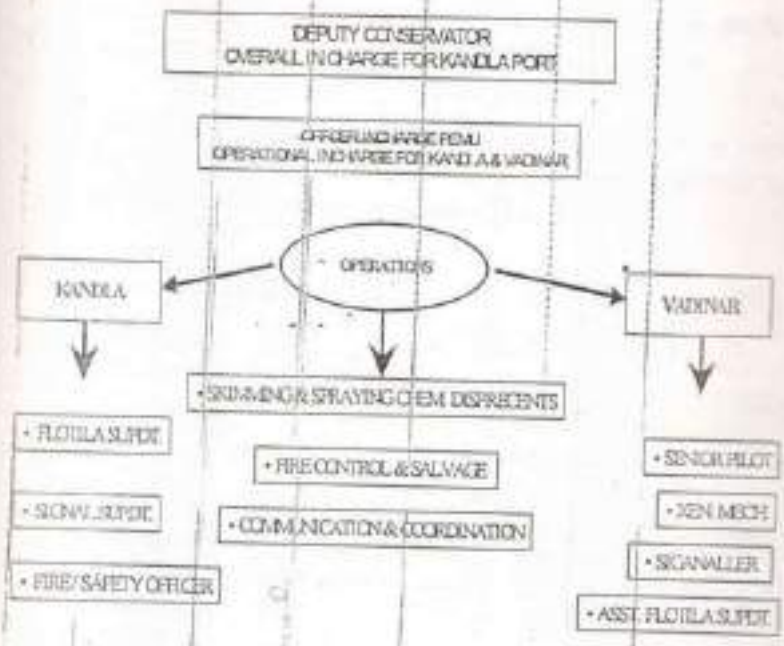
The OSRT, on reaching the site, shall commence their response activities w the preparation of standard POLREP message in the format placed Annexure-VI.

3.2 Oil Spill Response Team set up

The overall in-charge of the Oil Spill Response Team is Dy. Conservato and the operational In-charge of Response Team is lead by the Director of Po Environmental Management Unit. The Oil Spill Response Team is an inter divisional unit of Marine Department, drawn from trained personnel of Flotill Section, Fire Brigade and Environmental Management Unit, coordinated by the Director, Port Environment Management Unit. The organogram is as under :-

ORGANOGRAM

OIL SPILL RESPONSE ORGAINSATION STRUCTURE



3.3 Oil Spill Response Equipment & Accomplishments

- Standing stock of 5000 liters of chemical dispercents approved by the NIO/ZSI (separate inventories for Vadinar and Kandla are maintained). Adequate inventories are also maintained on Board Agni Shanti, Anti Pollution Vessels – Karishma at Kandla and Sagarika at Vadinar.

- MV SAGARIKA and MV KARISHMA are Oil & floating debris recovery vessels fitted with skimmer and dispercent spraying booms.

- Two Oil-cum-Debris recovery vessels namely MV Sagarika (Vadinar) and MV Karishma (Kandla) with the following systems/capabilities for oil spill recovery operations and floating garbage collection:

• Speed in picking up oil spill	- 0 – 2 knots
• Slope tank	- 25 m3
• Dispercent tank	- 1.0 m3
• Oil skimmer	- 30 m3
• Capacity of Oil Recovery	- 30 t/hrs.
• Capacity of garbage recovery	- 1.0m3/hrs
• Garbage tank capacity.	- 4 cu.mtrs.
• Recovered Oil/Slop/Transfer pump	- 30 Cu.M./hrs. with a standby pump of same capacity.

3.3 Oil Spill Response Equipment & Accomplishments

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• Capacity of Oil Recovery	- 30 t/hrs.
• Capacity of garbage recovery	- 1.0m3/hrs
• Garbage tank capacity.	- 4 cu.mtrs.
• Recovered Oil/Slop/Transfer pump	- 30 Cu.M./hrs. with a standby pump of same capacity.

3.4 Oil Spill Response Fleet of Kandla Port

VADINAR

Sr. No.	NAME OF THE PORT CRAFT	BULLADR PULL IN TONNES	TYPE OF VESSEL
1	❖ MV SAGARIKA	—	MULTI PURPOSE ANTI POLLUTION VASSEL
2	❖ MT GAJ RAJ	35.0	MARINE TUG
3	❖ MT BANNI	7.5	MARINE TUG
4	❖ MT SURAJBARI	5.0	MARINE TUG
5	MT KUTCH KESARI	40.0	MARINE TUG
6	MT VADINAR	5.0	MOORING TENDER

KANDLA

1	❖ MV KARISHMA	—	MULTI PURPOSE ANTI POLLUTION VASSEL
2	❖ FF AGNI SAINTHI	—	FIRE FLOAT
3	❖ MV KARISHMA	—	MULTI PURPOSE ANTI POLLUTION VASSEL
4	❖ MT KALINGA	35.0	MARINE TUG
5	❖ MT HEERA	35.0	MARINE TUG
6	❖ MT MEHUL	35.0	MARINE TUG
7	❖ MT CHEETAH	35.0	MARINE TUG
8	MT MEKAN	19.0	MARINE TUG
9	MT JUMBO	19.0	MARINE TUG
10	❖ MT SIKANDAR	19.0	MARINE TUG
11	❖ MT GALPADAR	7.5	HARBOR TUG
12	ML NIRISHAK	—	SURVEY LAUNCH
13	ML SURVESHAK	—	PILOT CUM SURVEY LAUNCH
14	ML LIZA	—	PILOT LAUNCH
15	ML TAPKESHWARI	—	PILOT LAUNCH
16	ML SHAKTI	—	G S LAUNCH
17	ML ROSE	—	G S LAUNCH
18	ML RAGINI	—	G S LAUNCH
19	ML MRINAL	—	G S LAUNCH
20	ML UNNATI	—	MOORING LAUNCH
21	ML VAISHALI	—	MOORING LAUNCH
22	ML MEGHA	—	MOORING LAUNCH
23	ML PRIYADRASHNI	—	MOORING LAUNCH
24	ML MRIGNAYANI	—	MOORING LAUNCH
25	ML VIJAY	—	MOORING LAUNCH

❖ INDICATES THAT THE VESSEL IS FITTED WITH CHEMICAL DISPERCENT SPRAYING BOOMS

4. Oil Spill Response System Upgradation Plan (near future)

4.1 Procurement of equipment (Oil spill containment boom system)

In view of the fragile echo system along the coastline of southern Gu Kutch it is essential to upgrade the Oil Spill Response system of Kandla Po State level Review Committee headed by the Chief Secretary to Government of Gujarat with regard to Oil Spill Prevention Preparedn measures in the Gulf of Kutch has emphasized this aspect in January, 20 Further, the NOS-DCP prepared by the Indian Coast Guard stro recommended that the Port Establishments in the region should eq themselves with adequate Oil spill containment boom systems.

Appropriate skimmers should also compliment these systems w adequate tank space for recovery of the spilled oil to tackle accidental oil spil the Tier level 1 & 2.

The Indian Coast Guard through its NOS-DCP also made its emphas on inter-institutional cooperation. In view of the above, Kandla Port proposes procure 500 meters of inflatable Oil spill containment boom system.

Details of proposed Oil spill containment boom system:

- Two sets of Diesel powered hydraulically operated Reel mounted inflatab boom systems are proposed to be installed on a suitable vessel wit adequate tank space for collection the recovered oil. The vessel shall be o a long-term charter preferably 3 to 5 years and shall be manned by the trained personnel on contract terms. In the vicinity of SBM operations, this vessel shall be kept in readiness at all times.

- The above mentioned system is contemplated as the same is compatible to the Oil spill containment system of RPL marine Terminal at Sikka. This aspect also satisfies the vision of inter-organizational cooperation if need arises (in the event of a Tier 3 level disaster).

- Within the purview of threat perception, logically evaluated scenario inclusive of worst disastrous situation which can result in oil spill in the context of Kandla Port operations are listed below:

  ✓ Ship accidents resulting in containment failure of ships' cargo/ships' own fuel oils due to :
  - ⇒ grounding and listing of ships
  - ⇒ ship to ship coalition
  - ⇒ ship colliding with SBM/Port structures

  ✓ Hose burst due to
  - ⇒ Failure of floating hose connection (ship to SBM.)
  - ⇒ Failure of under buoy hose
  - ⇒ Failure of valve systems
  - ⇒ Major structural failure of ships during severe sea conditions.
  - ⇒ Hose burst during transshipment/lighterage operations.

4.2 Oily waste reception facilities

The Government of India, is a signatory to MARPOL 73/78. The various annexes of the Convention having been ratified, particularly Regulation 12 of Annexure-I, it is required to create Oily waste reception facilities at Ports where the crude oil is loaded into Oil Tankers or all Ports having ship repair yards and tank cleaning facilities. In view of the above and various other Clauses under Regulation 12 of Annexure-I, Kandla Port had installed a 450 ton capacity tank near Old Kandla complimented with tank lorry. Despite the facility having been provided in Kandla Port, except for one instance, the system was not utilized

optimally to its capacity. The probable reasons for the under utilization of the system may be due to the following reasons:

- Very high berth occupancy
- Non-availability of Oily based reception barges with the Port
- Ambiguity which persists with regard to treatment of oily waste and ultimate disposal.
- Conflicting use of Custom Department with regard to duties on oily waste.

In view of the above probable reasons, the shipping industry perhaps was not motivated to optimally utilize the facility provided by Kandla Port.

Status quo remaining thus and with a futuristic overview, the Port Authorities have reviewed and discussed the issue with other Ports namely, Mumbai, JNPT and Chennai Ports and arrived at the following conclusions:

- That it will be apt for Kandla Port to declare the oily waste reception facility as open to private operators with valid license from the State/Central Pollution Control Board.

- These operators should essentially possess oily waste reception barges, tank lorries and a terminal point from where they can receive/discharge oily waste into a transit storage tank.

- Kandla Port may also contemplate providing infrastructural facilities to the parties who are interested in setting up oily waste treatment plants for the ultimate disposal of oily waste. In connection with the above, a press release is being issued in the leading newspapers.

Note:

At present, for the purpose of emergency, there are two private companies operating tanker barges with valid Port Craft License issued by Kandla Port Trust. These barges are available on hire. The particulars of the said companies are as follows:

Name of the company	Address	Contact person	Tel. No.
M/s. Jalsu Shipping Co.	Kewalramani House, Behind Seva Sadan-II, New Kandla	Mr. Suresh Kewalramani	(02836) 70828
M/s. A.V.Joshi & Co.	Maitri Bhavan, Plot No.18, Sector-8, Gandhidham	Mr. Ramesh Singhvi	(02836) 31388 31899

4.3 System to monitor sea surface currents on a regional scale

Surface current monitoring on a regional scale attains a great deal of importance in tracking oil slicks and in mitigating the adverse effects of oil spills. In view of the above it is proposed to acquire a system which operates on RADAR frequencies. The system is capable of logging data into a PC and covers an area of 30 Km radius from the location of the sensor with resolution cells of 100 m^2. Data thus obtained will be useful for analyzing complex circulation pattern off the creek mouths, which emerge from the Gulf of Kutch. This kind of analysis also enables successful investigations leading to identification of point sources of oil spill.

METEOROLOGICAL INFORMATION - KANDLA PORT

MAXIMUM TEMPERATURE	44.4 C	
MINIMUM TEMPERATURE	7.20 C	
MAXIMUM WIND VELOCITY	180 KmPH NNW (09-	
MAXIMUM GUST	200 KmPH NNW (09-	
AVERAGE RAINFALL	400 mm	
MINIMUM ANNUAL RAINFALL	75.60 mm	
MAXIMUM ANNUAL RAINFALL	1393 mm (1979)	
MAXIMUM RELATIVE HUMIDITY	100%	
MINIMUM RELATIVE HUMIDITY	01%	
MINIMUM DEW POINT	-33.30 C	
RANGE OF SEA WATER TEMPERATURE	16.8 C to 31.8 C	
RANGE OF SEA WATER SPECIFIC GRAVITY	1.001 to 1.034	
RANGE OF S P M IN SEA WATER	94 TO 863 mg/L	
RANGE OF SALINITY a)	8.50 TO 39.20 ppt (Aug 86)	
b)	41.40 TO 47.80 ppt (Nov 86)	
c)	42.20 TO 50.50 ppt (Feb 87)	

SEASONAL WIND DIRECTION

JAN TO FEB	N/NNW/ENE
MAR TO SEP	SW/WSW
OCT TO DEC	N/NNE

WAVE DATA OBSERVED AT GTS

SIGNIFICANT WAVE Ht.	2.20 m
HIGHEST WAVE Ht.	3.70 m
AVERAGE WAVE PERIOD	3 TO 15 SEC

PARTICULARS OF WIND GENERATED ANAMALOUS SEA WAVE:

DATE: 09-06-1990

DURATION: 0915 hrs. TO 1715 hrs

FETCH: >65 Km.

AVERAGE WIND VELOCITY: 180 TO 200 kmph (ESTIMATED)

WIND DIRECTION: 0915 TO 1315 hrs. WSW - LULL PERIOD 15 Minutes - 1230 TO 1715 hrs. NE

MAX. RAISE IN SEA LEVEL: 9.50 m. ABOVE C.D. AT 1440 hrs.

MONTH WISE AVERAGED METEOROLOGICAL DATA OF NEW KANGLA OBSERVATORY

LATITUDE = 23.03 N

LONGITUDE = 70.13 E

AVERAGED FOR THE YEARS 1973 – 1980

INDIA NO. 42939

FIRST RAINY DAY :

LAST RAINY DAY :

KPT	TEMPERATURE						WIND SPEED				AVERAGE PRESSURE		AVERAGE HUMIDITY		RAIN FALL	
MONTH	AVG.MAX. °C	DAY OF MONTH	MAX. °C	AVG.MIN. °C	DAY OF MONTH	MIN. °C	AVERAGE Km.P.H	DAY OF MONTH	MAX. Km.P.H	WIND DIR.	0830 Hrs mb	1230 Hrs. mb	0815 Hrs.(%)	1715 Hrs.(%)	TOTAL Inches.(mm)	RAINY DAYS
1	2	3	4	5	6	7	8	9	10		11.0	12.0	13	14	15	16
JAN	26.36	—	31.70	14.06	—	9.70	11.70	—	43.00	—	1017.2	1014.3	60.00	39.30	0.10	—
FEB	27.54	—	34.56	15.90	—	9.00	11.10	—	65.00	—	1015.3	1012.1	59.60	37.50	0.76	—
MAR	31.28	—	37.80	20.15	—	13.00	13.50	—	55.00	—	1013.3	1010.0	69.63	41.13	0.04	—
APR	34.62	—	42.60	23.63	—	18.50	17.22	—	55.00	—	1009.8	1006.8	73.78	45.11	0.89	—
MAY	35.23	—	42.10	33.03	—	19.80	21.44	—	60.00	—	1007.1	1004.1	77.00	55.11	4.60	—
JUN	35.14	—	41.10	27.96	—	24.20	21.69	—	71.00	—	1002.3	999.6	77.22	61.67	65.69	—
JUL	32.66	—	37.60	27.20	—	23.00	20.60	—	56.00	—	1001.8	999.6	*81.70	67.90	158.25	—
AUG	31.32	—	37.60	26.02	—	23.00	20.60	—	80.00	—	1003.2	1000.7	84.70	71.20	191.15	—
SEP	33.10	—	40.20	25.76	—	22.00	15.80	—	50.00	—	1008.0	1005.1	79.70	59.10	50.97	—
OCT	34.25	—	40.10	24.10	—	18.00	10.89	—	55.00	—	1012.2	1009.1	69.40	45.70	8.68	—
NOV	30.51	—	37.60	19.93	—	13.80	9.22	—	100.00	—	1014.7	1011.7	63.33	44.67	34.34	—
DEC	24.54	—	33.60	15.35	—	7.80	10.50	—	39.00	—	1017.2	1014.3	56.00	40.30	2.01	—
AVERAGE	31.38		38.08	23.76		16.88	15.39		69.75		1010.2	1007.3	71.00	50.47		
MAX. :			42.60						100.00		1017.2	1014.3				
MIN. :						7.60										
TOTAL:															0.17	

MONTH WISE AVERAGED METEOROLOGICAL DATA OF NEW KANDLA OBSERVATORY

LATITUDE = 23.03 N

LONGITUDE = 70.13 E

YEAR : [illegible]

INDEX NO 42838

FIRST RAINY DAY : [illegible]

LAST RAINY DAY : [illegible]

KEY	TEMPERATURE						WIND SPEED				AVERAGE PRESSURE		AVERAGE HUMIDITY		RAIN FALL	
MONTH	AVG.MAX. °C	DAY OF MONTH	MAX. °C	AVG.MIN. °C	DAY OF MONTH	MIN. °C	AVERAGE Km.P.H	DAY OF MONTH	MAX. Km.P.H	WIND DIR.	0830 Hrs mb	1730 Hrs. mb	0830 Hrs (%)	1730 Hrs (%)	TOTAL (mm.)	RAINY DAYS
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
JAN	24.8	30	29.2	11.0	23	10.5	10.0	20	18.0	N	1015.2	1013.3	71.0	51.0	0.0	0.0
FEB	27.6	23	31.8	16.2	9	11.7	9.0	14	21.0	SW	1016.5	1013.6	64.0	40.0	0.0	0.0
MAR	31.5	30	35.9	20.3	1	15.3	11.0	23	17.0	SSW	1013.0	1009.7	35.0	42.0	0.0	0.0
APR	34.2	30	37.1	21.6	3	18.7	14.0	28	29.0	WSW	1011.1	1007.2	65.0	45.0	0.0	0.0
MAY	35.9	20	41.6	25.7	4	21.0	20.0	28	30.0	SW	1006.9	1003.1	72.0	53.0	0.0	0.0
JUN	34.8	8	40.2	27.7	9	24.9	20.0	11	33.0	E	1001.5	1000.3	77.0	58.0	43.4	4.0
JUL	32.2	18	34.9	26.7	24	23.7	21.0	31	40.0	SW	1002.6	1000.4	82.0	69.0	226.4	17.0
AUG	31.9	22	33.9	26.0	22	24.4	19.0	1	38.0	SW	1004.5	1001.9	84.0	70.0	67.0	8.0
SEP	33.6	21	35.6	26.0	28	24.3	14.0	5	30.0	SW	1008.4	1005.2	78.0	56.0	7.4	3.0
OCT	34.6	8	37.4	24.0	28	22.0	9.0	11	21.0	SSW	1012.4	1008.8	69.0	40.0	0.0	0.0
NOV	31.7	1	36.1	20.9	28	17.8	8.0	30	16.0	NNE	1016.5	1013.0	58.0	38.0	0.0	0.0
DEC	26.6	7	30.4	15.8	27	7.2	9.0	26	20.0	NNE	1018.1	1014.8	59.0	44.0	0.0	0.0
AVERAGE	31.6		34.4	22.0		18.6	13.7		26.1		1010.7	1007.5	67.0	50.5		
MAX.			41.60						40.00		1018.1	1014.8				
MIN.						7.20										
TOTAL															344.2	12.0

MONTH WISE AVERAGED METEOROLOGICAL DATA OF NEW KANDLA OBSERVATORY

LATITUDE = 23.01 N YEAR: 1990

LONGITUDE = 70.13 E

INDEX NO. 42639

FIRST RAINY DAY: 27-02-89

LAST RAINY DAY: 30-10-89

MONTH	TEMPERATURE						WIND SPEED				AVERAGE PRESSURE		AVERAGE HUMIDITY		RAIN FALL	
	AVG.MAX. °C	DAY OF MONTH	MAX. °C	AVG.MIN. °C	DAY OF MONTH	MIN. °C	AVERAGE Km P.H	DAY OF MONTH	MAX. Km P.H	WIND DIR.	0830 Hrs mb	1730 Hrs. mb	0815 Hrs.(%)	1715 Hrs.(%)	TOTAL W(mm.)	RAINY DAYS
1	2	3	4	5	6	7	8	9	10		11.0	12.0	13	14	15	16
JAN	27.9	24	32.7	15.3	2	12.8	9.0	27	32.0	SSW	1017.5	1014.5	65.0	37.0	0.0	0.0
FEB	28.0	7	32.9	17.7	2	13.0	10.0	17	46.0	SSW	1014.7	1011.6	66.0	41.0	29.8	1.0
MAR	30.6	19	37.5	19.3	1	14.6	11.0	22	40.0	SSW	1013.9	1010.8	67.0	34.0	10.4	1.0
APR	34.0	30	35.9	23.4	5	21.1	16.0	20	46.0	SSW	1009.3	1005.8	77.0	51.0	0.0	0.0
MAY	35.2	23	38.1	27.4	7&8	25.4	20.0	14	47.0	SSW	1005.6	1001.8	75.0	55.0	0.0	0.0
JUN	35.2	1	38.3	28.4	25	27.7	22.0	14	48.0	SSW	1002.8	999.7	76.0	58.0	3.3	3.0
JUL	32.0	18	33.5	27.3	28	26.2	26.0	10	64.0	SW	1001.7	999.8	78.0	67.0	15.8	11.0
AUG	31.2	16	34.5	26.1	25	24.2	18.0	12	46.0	SW	1004.3	1001.9	85.0	73.0	200.6	16.0
SEP	32.7	21	34.9	26.0	16	24.6	13.0	12	44.0	SW	1007.9	1004.8	83.0	64.0	28.7	6.0
OCT	34.6	11	37.5	24.3	20	20.8	7.0	2	36.0	SE	1012.6	1009.2	67.0	44.0	0.0	0.0
NOV	31.1	2	33.6	20.6	25	17.0	6.0	2	41.0	SE	1015.6	1012.5	65.0	38.0	1.0	1.0
DEC	26.9	2	29.6	16.3	31	7.0	7.0	29	35.0	W	1017.6	1014.5	65.0	45.0	0.0	0.0
																39.0
AVERAGE	31.6		34.9	22.2		19.5	12.8		42.9		1010.3	1007.2	32.4	50.6		
MAX:		***	38.30		***			***	54.00		1017.6	1014.5				
MIN:						7.50										
TOTAL:															289.6	39.0

MONTH WISE AVERAGED METEOROLOGICAL DATA OF NEW KANDLA OBSERVATORY

LATITUDE = 23.01 N

LONGITUDE = 70.13 E

YEAR : 1991

AIDEA NO. 42639

FIRST RAINY DAY : 25-06-91

LAST RAINY DAY : 30-09-91

KPT	TEMPERATURE						WIND SPEED				AVERAGE PRESSURE		AVERAGE HUMIDITY		RAIN FALL	
MONTH	AVG. MAX. °C	DAY OF MONTH	MAX. °C	AVG. MIN. °C	DAY OF MONTH	MIN. °C	AVERAGE Km.P.H	DAY OF MONTH	MAX. Km.P.H	WIND DIR.	0830 Hrs mb	1730 Hrs mb	0818 Hrs.(%)	1718 Hrs.(%)	TOTAL mm.)	RAINY DAYS
1	2	3	4	5	6	7	8	9	10		11.0	12.0	13	14	15	16
JAN	25.5	27	35.6	15.1	1.0	8.9	12.0	7	36.0	BNW	1015.7	1013.6	63.0	35.0	0.0	0.0
FEB	28.1	08	31.9	17.1	17.0	10.7	9.0	15	31.0	N	1014.4	1012.3	27.0	34.0	0.0	0.0
MAR	32.9	29	42.7	21.4	1.0	17.5	10.0	22	37.0	SSW	1010.3	1007.7	60.0	36.0	0.0	0.0
APR	34.0	19	38.4	24.9	3.0	21.8	11.0	8	34.0	SW	1008.0	1005.1	68.0	45.0	0.0	0.0
MAY	34.5	31	40.2	27.0	1.0	26.2	10.0	2	36.0	SSW	1006.0	1003.4	78.0	55.0	0.0	0.0
JUN	34.6	01	42.6	28.8	1.0	26.8	15.0	19	47.0	SW	1000.0	997.8	78.0	66.0	0.0	0.0
JUL	32.8	15	38.0	27.9	27.0	25.6	15.0	4	38.0	SW	999.6	997.5	75.0	68.0	0.2*	1.0
AUG	31.6	24	34.0	27.1	15.0	26.1	14.0	10	30.0	SW	1002.2	1000.5	75.0	66.0	129.4	15.0
SEP	32.3	22	36.1	26.4	29.0	25.0	11.0	3	28.0	SW	1009.8	1006.3	69.0	51.0	28.5	14.0
OCT	35.8	10	38.1	24.1	19.0	22.2	9.0	14	27.0	SW	1009.8	1007.1	66.0	32.0	0.0	0.0
NOV	31.0	01	36.4	20.8	30.0	17.4	9.0	14	16.0	N	1014.7	1011.7	65.0	42.0	0.0	0.0
DEC	27.5	07	31.2	16.7	30.0	12.7	8.0	16	16.0	NNW	1017.6	1014.3	68.0	40.0	0.0	0.0
AVERAGE	18.5		37.1	27.1		20.1	11.1		31.3		1009.0	1006.4	66.0	47.5		30.0
MAX.		***	42.70		***			***	47.00		1017.6	1014.3				
MIN.						8.90										
TOTAL															158.1	30.0

MONTHWISE AVERAGE METEOROLOGICAL DATA OF NEW KANDLA OBSERVATORY

LATITUDE = 23.01 N

LONGITUDE = 70.13 E

YEAR : 1992

FIRST RAINY DAY : 22-06-92

LAST RAINY DAY : 05-09-92

MONTH	TEMPERATURE						WINDSPEED				AVERAGE PRESSURE		AVERAGE HUMIDITY		RAIN FALL	
	AVG.MAX. °C	DAY OF MONTH	MAX. °C	AVG.MIN. °C	DAY OF MONTH	MIN. °C	AVERAGE Km.P.H	DAY OF MONTH	MAX. Km.P.H	WIND DIR.	0830 HRS mb	1730 HRS mb	0830 Hrs(%)	1730 Hrs(%)	TOTAL (mm)	RAINY DAYS
1	2	3	4	5	6	7	8	9	10		11.0	12.0	13	14	15	16
JAN	25.0	11	31.8	14.4	18	10.3	10.0	12	17.0		1018.8	1016.0	65.0	46.0	0.0	0.0
FEB	26.6	25	31.7	17.4	19	10.6	10.0	27	21.0		1015.2	1013.2	69.0	51.0	0.0	0.0
MAR	30.6	22	34.2	19.8	09	17.1	12.0	06	36.0		1014.2	1011.8	75.0	63.0	0.0	0.0
APR	33.4	25	39.7	23.0	17	20.1	14.0	22	23.0		1011.1	1008.3	80.0	68.0	0.0	0.0
MAY	34.8	07	38.2	26.0	01	22.1	20.0	26	32.0		1007.5	1005.5	80.0	66.0	0.0	0.0
JUN	36.2	04	43.0	30.2	01	25.7	24.0	25	46.0		1001.9	998.8	83.0	68.0	28.0	1.0
JUL	34.0	15	38.5	30.3	28	26.5	21.0	31	34.0		1000.1	998.1	86.0	73.0	295.0	11.0
AUG	32.2	10	35.0	28.7	12	26.0	17.0	21	26.0		1002.1	999.7	86.0	72.0	44.0	10.0
SEP	30.8	30	34.5	26.4	26	24.6	16.0	24	20.0		1007.9	1005.1	82.0	59.0	71.7	2.0
OCT	31.4	08	35.4	26.2	31	22.0	9.0	10	22.0		1012.1	1008.9	80.0	59.0	0.0	0.0
NOV	31.0	08	35.0	23.0	27	18.5	8.0	21	16.0		1014.5	1013.3	83.0	56.0	0.0	0.0
DEC	27.7	06	31.8	19.0	14	15.8	7.0	13	14.0		1018.2	1015.3	78.0	46.0	0.0	0.0
AVERAGE	31.2	***	34.9	23.0	***	20.3	14.0	***	25.5		1010.5	1007.9	78.8	60.6		
MAX.			43.00						46.00		1018.8	1016.0				
MIN.						10.30										
TOTAL															438.7	24.0

MONTH WISE AVERAGED METEOROLOGICAL DATA OF NEW KANOLA OBSERVATORY

LATITUDE = 23.01 N

LONGITUDE = 70 13 E

YEAR : 1994

INDEX NO 42939

FIRST RAINY DAY : 13-06-94

LAST RAINY DAY : 15-09-94

KPT	TEMPERATURE						WIND SPEED				AVERAGE PRESSURE		AVERAGE HUMIDITY		RAIN FALL	
MONTH	AVG.MAX. °C	DAY OF MONTH	MAX. °C	AVG.MIN. °C	DAY OF MONTH	MIN. °C	AVERAGE Km.P.H	DAY OF MONTH	MAX. Km.P.H	WIND SER.	0330 Hrs mb	1330 Hrs. mb	0310 Hrs.(%)	1310 Hrs.(%)	TOTAL P(mm.)	RAINY DAYS
1	2	3	4	5	6	7	8	9	10		11.0	12.0	13	14	15	16
JAN	26.5	25	32.2	15.4	16	12.7	09	21	18.0	NNE	1016.5	1013.7	59.0	35.0	0.0	0.0
FEB	27.9	19	31.2	16.9	25	12.1	10	20	36.0	VAR	1014.9	1011.9	60.0	38.0	0.0	0.0
MAR	33.7	18	40.2	21.9	01	18.5	10	26	21.0	SSW	1013.9	1009.9	62.0	38.0	0.0	0.0
APR	33.7	09	37.8	23.8	08	19.1	16	6	37.0	NNE	1010.2	1006.6	73.0	53.0	0.0	0.0
MAY	34.7	15	37.7	25.6	06	22.1	20	25	31.0	WSW	1007.6	1004.3	78.0	60.0	0.0	0.0
JUN	36.0	06	42.7	28.4	16	25.1	18	2	47.0	WSW	1000.6	997.6	78.0	59.0	107.0	9.0
JUL	30.6	04	33.6	26.6	13	23.0	20	6	39.0	WSW	999.9	997.9	83.0	72.0	440.6	22.0
AUG	29.9	31	31.4	25.8	09	24.7	17	9	36.0	WSW	1002.9	1000.1	86.0	74.0	290.7	19.0
SEP	31.0	26	34.6	24.5	10	21.8	13	9	36.0	WSW	1008.2	1005.5	79.0	63.0	191.7	9.0
OCT	34.3	07	36.2	23.7	21	21.1	08	6	18.0	NNW	1013.1	1010.0	75.0	37.0	0.0	0.0
NOV	30.7	01	33.9	19.4	26	16.5	08	22	14.0	N	1016.5	1013.2	78.0	46.0	0.0	0.0
DEC	27.2	05	30.8	14.8	30	11.2	09	15	14.0	N	1018.5	1015.7	80.0	54.0	0.0	0.0
AVERAGE	31.3		35.2	22.2		19.8	0.0		28.9		1010.2	1007.2	74.3	57.6		
MAX.		***	42.70		***			***	47.00		1018.5	1015.7			***	***
MIN.						11.20										
TOTAL															1030.0	59.0

MONTHLY AVERAGED METEOROLOGICAL DATA OF NEW RANDLA OBSERVATORY

LATITUDE = 23.01 N YEAR : 1916

LONGITUDE = 78.13 E

INDEX NO. 42019

FIRST RAINY DAY : 05-03-05

LAST RAINY DAY : 30-12-05

HPT	TEMPERATURE						WIND SPEED				AVERAGE PRESSURE		AVERAGE HUMIDITY		RAIN FALL	
MONTH	AVG.MAX. °C	DAY OF MONTH	MAX. °C	AVG.MIN. °C	DAY OF MONTH	MIN. °C	AVERAGE Km.P.H	DAY OF MONTH	MAX. Km.P.H	WIND DIR.	0830 Hrs mb	1730 Hrs. mb	0818 Hrs.(%)	1718 Hrs.(%)	TOTAL in(mm)	RAINY DAYS
1	2	3	4	5	6	7	8	9	10		11	12	13	14	15	16
JAN	25.3	6	30.9	14.4	19	11.1	9.0	17	21.0	NNE	1016.4	1015.7	81.0	43.0	0.0	0.0
FEB	28.3	9	31.9	16.9	16	15.1	9.0	21	21.0	SSW	1015.2	1013.2	73.0	38.0	0.0	0.0
MAR	30.3	22	36.4	19.6	11	15.5	13.0	9	26.0	NNW	1013.7	1010.6	70.0	39.0	0.2	1.0
APR	34.5	12	37.8	23.6	7	20.1	13.0	15	29.0	WSW	1011.1	1007.6	71.0	38.0	0.0	0.0
MAY	36.8	29	44.0	26.8	2	25.1	19.0	18	32.0	SW	1006.1	1003.5	75.0	59.0	0.0	0.0
JUN	35.7	15	39.0	28.6	3	27.2	22.0	30	34.0	SSW	1002.9	999.8	88.0	65.0	0.0	0.0
JUL	33.1	10	36.7	27.6	17	25.2	19.0	2	38.0	SW	999.9	997.6	86.0	71.0	190.6	19.0
AUG	32.5	31	34.4	26.9	7	24.5	21.0	13	40.0	WSW	1003.7	1001.1	82.0	67.0	11.3	14.0
SEP	34.3	2	38.4	28.2	19	24.7	16.0	4	32.0	WSW	1007.8	1004.7	76.0	56.0	1.4	1.0
OCT	34.4	10	36.6	25.9	31	21.7	9.0	10	10.0	NNW	1011.1	1007.7	70.0	51.0	78.3	3.0
NOV	34.1	12	33.8	20.0	30	14.7	7.0	30	16.0	NNE	1014.6	1011.3	59.0	37.0	0.0	0.0
DEC	27.9	14	30.8	16.6	1	13.1	9.0	8	17.0	NNE	1018.7	1015.7	69.0	51.0	0.2	1.0
AVERAGE	32.3		36.1	22.8		19.8	13.8		26.3		1010.3	1007.3	75.0	51.3		
MAX.		***	44.00		***			***	40.00		1018.7	1015.7			***	***
MIN.						11.1										
TOTAL															282.0	39.0

MONTH WISE AVERAGED METEOROLOGICAL DATA OF NEW RANDLE OBSERVATORY

LATITUDE = 23.01 N YEAR: 1998

LONGITUDE = 70.11 E

INDEX NO. 42630

FIRST RAINY DAY: 15-01-98

LAST RAINY DAY: 11-09-98

SPT	TEMPERATURE						WIND SPEED				AVERAGE PRESSURE		AVERAGE HUMIDITY		RAIN FALL	
MONTH	AVG.MAX. °C	DAY OF MONTH	MAX. °C	AVG.MIN. °C	DAY OF MONTH	MIN. °C	AVERAGE Km.P.H	DAY OF MONTH	MAX. Km.P.H	WIND DIR.	0830 Hrs mb	1730 Hrs. mb	0818 Hrs.(%)	1738 Hrs.(%)	TOTAL M(mm.)	RAINY DAYS
1	2	3	4	5	6	7	8	9	10		11.0	12.0	13	14	15	16
JAN	25.90	13	28.9	14.8	18	9.2	9.0	21	18	SSW	1016.4	1013.6	66.0	41.0	1.1	1.0
FEB	29.20	20	35.3	17.2	5	13.4	9.0	25	32	SW	1014.8	1011.5	64.0	36.0	0.0	0.0
MAR	33.80	20	40.0	22.1	7	18.1	11.0	25	32	WSW	1011.9	1008.3	62.0	35.0	0.0	0.0
APR	35.10	15	41.8	24.3	10	21.0	14.0	21	30	SW	1009.3	1005.9	77.0	48.0	1.8	1.0
MAY	34.90	8	41.2	26.4	6	24.1	20.0	10	48	WSW	1008.1	1005.6	84.0	59.0	8.0	0.0
JUN	34.50	16	39.4	28.2	21	24.3	20.0	14	38	SSW	1002.1	999.2	80.0	64.0	256.0	7.0
JUL	33.50	15	36.8	28.0	8	25.1	18.0	3	30	WSW	1001.6	999.0	87.0	74.0	68.0	10.0
AUG	31.70	24	33.9	25.9	20	21.3	21.0	8	40	WSW	1004.9	1002.5	86.0	75.0	18.5	6.0
SEP	32.90	23	35.5	27.5	21	24.7	16.0	8	40	SSW	1007.3	1004.1	84.0	68.0	8.5	1.0
OCT	34.80	16	38.4	25.1	31	21.6	10.0	24	26	NE	1011.6	1008.5	87.0	44.0	0.0	0.0
NOV	31.20	7	34.6	18.3	21	13.1	7.0	3	20	SW	1015.5	1012.2	62.0	36.0	0.0	0.0
DEC	28.00	3	30.7	15.0	8	11.1	8.0	7	20	NNE	1017.8	1014.6	56.0	39.0	0.0	0.0
AVERAGE	32.83			22.73			13.50		31.7		1010.1	1007.1	73.0	52.0		
MAX.			41.80						48.00		1017.8	1014.6				
MIN.						9.20									313.0	26.0
TOTAL																

MONTH WISE AVERAGED METEOROLOGICAL DATA OF NEW KANSLA OBSERVATORY

LATITUDE = 21.01 N YEAR : 1998

LONGITUDE = 72.13 E

INDEX NO.42639

FIRST RAINY DAY : 08-06-98

LAST RAINY DAY : 12-10-98

KPT	TEMPERATURE						WIND SPEED				AVERAGE PRESSURE		AVERAGE HUMIDITY		RAIN FALL	
MONTH	AVG.MAX. °C	DAY OF MONTH*	MAX. °C	AVG.MIN. °C	DAY OF ONTH*	MIN. °C	AVERAGE Km.P.H	DAY OF MONTH*	MAX. Km.P.H	WIND DIR.	0800 Hrs mb	1730 Hrs. mb	0814 Hrs (%)	1716 Hrs (%)	TOTAL In(mm.)	RAINY DAYS
1	2	3	4	5	6	7	8	9	10		11.0	12.0	13	14	15	16
JAN	25.70	6	29.30	14.10	19	10.80	9.00	17	15.00	NNE	1017.3	1014.6	65.0	36.0	0.00	0.0
FEB	28.40	12	32.90	18.60	20	11.00	10.00	21	20.00	SSW	1015.8	1013.9	73.0	35.0	0.00	0.0
MAR	32.80	22	40.60	21.20	2	16.00	10.00	8	15.00	NNW	1013.8	1010.5	70.0	42.0	0.00	0.0
APR	34.60	5	39.90	25.00	25	21.40	10.00	15	23.00	WSW	1010.8	1007.3	78.0	51.0	0.00	0.0
MAY	36.00	11	40.70	27.80	4	20.00	18.00	18	30.00	SW	1006.6	1003.7	78.0	42.0	0.00	0.0
JUN	34.80	16	42.50	28.00	16	22.00	21.00	50	60.00	SSW	1002.5	999.7	83.0	68.0	50.90	4.0
JUL	32.90	29	35.50	27.40	31	25.50	21.00	2	44.00	SW	1001.7	996.5	86.0	71.0	123.80	16.0
AUG	33.00	24	36.10	25.80	10	25.00	21.00	13	40.00	WSW	1004.3	1002.0	85.0	65.0	37.30	8.0
SEP	34.10	15	38.30	25.50	23	25.00	17.00	4	42.00	WSW	1006.8	1003.5	88.0	61.0	38.20	5.0
OCT	33.70	9	37.70	25.50	22	25.30	8.00	15	34.00	NNW	1010.2	1007.0	83.0	57.0	104.10	3.0
NOV	31.00	3	34.40	20.00	29	16.00	6.00	30	14.00	NNE	1014.8	1011.4	73.0	44.0	0.00	0.0
DEC	27.80	1	30.30	17.10	28	14.10	4.00	8	22.00	NNE	1017.4	1014.5	78.0	46.0	0.00	0.0
AVERAGE	32.19			2287			13.50				1010.2	1007.3	78.17	51.42		
MAX.			42.50						60.00		1017.4	1014.6				
MIN.						10.80										
TOTAL															363.30	38.0

MONTH WISE AVERAGED METEOROLOGICAL DATA OF NEW KANDLA OBSERVATORY

LATITUDE = 23.01 N YEAR : 2008

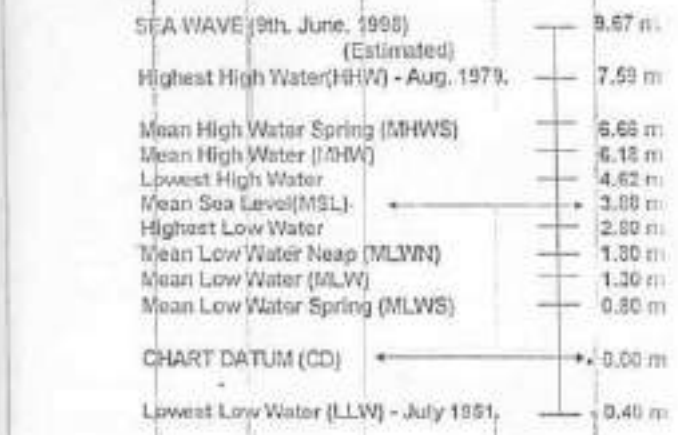
LONGITUDE = 72.13 E

INDEX NO. 42929
FIRST RAINY DAY : 15-02-08
LAST RAINY DAY : 12-10-08

NO.	TEMPERATURE						WIND SPEED				AVERAGE PRESSURE		AVERAGE HUMIDITY		RAIN FALL	
MONTH	AVG. MAX. °C	DAY OF MONTH	MAX. °C	AVG. MIN. °C	DAY OF MONTH	MIN. °C	AVERAGE Km.P.H.	DAY OF MONTH	MAX. Km.P.H.	WIND DIR.	0800 Hrs mb	1200 Hrs. mb	0818 Hrs.(%)	1718 Hrs.(%)	TOTAL in(mm)	RAINY DAYS
1	2	3	4	5	6	7	8	9	10		11.0	12.0	13	14	15	16
JAN	24.3	16	27.9	15.5	22	11.4	4.0	29	30.00	SW	1015.9	1013.3	83.0	54.0	0.0	0.0
FEB	28.8	28	33.8	18.1	2	14.0	6.0	15	46.00	N	1016.0	1013.4	79.0	50.0	27.5	2.0
MAR	32.8	29	37.7	20.9	11	19.3	7.0	16	34.00	SSW	1011.0	1007.7	67.0	43.0	0.0	0.0
APR	36.3	5	41.1	23.7	13	21.8	13.0	27	40.00	SW	1009.1	1005.6	79.0	55.0	0.0	0.0
MAY	34.6	4	38.8	28.4	20	24.3	22.0	30	60.00	S	1005.2	1002.2	79.0	52.0	25.8	3.0
JUN	34.1	14	35.8	26.0	2	23.3	23.0	2	43.00	WSW	1003.5	1001.3	84.0	67.0	24.3	2.0
JUL	33.1	7	36.8	27.6	2	24.8	23.0	28	40.00	SW	1001.2	999.1	82.0	66.0	8.6	6.0
AUG	33.2	15	34.2	26.8	4	25.6	21.0	1	40.00	NW	1008.9	1004.8	78.0	60.0	16.9	6.0
SEP	34.7	28	36.5	26.6	19	20.2	16.0	20	24.00	SW	1006.7	1004.5	74.0	53.0	3.4	2.0
OCT	34.1	8	38.7	25.2	20	22.6	6.0	10	25.00	SSE	1011.0	1006.8	78.0	56.0	132.0	7.0
NOV	33.2	3	36.9	21.8	20	16.7	7.0	10	30.00	SW	1016.7	1012.8	79.0	40.0	0.0	0.0
DEC	27.8	5	30.8	16.3	21	13.8	3.0	11	18.00	NE	1017.2	1013.7	66.0	41.0	0.0	0.0
AVERAGE	31.87			23.87			12.08				1010.2	1003.1	76.58	53.92		
MAX.			43.10						60.00		1017.2	1013.7				
MIN.						11.40										
TOTAL															256.35	29.0

Details of Tide levels and tidal stream

KANDLA PORT TIDE LEVEL REFFERED TO CHART DATUM



PLACE	Lat. N	Long. E	HEIGHT IN METRES ABOVE DATUM				
			MHWS	MHWN	MLWN	MLWS	MSL
KANDLA	23° 01'	70° 13'	6.7	5.7	1.8	0.8	3.5

Tidal stream information of Kandla creek

KANDLA		50 m off Berth No. 5	
Hours		Direction	Rate (Kn) Sp
B	6	100°	0.80
E	5	040°	0.50
F	4	300°	1.5[illegible]
O	3	295°	1.7[illegible]
R	2	270°	1.6[illegible]
E	1	340°	1.1[illegible]
HW		068°	0.2[illegible]
A	1	160°	0.7[illegible]
F	2	250°	1.0[illegible]
T	3	225°	1.3[illegible]
E	4	210°	1.20
R	5	175°	0.0[illegible]
	6	140°	0.45

Tidal stream information at SBM – I

VADINAR		Lat. : 22° 31' 00" N Long.: 69° 41' 30" E		
Hours		Direction	Rate (Kn) Sp	Np
B	6	354°	0.2	0.1
E	5	038°	1.2	0.8
F	4	042°	1.5	1.0
O	3	049°	1.5	1.0
R	2	047°	1.2	0.8
E	1	036°	0.5	0.3
HW		198°	0.4	0.2
A	1	202°	1.0	0.7
F	2	232°	1.3	1.0
T	3	222°	1.4	1.0
E	4	226°	1.3	0.9
R	5	232°	0.7	0.5
	6	310°	0.1	0.1

...s of Emergency Response Centers

FACILITY	A.O.BUILDING, GANDHIDHAM	P & C BUILDING, NEW KANDLA	VARINAR SIGNAL STATION
...LEPHONE	02836 32990	02836 70277 02836 70549	02833 56555
...X	02836 33708	02836 70338	02833 56540
...AIL	kpt@guj1.guj.nic.in	—	—
...NDS OF IMD	—	INSTALLED	—
PLANET-1 SATELLITE PHONE VOICE FAX DATA	762092 777 762092 778 762092 779	762092 789 762092 790 762092 791	762092 786 762092 787 762092 788

ANNEXURE -IV

Contact numbers of resource personnel of the OSRT.:

	Name	Designation	Tel (O)	Tel (R)	Fax
1	KANDLA Capt. P.C.Chaturvedi	Dy.Conservator	33585 20235	34374	35982
	G.Mallikarjun Rao	Coordinator, PEMU	70277	27327	32040
	C.U.Singh	Flotilla Supdt.	70280	30870	
	M.D.Samuel	Fire-cum-Safety Officer	70176 70178	70267	
	Badrinarayan	Signal Supdt.	70194 70549		
	Name	Designation	Tel(O)	Tel(R)	Fax
2	VADINAR S.K.Ketak	Suptd. Engineer	(02833) 56749	(02833) 56522	(02833) 56540
		Senior Pilot	----	----	(02833) 56540
		Asstt.Flotilla Suptd.	(02833) 56574	----	(02833) 56540

Spill Report Form and POLREP Message Format

rticulars of person / organisation :
porting incident

a. Title :

b. Company :

c. Telephone / FAX / Telex No. :

d. Date / Time :

e. Spill location :

f. Type and Quality of oil spill :

g. Cause of spill :

h. Response to spillage, if any :

i. Any other information :

POLREP MESSAGE FORMAT

(See amplification in succeeding table)

Reference : IMO - 560 (1995)

Address
Date
Identification
Serial Number

From ..... To .....
Time Group

1.	Date and time
2.	Position
3.	Incident
4.	Outflow
5.	Acknowledge
40.	Date and Time
41.	Position
42.	Characteristics of pollution
43.	Source and cause of pollution
44.	Wind direction and speed
45.	Current or tide
46.	Sea state and pollution
47.	Drift of pollution
48.	Forecast
49.	Identity of observer and ships on scene
50.	Action taken
51.	Photographs or samples
52.	Names of other agencies informed
53-59.	Spare
60.	Acknowledge
80.	Date and time
81.	Request for assistance
82.	Coast
83.	Pre-arrangements for the delivery
84.	Assistance to where and how
85.	Other agencies requested
86.	Change of command
87.	Exchange of information
88.	Names and number of
89.	Description of equipment
90.	ETA and arrival information
91.	Place of embarkation
92.	Place of disembarkation
93-98.	Spare
99.	Acknowledge

PART III (POLFAC)

CONTENTS	REMARKS
51 REQUEST FOR ASSISTANCE	Type and amount of assistance required in the form of - specified equipment - specified equipment with trained personnel - dispersible strike teams - personnel with special expertise with indication of country requested
52 COST	Requirements for cost information to requesting country of delivered assistance
53 PRE ARRANGEMENTS FOR THE DELIVERY OF ASSISTANCE	Information concerning customs clearance, access to territorial waters, etc. of the aid country.
54 TO WHOM ASSISTANCE SHOULD BE RENDERED AND HOW	Information concerning the delivery of the assistance, e.g. rendezvous a[illegible] frequencies to be used, call sign and name of Supreme On-Scene Co[illegible] country, or land-based authorities with telephone number, telex number a[illegible]
55 NAMES OF OTHER STATES AND ORGANIZATION	Only to be filled in if not covered by figure 41, e.g. if further assistance [illegible] States.
56 CHANGE OF COMMAND	When a substantial part of an oil pollution or serious threat of oil pollution [illegible] into the zone of another Contracting Party, the country which has assumed [illegible] commander of the operation may request the other country to take over the [illegible]
57 EXCHANGE OF INFORMATION	When a mutual agreement has been reached between two parties on a [illegible] the country crossboring the supreme command should give a report on all [illegible] to the operation to the country taking over the command.
58-99	SPARE FOR ANY OTHER RELEVANT REQUIREMENTS OR INSTRUCTIONS
99 ACKNOWLEDGE	When this figure is used the table should be acknowledged as soon as possible [illegible] national authority.

ANNEXURE – L

ISO 14001:2015 certificate

Your Quality Partner

JOVIAL

Certificate of Registration

This is to certify that

Environmental Management System

of

Deendayal Port Authority

Administrative Office Building,
Post Box No.50,
Gandhidham (Kutch)-370 201.
Gujarat State, INDIA.

complies with the requirements of

ISO 14001 : 2015

This certificate is valid concering all activities related to

"Providing Port Facility and Related Maritime Services for Vessels and Cargo Handling Including Storage."

Jan. 01, 2020
Date of Initial Registration

Jan. 02 2023	Jan. 02, 2026	E:201051	
Date of Issue	*Valid untill**	*Certificate No.*	*Managinig Director*

JOVIAL CERTIFICATION SERVICES PVT. LTD.

website : www.jovialcertification.com Email : info@jovialcertification.com

GLOBAL ISO

Accreditation by Global Accreditation body for Certification and Training: GABCT Ltd, UK
48 Cheyneys Avenue, Edgware, Middlesex, London HA8 6SF

https://globalaccreditation.co.uk/certifiedorganizations

This Certificate is only valid if it is Available / Valid on Jovial Website at https://jovialcertification.com/clientregister
The Certificate of Registration remains the property of Jovial Certification Services Pvt. Ltd.
and Shall be returened immidiatly upon suspenssion request.

*In Case if Survelliance Audit is not allowed to be conducted as per schedule, the certificate shall be suspended or withdrawn.

Version 1.2

ANNEXURE – M

Annual Return of Hazardous waste in Form IV

DEENDAYAL PORT AUTHORITY
(Erstwhile: DEENDAYAL PORT TRUST)

Administrative Office Building
Post Box NO. 50
GANDHIDHAM (Kutch).
Gujarat: 370 201.
Fax: (02836) 220050
Ph.: (02836) 220038

www.deendayalport.gov.in

Date: 19/06/2023

EG/WK/EMC/CCA/ Part(III)/ 325

To,
The Member Secretary
Gujarat Pollution Control Board
Paryavaran Bhavan,
Sector 10A, Gandhinagar - 382010

Sub: Submission of Annual Return of Hazardous waste in format form IV for the financial year 2022-23 reg.

Ref.:
1) KPT letter no. EG/WK/4660(EC)/549 dated 20/6/2012
2) KPT letter no. MR/GN/1527(Part I)/2012 dated 20/5/2013
3) KPT letter no. MR/GN/1527(Part I)/336 dated 17/05/2014
4) KPT letter no. MR/GN/1527/ (Part I)/dated 27/04/2015
5) KPT letter no. EG/WK/EMC/CCA (Part II)/217 dated 27/6/2016
6) KPT letter no. EG/WK/EMC/CCA (Part II)/213 dated 19/6/2017
7) DPT letter no. EG/WK/EMC/CCA (Part II)/294 dated 13/6/2018
8) DPT letter no. EG/WK/EMC/CCA (Part II) dated 27/5/2019
9) DPT letter no. EG/WK/4751 (CCA Renewal) dated 22/5/2020
10) DPT letter no. EG/WK/4751 (CCA Renewal)/13 dated 30(4)/4(5)/2021
11) DPT letter no. EG/WK/4751 (CCA Renewal)/131 dated 06/07/2022

Sir,

It is requested to kindly refer above cited references for the said subject.

In this connection, it is to state that, the Deendayal Port Authority had obtained renewal of consent order from the GPCB Vide order no. AWH - 110594 dated 22/01/2021 valid up to 21/07/2025 for Deendayal Port Authority area.

In this regard, as per statutory requirement, the DPA has regularly submitted Annual Returns (as mentioned in reference above) in format Form IV to the GPCB.

Now please find the enclosed herewith Annual Return of Hazardous Waste in Form IV for the year 2022-23

This is for kind information and record please.

Encl: As above

Yours faithfully

Manager (Environment)
Deendayal Port Authority

Enclosure – A

Annual Return of Hazardous waste Return (Form IV)
For Deendayal Port Authority, Kandla
For the FY @ 2022-2023

"FORM-IV"

[(See rule 6(%), 13(8), 16(6) and 20(21)
(To be submitted to State Pollution Control Board by 30th day of June of every year for the preceding period April 22 to March 23)

Sr. No.	Particulars	Details
1.	Name and Address of the Facility	**Deendayal Port Authority** Administrative Office Building Post Box No. 50 Gandhidham Dist.: Kutch- 370201 Gujarat State Tel. No.: 02836-233192 Fax No.: 02836-220050
2.	Authorization No. and Date of issue	Consent order no. AWH – 110594 granted by the GPCB dated 22/01/2021 and correction to consent order done dated 09/04/2021
3.	Name of Authorized Person and full address with telephone, Fax number and E-Mail	**Mr. Raveendra Reddy** **Chief Engineer** **Deendayal Port Authority** Administrative Office Building Post Box No. 50 Gandhidham Dist.: Kutch- 370201 Gujarat State Tel. No.: 02836-233192 Fax No.: 02836-220050
4.	Production during the year (product wise) wherever applicable	NA Deendayal Port Authority has only loading & unloading activities for dry cargo and liquid cargo. During FY 2022-23 Total Cargo Handled is **137.5** MMTPA

PART A. To be filled by Hazardous Waste Generator

1.	Total quantity of waste generated category wise	Used oil/Waste residue containing oil 1. **Used Spent Oil:** 4758.79 MT 2. **Waste residue containing oil:** 9157.58 MT
2.	Quantity Dispatched a. To disposal Facility b. To recycler or co-processor or pre-processor c. Others	Used Oil/Waste residue containing oil has been disposed of through CPCB/GPCB authorized vendor (Annexure-1)
3.	Quantity utilized inhouse -if any	NA
4.	Quantity in storage at the end of the year	NA

PART B To be filled Treatment, Storage and Disposal Facility Operator

1.	Total Quantity Received 1. Direct Landfill 2. Incineration 3. Land fill after treatment	NA
2.	Quantity at stock at the beginning of the year 1. Direct Landfill 2. Incineration 3. Land fill after treatment	
3.	Quantity treated (Landfill) Land fill after Treatment	
4.	Quantity disposed in landfill as such and after treatment 1. Direct Landfill 2. Land fill after treatment 3. Incineration Ash 4. Salts from Spray Dryer 5. Total	
5.	Quantity incinerated (if applicable)	
6.	Quantity processed other than specified above	
7.	Quantity in storage at the end of the year 1. Incineration 2. Landfill after treatment	

PART C To be filled by recyclers or co-processor or other users

1.	Quantity of the waste received during the year 1. Domestic sources 2. Imported (if applicable)	NA
2.	Quantity in stock at the beginning of the year	
3.	Quantity recycled or co processed or used	
4.	Quantity of products dispatched (wherever applicable)	
5.	Quantity of waste generated	
6.	Quantity of waste disposed	
7.	Quantity re-exported (wherever Applicable)	
8.	Quantity in storage at the end of the year	

Manager (Environment)

Deendayal Port Authority

Date: 13/06/23

Place : Gandhidham

DEENDAYAL PORT AUTHORITY - MARINE DEPARTMENT

Statement of Hazardous & Non Hazardous Waste disposal from the vessels at Kandla & Vadinar Port Year 2022-23

Sr.No.	MONTH	HAZARDOUS WASTE DATA for FY 2022-23		
		Total	Used spent Oil	Waste residue containing oil
		Quantity Disposed (MT)		
1	Apr-22	1237.33	412.44	824.89
2	May-22	1285.56	428.52	857.04
4	Jun-22	1568.41	522.80	1045.61
5	Jul-22	1238.46	412.82	825.64
3	Aug-22	1414.94	471.65	943.29
4	Sep-22	872.60	290.87	581.73
5	Oct-22	1210.04	403.35	806.69
3	Nov-22	938.71	312.90	625.81
4	Dec-22	1286.64	428.88	857.76
5	Jan-23	1284.40	428.13	856.27
3	Feb-23	762.19	254.06	508.13
4	Mar-23	637.09	212.36	424.73
Total	--		***4578.79***	***9157.58***
Total Hazardous waste Genreted for FY 2022-23				***13736.37***

उप संरक्षक
दीनदयाल पत्तन प्राधिकरण
Deputy Conservator
Deendayal Port Authority

Marine Department

Statement showing the Collection and disposal of Hazardous and Non-Harardous Wastes carried out by various parties from April - 2022 to Mar - 2023

No.	Name of Party	Type of Licence	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23	Total
1	Alicid Organic Industries Ltd	Hazardous	-	-	-	-	-	-	-	-	-	-	-	-	-
2	Amar Hydrocarbon Pvt. Ltd	Hazardous	-	-	-	-	-	-	-	-	-	19.00	-	-	19.00
3	Atlas Organics Pvt. Ltd	Hazardous	21.39	35.28	-	-	34.06	-	-	18.80	10.98	-	17.06	-	137.57
4	Aviation Corporation	Hazardous	35.12	50.34	-	-	-	-	-	-	-	-	-	-	85.46
5	Fine Refiners Pvt. Ltd	Hazardous	-	14.50	53.77	21.08	-	20.11	16.32	-	43.56	-	39.65	-	208.99
6	Mahalaxmi Asphalt Pvt Ltd	Hazardous	-	-	-	-	-	-	-	-	-	-	-	-	-
7	Priyansi Corporation	Hazardous	52.91	22.44	11.38	30.33	-	30.65	-	-	17.56	-	49.18	36.05	250.50
8	Revolution Petrochem LLP	Hazardous	874.00	965.00	964.00	710.12	1,058.06	463.81	713.57	524.23	787.61	888.73	339.75	257.12	8,546.00
9	Shana Oil Process	Hazardous	-	-	-	-	-	-	-	-	-	-	-	-	-
10	United Shipping Company	Hazardous	253.91	198.00	539.26	476.93	322.82	358.03	480.15	395.68	426.93	376.67	316.55	343.92	4,488.85
11	Chitrakut Trading & Industries	Non-Hazardous	-	0.16	0.19	0.19	0.17	0.35	6.36	-	31.38	12.42	3.94	16.54	71.70
12	Golden Shipping Services	Non-Hazardous	77.42	38.26	19.63	1.14	30.28	8.36	21.82	26.57	15.06	22.82	18.42	46.48	326.26
13	Green Earth Marine Solution	Non-Hazardous	-	39.72	3.46	2.88	3.24	2.30	-	3.60	-	1.30	2.88	-	59.38
14	Harish A. Pandya	Non-Hazardous	3.58	0.06	3.20	-	-	4.47	1.13	-	0.22	-	5.70	4.89	23.25
15	K M Enterprise	Non-Hazardous	30.15	47.56	57.24	101.56	64.00	35.28	46.08	63.36	72.93	65.02	91.77	41.82	716.77
16	Naaz Shipping Services Ent	Non-Hazardous	-	-	-	-	-	-	-	-	-	10.80	-	-	10.80
17	New India Marine Work	Non-Hazardous	1.44	2.16	-	-	-	-	-	-	-	-	2.16	1.08	6.84
18	Omega Marine Services	Non-Hazardous	350.63	73.10	42.15	-	104.40	25.46	23.69	45.97	53.31	19.80	43.32	23.29	805.12
19	V K Enterpris	Non-Hazardous	23.76	28.08	12.96	10.80	15.12	17.28	10.80	12.96	15.12	10.80	12.96	10.80	181.44
20	Vishwa Trade-link Inc	Non-Hazardous	21.92	11.74	20.65	30.10	29.38	29.88	31.48	35.44	14.59	15.91	10.52	20.02	271.63
		Hazardous Total	**1,237.33**	**1,285.56**	**1,568.41**	**1,238.46**	**1,414.94**	**872.60**	**1,210.04**	**938.71**	**1,286.64**	**1,284.40**	**762.19**	**637.09**	**13,736.37**
		Non-Hazardous Total	**508.90**	**240.84**	**159.48**	**146.67**	**246.59**	**123.38**	**141.36**	**187.90**	**202.61**	**158.87**	**191.67**	**164.92**	**2,473.19**

उप संरक्षक
दीनदयाल पत्तन प्राधिकरण
Deputy Conservator
Deendayal Port Authority

ANNEXURE – N

Environmental Statement in Form V

DEENDAYAL PORT AUTHORITY
(Erstwhile: DEENDAYAL PORT TRUST)

दीनदयाल पत्तन प्राधिकरण
DEENDAYAL PORT AUTHORITY

Administrative Office Building
Post Box NO. 50
GANDHIDHAM (Kutch).
Gujarat: 370 201.
Fax: (02836) 220050
Ph.: (02836) 220038

www.deendayalport.gov.in

EG/WK/4751 (CCA Renewal)/ 326

Date: 19/06/2023

To,
The Member Secretary
Gujarat Pollution Control Board
Paryavaran Bhavan,
Sector 10A, Gandhinagar - 382010

Sub: Submission of Environmental statement in format form V for the financial year 2022-23 reg.

Ref.:
1) KPT letter no. MR/GN/1527(Part I)/535 dated 16/6/2012
2) KPT letter no. MR/GN/1527(Part I)/2011 dated 20/5/2013
3) KPT letter no. MR/GN/1527(Part I)/337 dated 17/05/2014
4) KPT letter no. MR/GN/1527/ (Part I)/dated 27/04/2015
5) KPT letter no. EG/WK/EMC/CCA (Part II)/218 dated 27/6/2016
6) KPT letter no. EG/WK/EMC/CCA (Part II)/214 dated 19/6/2017
7) DPT letter no. EG/WK/EMC/CCA (Part II)/294 dated 13/6/2018
8) DPT letter no. EG/WK/EMC/CCA (Part II) dated 27/5/2019
9) DPT letter no. EG/WK/4751 (CCA Renewal) dated 22/5/2020
10) DPT letter no. EG/WK/4751 (CCA Renewal)/14 dated (30)04/(4)5/2021
11) DPA letter no. EG/WK/4751 (CCA Renewal)/132 dated 06/07/2022

Sir,

It is requested to kindly refer above cited references for the said subject.

In this connection, it is to state that, the GPCB has renewed the consolidated consent & Authorization granted to Deendayal Port Authority (Erstwhile Deendayal Port Trust) and issued CCA order no. AWH-110594 vide PC/CA-KUTCH-812 (5)/GPCB ID 28494/581914 dated 21/01/2021 valid upto 21/07/2025

In this regard, as per statutory requirement, the DPA has regularly submitted Annual Returns (as mentioned in reference above) in format Form V to the GPCB.

Now please find the enclosed herewith Environmental Statement in Form V for the year 2022-23

This is for kind information and record please.

Encl : As above

Yours faithfully

19/06/23

Manager (Environment)
Deendayal Port Authority

Enclosure – A

Environmental Statement (Form V)
For Deendayal Port Authority, Kandla
For the FY @ 2022-2023

"FORM-V"
(See rule -14)

From:
Deendayal Port Authority,
Administrative Office Building,
Post Box No.: 50, Gandhidham,
Dist.: Kutch – 370 207. Gujarat State.
Tel No.: O: 02836-220038
Fax No.: 02836-220050

To,
The Member Secretary,
Gujarat Pollution Control Board,
Paryavaran Bhavan, Sector - 10A,
Gandhinagar – 382043

Environmental statement for the financial year ending the 31st March, 2023

"PART-A"

1) Name and Address of the owner/occupier of the industry or process		
➢ NAME	:	Mr. Raveendra Reddy Chief Engineer
➢ ADDRESS	:	**Deendayal Port Authority** Administrative Office Building, Post Box No.: 50, Gandhidham, Dist.: Kutch – 370 207. Gujarat State. Tel No.: O: 02836-220038 Fax No.: 02836-220050
➢ Industry Category Primary – (STC code) Secondary – (STC code)	:	Major port Authority under the administrative control of Ministry of Ministry of Ports, Shipping and waterways, GOI
➢ Year of Establishment	:	8th April 1955
➢ Date of the last Environment audit report submitted	:	27th June, 2016

"PART-B"

WATER AND RAW MATERIAL CONSUMPTION

Sr.No.	WATER CONSUMPTION	(M^3/Day)
1.	Process	**652676.55**
2.	Cooling	
3.	Domestic Purpose	
Total water consumption for the period from April 2022 to March 2023 was **KL** hence, average water consumption for per day – **1788 M^3/day**		

I. Water Consumption

Sr. No.	Name of Products	Process Water Consumption per unit of products output	
		During the current financial year 2021-22	**During the current financial year 2022-23**
01.	Dry Cargo Handling	**127.10 MT**	**137.5 MT**
02.	Liquid Cargo Handling		
Deendayal Port Authority has only loading & unloading activities for dry cargo and liquid cargo. Hence consumption of process water consumption per unit of output with respective to production is not applicable. During FY 2022-23 Total Cargo Handled is **137.5** MMTPA However, Details of the Domestic water consumption for the financial year 2022-23 please refer **Annexure-1**			

II. Raw material Consumption

Sr.No.	Name of Raw Material	Name of Products	Consumption of Raw material per unit of output	
			During the current financial year 2021-22	**During the current financial year 2022-23**
1.	Deendayal Port Authority has only loading & unloading activities for dry cargo and liquid cargo. Hence consumption of raw material per unit of output with respective to production is not applicable			

"PART-C"

POLLUTION DISCHARGED TO ENVIRONMENT/UNIT OF OUTPUT (PARAMETERS AS SPECIFIED IN THE CONSENT)

Pollutant	Quantity of Pollutant Discharged (mass/day)	Concentration of Pollution in Discharge (mass/volume)	% of Variation from prescribed standard with reasons
Please Refer **Annexure -II** for Environmental Monitoring Reports of • Ambient Air Quality Monitoring • Drinking Water Quality Monitoring • Marine Water Monitoring • Noise Level Monitoring			

"PART-D"
HAZARDOUS WASTE
[AS SPECIFIED UNDER HAZARDOUS WASTE (MANAGEMNET AND HANDLING) RULES -1989 & AMENDMENT RULES -2008]

Sr.No.	Hazardous Waste	Total Quantity in MT/Year	
		During the current financial year 2021-22	During the current financial year 2022-23
1.	5.1- Used Spent Oil	3195.28	4578.79
2.	5.2- Waste Residue Containing Oil	6390.57	9157.58
• Details of Hazardous Waste generated during the financial year 2022-23 please refer **Annexure-III**			
a. From Process: NA b. From Pollution Control facility: NA			

"PART-E"
SOLID WASTE

Sr.No.	Solid Waste	Total Quantity in MT/year	
		During the current financial year 2021-22	**During the current financial year 2022-23**
1.	From Process	Nil	Nil
2.	From pollution Control Facility	Nil	Nil
a.	Quantity Recycled or Reutilized within the unit	Nil	Nil
b.	Sold	Nil	Nil
c.	Disposed Off	**1724.08 MT**	**2473.19 MT**
Details of Solid Waste (Non-Hazardous Waste) generated during the financial year 2022-23 please refer **Annexure-IV**			

"PART-F"

PLEASE SPECIFY THE CHARACTERISTICS (IN TERMS OF CONCENTRATION AND QUANTUM) OF HAZARDOUS AS WELL AS SOLID WASTES AND INDICATE DISPOSAL PRACTICE ADOPTED FOR BOTH THESE CATEGORIES OF WASTES.

Hazardous Waste:
Companies authorized by Central Pollution Control Board (CPCB) and State Pollution Control Board (SPCB) have been awarded the work of collection, transporting and disposal of hazardous Waste by the Deendayal Port Authority. The same will be hand over to authorize parties for further Treatment & disposal.

Solid Waste:
Garbage facility is provided as per MARPOL Act 73/78 to the vessel berthed at Deendayal Port Authority. Companies authorized by Central Pollution Control Board (CPCB) and State Pollution Control Board (SPCB) have been awarded the work of collection, transporting and disposal of solid waste by the Deendayal Port Authority. The same will be hand over to authorize parties for further treatment and disposal.

"PART-G"

IMPACT OF THE POLLUTION ABATEMENT MEASURES TAKEN ON CONSERVATION OF NATURAL RESOURCES AND ON THE COST OF PRODUCTION.

DPA has awarded the work of "Preparing and Monitoring of Environmental monitoring and management plan for Deendayal Port Authority Kandla and Vadinar to Gujarat Environment Management Institute (GEMI), Gandhinagar (An autonomous Institute of Government of Gujarat).

Further for Pollution Abatement measures taken for Conservation of Natural Resources DPA appointed renowned agency i.e M/s. GUIDE, Bhuj for the following work.

1. Regular Monitoring of Mangrove Plantation.

2. Preparation of detailed marine Biodiversity management plan for the impact of the project activities as per the requirement of EC & CRZ Clearance accorded by the MoEF&CC, GOI for the project "Creation of water front facilities (Oil jetties 8,9,10,11) and development of land of area 554 acres for associated facilities for storage at old Kandla, Gandhidham, kutch, Gujarat by M/s Deendayal Port Authority"

3. Regular monitoring of marine ecology in and around the Deendayal Port Authority area and continuous monitoring programme covering all season on various aspects of the coastal environ covering physico-chemical parameters of marine sediments samples coupled with biological indices, as per the requirement of EC & CRZ clearance accorded by the MoEF&CC,GOI to the various projects of the Deendayal port Authority.

4. Study on dredged material for presence of contaminant as per EC and CRZ clearance accorded by the MoEF&CC, GOI dated 19/12/2016 – specific condition vii

"PART-H"

ADDITIONAL MEASURES / INVESTMENT PROPOSAL FOR ENVIRONMENTAL PROTECTION INCLUDING ABATEMENT OF POLLUTION, PREVENTION OF POLLUTION

The allocation made under the scheme of "Environmental Services & Clearance there of other related Expenditure" during BE 2023-2024 is Rs. 274 Lakhs

"PART-I"

ANY OTHER PARTICULAR FOR IMPROVING THE QUALITY OF THE ENVIRONMENT

1. DPA is ISO 14001:2015 certified port for "Providing port facility and related maritime services for vessel and Cargo handling including storage
2. DPA has appointed M/s GEMI, Gandhinagar for the work "Making Deendayal Port a Green Port– Intended Sustainable Development under the Green Port Initiatives". M/s GEMI, Gandhinagar had submitted the Final Report on 10/03/2021
3. DPA has accorded the work of Afforestation project in Deendayal Port Area to Forest Department, GoG which includes plantation and maintenance work of 1100 plants per ha.
4. DPA has accorded the work of green belt development in Deendayal port Authority and its Surrounding areas charcoal site to GUIDE for the plantation of 5000 saplings of suitable species.
5. DPA has planted 7500 trees in Deendayal port trust area during the year 2014-15 6000 trees during financial year 2016-17 and the same has been regularly maintained.
6. DPA has planted 4000 trees at A.O building, Gopalpuri residential colony and along the road side at Kandla. Further, approximately 885 no. of trees have been planted since September 2015 onwards.
7. Continuous water sprinkling has been carried out on the top of the heap of coal, at regular intervals to prevent dusting, fire and smoke. DPA already installed sprinkling system inside Cargo Jetty area for coal dust suppression in coal yard (40 Ha. Area) at the cost of Rs. 14.44 crores.
8. DPA has installed Mist Canon at the Port area to minimize the coal dust.
9. Deendayal port Authority (traffic department) issued a Circular (SOP) to the trade with regard to control of dust pollution arising out of coal handling and ensuring safety in coal handling. In case of any violations of SOP, provision of impose of penalty of Rs. 10000/- has been made and if violation is repeated thrice, the same will lead to ban of concerned party into port area. The DPA is taking all the measures to reduce coal dust by implementing the coal handling guidelines through port users.

10. All trucks before leaving the storage yard have been covered with tarpaulin and also trucks are also not over loaded as well as there is no spillage during transportation and there is adequate space for movement of vehicles at the surrounding area.
11. DPA has constantly improving the house keeping in the dry cargo storage yard and nearby approved areas leading to roads. Adequate steps under the provisions of air prevention and control of pollution Act 1981, Environmental Protection Act 1986 are taken.
12. DPA commissioned STP of capacity 1.5 MLD for treatment of domestic waste water for entire DPA area. (Details of domestic waste water generation is attached herewith as **Annexure V**)
13. Deendayal Port Authority had carried out mangrove plantation in an area of 1500 ha. through various government agencies like Gujarat Ecology Commission, State Forest Department.
14. It is also relevant to mention here that, DPA entrusted work to Forest Department, GoG (Social Forestry Division, Bhuj) during August, 2019 for green belt development in and around port area 31.942 hectares (approx. 35200 plants at various locations) at a cost of Rs. 352.32 lakhs.
15. DPA is involved in various CER activities like providing the proper sanitation and development of better roads for connectivity
16. DPA is managing its plastic waste as per Plastic Waste Management Rules – 2016 and amendments made therein. In order to strictly implement the said rules, DPT had issued a circular regarding plastic waste minimization, source segregation, recycling etc. vide its Circular no. EG/WK/4751/Part 243(A) dated 03/09/2021
17. DPA has entrusted the work to GEMI, Gandhinagar for "Preparation of Plan for Management of Plastic Waste, Solid Waste, C&D Waste, E-waste, Hazardous Waste including Bio-medical Waste and Non-hazardous waste in the Deendayal Port Authority Area
18. DPA has assigned the work to TERI, New Delhi for "Transition of Business Operations to Water Neutrality – Water Neutrality of Deendayal Port, Kandla (Phase I- Study and assessment)
19. Recently, DPA has entrusted the work to GEMI, Gandhinagar for "Study of CO_2 Emission Estimation and Reduction Strategy under Maritime India Vision 2030.
20. Initiative for Installation of Continuous Ambient Air Quality Monitoring System (CAAQMS) for monitoring of Air quality is under process.

ANNEXURE – O

Forwarding letter of CCA amendment application

Forwarding & Undertaking Letter from Industry

Application for consent for establishing / operation the industrial plant / plants under Section 21 of the Air (prevention & Control of Pollution) Act, 1981

Important Note : This Document or its copy does "NOT" serve as a Supporting Document Proof of Industry's Submission of an Application for a NOC / Consent. This Letter does "NOT" ensure that the Application FEES has been paid.

Application Purpose : CCA Amendment Application : DPA had obtained Consolidated Consent & Authorization from the Gujarat Pollution Control Board (Ref.: GPCB order no. AWH-72820 dated 31/08/2015 & subsequent amendment GPCB letter no. PC/CCA-Kutch-812 (4)/GPCB ID 28494/516264 date of issue 17/05/2019 for inclusion of Cargo berth no. 14 & 16 - valid up to 21/07/2020) for entire Deendayal Port area, which Includes General Cargo Berth No. 1 to 16, Oil jetties 1 to 4 (Oil Jetties), Barge jetties at Bunder Basin & at Tuna etc. and associated area already developed for Port operations.Subsequently, DPA obtained renewal of above Consent Order from the GPCB vide letter no. GPCB/CCA-Kutch -812(5)/ID-28494/581914 dated 22/01/2021 (AWH-110594) valid up 21/07/2025. Further, the GPCB vide letter dated 9/4/2021 had also issued correction in above CCA Order dated 22/1/2021.In this regard, it is relevant to submit here that, at the time of application to the GPCB for renewal of Consent Order, DPA vide letter dated 20/06/2020

From : **Kandla Port Trust, At Kandla, Category: RED / LARGE**
PLOT NO:Kandla,
kandla, □
A.O Building Gandhidham - 370201
Contact Person: Shri Rajendra Prasad, Mob:9727754360, Ph:-
DIST: Kutch East, TAL: Gandhidham, SIDC: Not In Gidc

Print Date: 08/08/2023

PCB-ID : 28494
INWARD : 277270
Dt:23/05/2023

To,
The Member Secretary,
Gujarat Pollution Control Board
Paryavaran Bhavan, Sector-10/A,
Gandhinagar - 382010

Scrutinized By: Mr. Ghatalia kalpesh c(675)

I / We here by Submitting application for CCA ,Inward No : 277270 ,Date : 23/05/2023 for COE(CCA-Ammendment).

Applying For : W,H Validity : 5 Years Grant By : CHR

Air Sector :0 Water Consumption : 3000.000 klpd

Haz Sector : 5000~Large Scale Industry No of Plants : 1 Incenerator : 0

Investment	Air	Water	Hazardous
3261.8783 Crs	0	40000	5000+5000
0 Rs	0 Years	3 Years	3 Years

Payable Fees : Air : 0, Water : 120000, Haz : 30000

Paid Amount : 150000, DD No : YSBI1900747732, Dt: 5/22/2023, at SBI , ***

Query / Reply:

	I / We have Uploaded the following PDFs	Date	# Files	Size(kb)	#Page
1	ENV - Environment Statement , Form-V	20/06/23	0	-1	-1
2	ANN - Annual Return : Form 4	20/06/23	0	-1	-1
3	SSI - SSI-IEM-C.A Certi / Investment Proofs	25/03/23	0	2254	7
4	ACC - Form V under HW Rules (Accident cases)	21/07/22	1	580	11
5	000 - Any Specific Information Called for [in SCRUTINY]	01/10/21	1	135253	414
6	PLI - PLI Policy	31/08/20	1	1318	9
7	WAT - *** BreakUp of Water Uses & balance	13/04/10	1	55	1
8	1PE - *** 1 Page Explaination (Purpose of Application)		0	-1	-1
9	EIA - Executive Summary Statement		0	0	0

I, the applicant declare that I have submitted full and complete documents and information in conformity to the applicable acts / rules. I am aware that, any delay / rejection in the processing of application on account of incorrect / incomplete information shall be mine responsibility.

Company s SEAL **1 (Through XGN)** N I C

(B.Rajendra Prasad, Superintending Engineer (D) & EMC (I/C))

Note: I am hereby enclosing along with my application.

Please Attach Copy of NEFT/RTGS Challan with this Letter if you are paying through NEFT/RTGS.

ANNEXURE – P

Disaster Management Plan

ANNEXURE-VII

(Disaster Management Plan)

Private & Confidential

Disaster Management Plan

For

Kandla Port Trust

(ISO 9001:2008 Certified Port)

Post Box No: 50,

Gandhidham (Kutch) – 370201

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By

Telos Consultancy Services (P) Ltd.,

Mumbai

Disaster Management Plan
(Upgraded)

for

Kandla Port Trust

Post Box No: 50

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1 PREFACE

Telos Consultancy Services (P) Ltd., Mumbai (Telos) is appointed by **Kandla Port Trust, Gandhidham (Kutch) – 370201** for Updating Onsite Emergency Plan / Disaster Management Plan **for Kandla Port Trust.**

The Disaster Management Plan (DMP) for Kandla Port has been developed to provide procedures for the implementation and continual development of the Internal Action Plan.

The Internal Action Plan is an interactive document which will be continuously refined and updated every year.

This plan has been formulated to fulfil the requirements of the relevant standards and guidelines set forth by the concerned authorities.

It should be noted that the findings and recommendations of the study are based on the data provided and discussions held during the site visit with the port personnel at the time of the site visit on 18th & 19th August 2010.

Documents provided by Kandla Port Trust for reference are:-

1. Kandla Port Trust – Internal action plan up dated July 2010.
2. DMP – Kandla Port Trust – Prepared by Tata AIG Risk Management in the year 1999.
3. Copies of DMP of chemical / POL Terminals on Kandla Port Property.
   a) JRE tank terminal (P) Ltd.
   b) CRL
   c) BPCL
   d) United storage and tank terminals Ltd – Liquid Terminal
   e) United storage and tank terminals Ltd – Liquefied Gas Storage and handling terminals.
   f) Indo Nippon chemical Company Ltd.
   g) Rishi Kiran Logistics (P) Ltd,
   h) INEOS ABS (India) Ltd
   i) Friends oil and chemical terminals (P) Ltd
   j) Indian oil (LPG)
   k) Indian Oil
   l) IOC Marketing Division
   m) HPCL
   n) Friends salt works and allied industries
   o) IFFCO
4. Layout Map of Kandla Port Trust – DRG. NO: KPH/09
5. Layout of Fire fighting line at Kandla Port Trust
6. Layout of proposed oil pipe line at oil jetty Kandla Port Trust

Telos has exercised all reasonable skill, care and diligence in carrying out the study. This report / document is not deemed to be any undertaking, warranty or certificate.

2 INTRODUCTION

The important aspect in emergency management is to prevent by Technical & Organizational measures, the unintentional escape of hazardous materials out of the facility and minimize accidents and losses.

Emergency planning also demonstrates the organizations commitment to the safety of employees and public and increases the organizations safety awareness.

The format and contents of the Disaster Management Plan (DMP) have been developed taking into consideration the guidelines, and other accepted industry good practice principles formulated as a result of lessons learned in actual emergencies requiring extensive emergency response.

This master document is to be studied in advance and used for training purpose also. This master document will be upgraded once in every three years by reviewed annually.

2.1 Objectives of DMP

The objective of DMP is to describe the facility emergency response organization, the resources available and response actions applicable to deal with various types of emergencies that could occur at the facility with the response organization structure being developed in the shortest time possible during an emergency. Thus, the objectives of emergency response plan can be summarized

- Rapid control and containment of the hazardous situation.
- Minimizing the risk and impact of event / accident.
- Effective rehabilitation of the affected persons and preventing of damage to property.

In order to effectively achieve the objectives of the emergency planning, the critical elements that form the backbone of the DMP are

- Reliable and early detection of an emergency and careful planning.
- The command co – ordination and response organization structure along with efficient trained personnel.
- The availability of resources for handling emergencies.
- Appropriate emergency response actions.
- Effective notification and communication facilities
- Regular review and updating of the DMP
- Proper training of the concerned personnel.

FOREWORD

"The document On-site Disaster Management Plan is prepared with the objective of defining the functions and responsibilities of all concerned managerial, operational and supporting services department personnel with respect to detection and effective implementation of action plan. The ultimate goal is the effective containment of the emergency situation by proper mitigative action at the place of occurrence, cautioning people in adjoining affected locations, prompt rescue and medical aid to affected persons and communication to civil authorities for rushing in help from outside. All concerned are hereby requested to carefully study and thoroughly familiarize themselves with it in order to ensure its effectiveness in times of emergency"

(Mr. P. D. Vaghela)
Date: ----/-----/2010 Chairman
Kandla Port Trust

2.2 Responsibility

Responsibility for establishing and maintaining a state of emergency preparedness belongs to the DC. He is responsible for maintaining distribution control of the plan, and for ensuring that the plan and applicable implementing procedures are reviewed annually. The Fire Safety In charge is responsible for the training of personnel to ensure that adequate emergency response capabilities are maintained in accordance with the plan. He is also responsible for ensuring the adequacy of the conduct of drills, as outlined in the On-site Disaster Management Plan. All employees of various departments are responsible for carrying out their responsibilities, as defined in this Plan.

3 FACILITY DESCRIPTION

3.1 Introduction

3.1.1 Unique Location

The Major Port of Kandla situated about 90 km off the mouth of Gulf of Kachchh in the Kandla Creek at Latitude 23 degree 1minute North and Longitude 70 degree 13 minutes east, is the lone Major Port on the Gujarat coast line along the West Coast of the country. Amongst the 12 Major Ports in the country, Kandla occupies an enviable position, both in terms of international maritime trade tonnage handled and financial stability and self-sufficiency attained year after year. A gateway to the north-western part of India consisting of a vast hinterland of 1 million sq. km stretched throughout 9 states from Gujarat to Jammu & Kashmir, the Port has a unique location advantage. The Port's hinterland is well connected with infrastructural network of broad gauge and railway system as well as State and National Highways

3.1.2 The Evolution

January 20, 1952, Pandit Jawaharlal Nehru, the then Prime Minister of India, laid the foundation stone at Kandla for the new port on the western coast of India. It was declared as a Major Port on April 8, 1955 by Late Lal Bahadur Shastri, the then Union Minister for Transport. The Kandla Port Trust was constituted in 1964 under the Major Port Trusts Act, 1963. Since then, this Major Port of Kandla has come a long way in becoming the 'Port of the New Millennium'.

3.1.3 The Strengths to Anchor On

Excellent infrastructural facilities, well-connectivity with the rest of the country by road and rail networks, all-round services provided with efficiency and transparency, lowest port tariff and the envious cost-effectiveness are the major strengths of Kandla Port.

3.1.4 Vision

"To be Asia's Supreme Global Logistic Hub"

3.1.5 Mission

To transform the Port of Kandla into a most globally competitive logistics hub with international excellence leaving imprints in the international maritime arena by exploring its fathomless growth potentialities.

3.2 Business Horizon

As the portal to the West and North India and due to its unique location advantage, a vast hinterland of 1 million sq. km can be assured for from Kandla.
The hinterland of the Kandla Port consists of the states of J &K, Punjab, Himachal Pradesh, Haryana, Rajasthan, Delhi, Gujarat and parts of Madhya Pradesh, Uttaranchal and Uttar Pradesh.

Kandla Port is the gateway port for the vast granaries of Punjab and Haryana and the rich industrial belt of West and North India.

3.2.1 Advantage of Kandla Port

- ISO 9001 – 2008 Certified Port.
- All weather port – 365 days, 24 hours.
- Protected and safe harbor.
- 12 berths stretching 2.55 km in a straight line
- Facilities for liquid cargo, POL products, chemicals and edible oil.
- Storage facility for LPG to the tune of 30,000 cu.m.
- Port with highest liquid storage capacity in the country.
- Excellent road and rail connectivity.
- High capacity cranes for dry cargo.
- Transparent and notified tariff.
- 12.5 meter draught.
- Security by CISF.

3.3 Port Logistics

3.3.1 Navigation Facilities

- Round-the-clock navigation.
- Permissible draught 12.5 meters.
- Ships with 240 meters length overall and 65,000 DWT are accommodated presently.
- Safe, protected and vast anchorage at outer harbour for waiting and lighter age purpose.
- 22 lighted navigational buoys with solar lights, as per IALA system, are provided in the navigational channel.
- Light house as an aid for night navigation.
- Fully equipped signal station operational round-the-clock.
- Four lighted shore beacons.

3.3.2 Flotilla

- 9 Harbor tugs of various sizes.
- Five high speed pilot launches.
- One state of the art fully computerized survey launch
- Two harbor tugs of 7.5 tons Bollard Pull
- Ten new FRP mooring launches.
- Four general service launches.
- One Fire float.
- One heave up barge for maintenance of navigational aids.
- Two pilot and oil cum debris recovery vessels, one at Kandla and one at Vadinar.
- Two new patrolling launches for marine surveillance by CISF.

3.4 Strategic & Climatic Advantage

- All-weather port.
- Tropical and dry climatic conditions to handle any type of cargo throughout the year.
- Temperature varying from 25 degree Celsius to 44 degree Celsius.
- Scanty rainfall facilitates round-the-year operations.
- Uninterrupted and smooth port operations on 365 days a year.
- No adverse wave effect, being a protected and sheltered harbour situated in the Creek.
- The only Indian Major Port nearest to the Middle East and Europe.

3.5 Port Location

- Latitude: 23°01"N
- Longitude: 70°13"E

Kandla Port is situated in the Kandla Creek and is 90km from the mouth of the Gulf of Kutch.

3.5.1 Location - Latitude :23° 1' N, Longitude:70° 13' E

Figure 1 – Over view of Kandla Port Trust

3.6 Future Vision of KPT as per Business Plan

3.7 Steel Floating Dry Dock

The existing steel floating dry dock caters to the need of Port crafts as well as outside organizations and has capacity to accommodate vessels of following parameters.

- LOA maximum up to 95 meters.
- Breadth maximum up to 20 meters.
- Draught maximum up to 4.5 meters.
- Lift displacement maximum up to 2700 tones.

3.8 Infrastructure Advantages at Kandla Port

- Twelve dry cargo berths are available, with quay length of 2532 meter.
- Six oil jetties.
- Total custom bonded port area inside the custom fencing is 253 hectares.
- One deep draught mooring and four cargo moorings in the inner harbor area for stream handling.

3.8.1 Chemical & Liquid handling Complex

- Total storage capacity : 21.89 Lakh KL
    - Private sector storage terminals – 9.81 Lakh KL.
    - Public sector and cooperative undertaking – 12.08 Lakh KL.
- Loading arms for simultaneous loading and unloading.
- Near zero waiting period for vessels.
- Capacity utilization at international levels ensuring demurrage free handling.
- Excellent discharge rates and faster turnaround.
- Lowest vessel related charges and wharfage charges.
- Suitable for A, B, C. LG, NH, EO classes of liquid and chemicals.
- Chemical storage tank farms in the vicinity of liquid jetties.
- Tanks for storage of all categories of liquid cargoes like chemicals LPG, cryogenic cargoes, ammonia, acids, petroleum products, edible oils. Etc.
- Efficient handling ensuring minimum losses.
- Sophisticated pipeline network (including stainless steel pipes)
- Sufficient parking space inside and outside the storage facilities.

3.9 Road Network

- Four lane National Highway No: 8-A extended right up to the Ports main gate.
- Fully developed road network, both in and around the Port area to facilitate faster movement of cargo.
    - Inside Cargo Jetty Area – 30 km.
    - Outside Cargo Jetty Area – 31 km.
    - Railway Inside Cargo Jetty Area – 13 km.

3.10 Storage Facilities

Kandla Port offers excellent and vast dry cargo storage facilities inside the custom bonded area for storage of import and export cargoes.

The existing storage facilities at the dry cargo jetty area are:

Sr No	Description	No	Area (Sq M)	Capacity in (Tones)
01	Warehouses	33	1.68 Lakhs	4.47 Lakh
02	Open storage space	67	13.10 Lakhs	32.27 Lakh

3.10.1 Private Sector Liquid Storage Facilities

Sr No	Name of the Terminal Operator	No of Tanks	Capacity in (KL)
01	CRL (Chemicals & Resins Ltd)	112	247000
02	FSWAI (Friend Salt Works & Allied Industries)	132	271650
03	Kesar Enterprise	44	90081
04	N P Patel Pvt Ltd	09	38497
05	FOCT (Friend Oil & Chemicals Terminal	21	39263
06	USTTL – Liquid Terminal	22	63038
07	Agencies & Cargo Care Limited	27	50000
08	J K Synthetics	14	25176
09	IMC Limited	04	25288
10	J R Enterprises	15	25320
11	Indo Nippon Chemicals Ltd	10	17200
12	Liberty Investment	06	16016
13	Bayer ABS Ltd	11	13310
14	Deepak Estate Agency	09	13212
15	Tejmalbhai & Company	08	12577
16	Avean International Care Ltd	11	12160
17	USTTL Gas Terminal	04	5720
18	Parker Agrochem Export Ltd	06	15000
	Total Capacity	**465**	**980508**

3.10.2 Public Sector Liquid Storage Facilities

Sr No	Name of the Terminal Operator	No of Tanks	Capacity in (KL)
01	Indian Oil Corporation	38	575838
02	Bharat Petroleum Corporation	21	230000
03	Hindustan Petroleum Corporation	28	204000
04	IOC – LPG	02	30000
05	IFFCO	11	110000

06	NDDB	09	58530
	Total Capacity	**109**	**1208360**

3.11 Container Handling Facilities

- 545 meter of quay length.
- 4 RMQCs
- 2 Harbour mobile crane.
- 4 RTGCs, 4 reach stackers, 18 prime movers.
- 40 Hectare plot for container yard.
- 6 Container freight stations serving the Port.
- Reefer plug points.
- Regular feeder service to JNPT, Mumbai, UAE, Colombo, Bandar Abbas, Muscat, Korea, Cochin, Tuticorin, Pipavav, Mangalore (optional) and other destinations.
- Most economical handling charges and concessional TAMP tariff for coastal vessels.
- Nearest port to Delhi and surrounding areas.
- Railway line adjacent to container yard.
- Separate stacking area for dangerous goods.

3.12 Port Equipments

3.12.1 Wharf Cranes

- 12 wharf cranes of the following capacities:
  - Two of 12 tones.
  - Four of 16 tones.
  - Six of 25 tones.
- The rated capacity of the 16 ton crane is 400 tones / hour.
- The rated capacity of the 25 ton crane is 400 tones / hour.

3.12.2 Weighbridges

- Nine weighbridges inside the port, which includes:
  - Two Weighbridge of 40 MT capacities.
  - One Weighbridge of 50 MT capacity
  - Two Weighbridge of 60 MT capacity
  - Two Weighbridge of 80 MT capacity
  - Three Weighbridge of 100 MT capacities.

3.12.3 Other Support Equipment

- Easy availability of other support loading equipments such as Forklifts, Tractor - Trailers, Pay-loaders of various capacities.
- Private handling, equipments like Mobile Cranes, Top lifters, pay-loaders, Forklifts, Heavy-duty Trailers etc. available on hire at competitive rates.

3.13 Berths at Kandla Port

3.13.1 Details of Draught

Sr No	Name of Berth	Draught (in Meters)	DWT (In Metric Tons)
1	Cargo Berth No.1	9.80	45000
2	Cargo Berth No.2	9.80	45000
3	Cargo Berth No.3	9.80	45000
4	Cargo Berth No.4	9.80	45000
5	Cargo Berth No.5	9.10	35000
6	Cargo Berth No.6	9.10	35000
7	Cargo Berth No.7	12.00	55000
8	Cargo Berth No.8	12.00	55000
9	Cargo Berth No.9	12.00	55000
10	Cargo Berth No.10	12.00	55000
11	Cargo Berth No.11	12.50	65000
12	Cargo Berth No.12	12.50	65000
13	Oil Jetty No. 1 (Nehru Jetty)	10.40	40000
14	Oil Jetty No. 2 (Shastri Jetty)	10.00	52000
15	Oil Jetty No. 3 (Indira Jetty)	10.70	40000
16	Oil Jetty No. 4 (Rajiv Jetty)	10.70	56000
17	Oil Jetty No. 5 (IFFCO)	9.50	45000
18	Oil Jetty No. 6 (IOCL)	10.10	45000

3.13.2 Details of Berths

No of Berth	No of Bollard		No of Panels	Length of Each Panel	Length of Berth (m)	Draught (in Meters)	DWT (In Metric Tons)
1	1 to 8	08	08	22.866	182.93	9.80	45000
2	8 to 16	08	08	22.866	182.93	9.80	45000
3	17 to 24	08	08	22.866	182.93	9.80	45000
4	25 to 32	08	08	22.866	182.93	9.80	45000
5	33 to 41	09	09	22.866	205.79	9.10	35000
6	42 to 50	09	09	22.866	205.79	9.10	35000
7	51 to 58	08	08	(30.440 x 7) + 22.56 + (3.00)	238.64	12.00	55000

8	59 to 68	10	06	(45.72 x 3) + 30.44 + 27.44 + (18.00)	213.04	12.00	55000
9	69 to 76	08	05	(45.72 x 3) + 25.72 + (18.05)	182.93	12.00	55000
10	77 to 85	09	05	(59.10 x 2) + (43.20 x 2) + (4.81)	209.41	12.00	55000
11	86 to 98	13	05	(59.00 x 4) + (45.00)	281.00	12.50	65000
12	-----	---	---		264.00	12.50	65000
Total			79		2268.32		

3.13.3 Details of Existing Godown

Sr No	Godown No	Size of Godown (in M)	Area in Sq Meters	Capacity in (Tons)
1	Godown – 1 (WH-A)	152.44 x 36.59	5578	9817
2	Godown – 2 (WH-B)	152.44 x 36.59	5578	10500
3	Godown – 3 (W.H -C)	152.44 x 36.59	5578	10500
4	Godown – 4 (W.H.D)	152.44 x 36.59	5578	10500
5	Godown – 6 (C.F.S. - II)	90.00 x 36.00	3240	12400
6	Godown – 7 (C.F.S. – I)	90.00 x 36.00	3240	12400
7	Godown – 8 (F.B.S.S)	236.00 x 30.00	7080	13300
8	Godown – 9 (Bagging Plant)	287.00 x 19.20	5510	10400
9	Godown – 10	132.00 x 22.50	2970	11400
10	Godown – 11	186.00 x 22.50	4185	7900
11	Godown – 12	170.00 x 22.50	3825	7200
12	Godown – 13	162.00 x 22.50	3645	6900
13	Godown – 14	192.00 x 22.50	4320	8100
14	Godown – 15	162.00 x 22.50	3645	6900
15	Godown – 16	192.00 x 22.50	4320	9100
16	Godown – 17	174.00 x 22.50	3915	15000
17	Godown – 18	138.00 x 45.00	6210	23800
18	Godown – 19	192.00 x 22.50	4320	8100
19	Godown – 20	192.00 x 22.50	4320	8100
20	Godown – 21	192.00 x 22.50	4320	8100
21	Godown – 22	192.00 x 22.50	4320	8100

22	Godown – 23	174.00 x 22.50	3915	7400
23	Godown – 24	156.00 x 45.00	7020	26900
24	Godown – 25	132.00 x 22.50	2970	5600
25	Godown – 26	99.06 x 36.55	3621	13900
26	Godown – 27		1943	6995
27	Godown – 28	173.88 x 30.50	5503	19092
28	Godown – 29	137.55 x 50.00	6888	24797
29	Godown – 30	126.00 x 49.00	6174	22226
30	Godown – 31	140.00 x 50.00	7000	25200
31	Godown – 32	307.45 x 40.00	12298	44273
32	Godown – 33	133.00 x 40.00	5320	19152
	Total Available Presently		158349	434052

3.14 Various Private Terminal Storages at Kandla & the chemicals POL products handled.

3.14.1 Bharat Petroleum Corporation Ltd

- Motor Spirit (MS)
- HSD – High Speed Diesel
- SKO – Superior Kerosene Oil
- Ethanol (Ethyl Alcohol)
- Naphtha
- LDO – Light Diesel Oil

3.14.2 CRL

- Benzene
- Toluene
- Aniline
- Butanol (Butyl Alchol)
- H Phenol
- CTC – Carbon Tetra Chloride
- Caster Oil
- CPS
- Phenol
- De Alcohol (Denatured Alcohol)
- IPA – Iso Propyl Alcohol
- Butyl Acetate
- MEK (Methyl Ethyl Ketone)
- Methyl Alcohol / Methanol
- Hexane
- Vinyl Acetate
- MIBK

- BAM
- Propylene
- Cyclo Hexane
- Caustic Soda (Sodium Hydroxide)
- Acetic Acid
- Nonene
- EDC (Ethylene Di Chloride)

3.14.3 United Storage & Tank Terminals Ltd

- LPG – Liquefied Gas Storage & Handling terminal
- 1:3 Butadiene
- Crude C 4 Mix
- Butane – 1

3.14.4 Indo Nippon Chemicals Co Ltd

- ISO Butanol
- A – Olefin
- Waksol (Parafin)
- VAM – Vinyl Acetate Monomer
- MDC – (Methyle Metacrylate)
- Toluene
- Naphtha
- IPA

3.14.5 Rishi Kiran Logistics (P) Ltd

- Butyl Cellsolve
- Chloroform
- DO Wanol
- HNP
- N – Parafin
- Methanol
- Polyether Polyol
- Papi 27 Polymeric
- Tri chloric ethylene
- Vinyl chloride monomer.

3.14.6 Ineos ABS (India) Ltd

Chemicals Stored

- Styrene
- ACN
- Chloroform
- Parafin

Chemicals Proposed

- Methyl Ethyl Ketone (MEK)

- Benzene
- Methanol
- HNP
- Acetone
- Butyl Acrylate
- Butanol
- 1 – Butanol
- CTC (Carbon Tetra Chloride)
- Cyclo Hexonol
- Cyclo Hexanone
- Cumene
- Di Octylphthalate
- Ethanol – IPA (Mix)
- Ethanol
- Ethyl Hexonol
- Ethyl Benzene
- Hexane
- Heptane
- Iso Propanol
- P – Xylene
- Propylene Trimer
- C – 9 – Hydrocarbons
- Toluene
- Vinyl Acetate
- Mixed xylene
- N – Tetra Decane
- Polvoal

3.14.7 Friends Oil & Chemical Terminal (P) Ltd

- Furnace Oil
- Styrene
- C – Palm Oil
- Mix – HSD & Naphtha
- CPO (NEG) – Crude Palm Oil
- Acrylate Bam
- Butyle Glycol
- Mosstanoll
- Butyl Glycol
- Cubutol
- Methyl Methacr
- ISO Nanano
- CDSBO

3.14.8 Indian Oil (LPG)

- LPG

3.14.9 Indian Oil

- Motor Spirit (MS)
- High Speed Diesel (HSD)
- SKO (Superior Kerosene Oil)
- LAN

3.14.10 Hindustan Petroleum Company Limited

- Furnace Oil (FO)
- High Speed Diesel (HSD)
- Light Diesel Oil (LDO)
- SKO (Superior Kerosene Oil)
- Motor Spirit (MS)

3.14.11 Friends Salt Works & Allied Industries

- Naptha
- Toluene
- N – Proanol
- HNP
- Mixed Parafin
- Solvent – CS
- Iso Prophyl Alcohol (IPA)
- Methenol
- N – Parafin C9 – C
- M – xylene
- High Speed Diesel (HSD)
- Mosstanol
- Methylene Chloride
- Ethyl Acetate
- Vinyl Acetate
- HA – 100
- MEK
- Acetone
- Crude Benzene
- Heavy Aromatics
- Butyl Acrylate
- Shell Sarasol – 4
- Carbon Tetra Chloride (CTC)
- HA – 170
- MBK
- De Natured Spirit
- Nonene
- Condensate
- Caradol SC- 56 – 0
- N – Parafin
- Butyl Acetate

- LAB
- Naptha
- Hexane
- ISO – Decyl Alcohol
- Sodium Hydroxide (Caustic Soda)
- Methyl Met
- Butyl Arylate
- MIBK
- DHSO – But
- Crude PEG
- CPKO
- Crude PNEG

3.14.12 IFFCO

- Anhydrous Liquid Ammonia
- Phosphoric Acid
- Potosh
- Urea
- Hydrochloric Acid
- Sulphuric Acid
- LSHS
- Furnace Oil

3.14.13 IOC (Marketing)

No list of chemicals is provided

3.14.14 JRE Tank Terminal (P) Ltd (Liquid Storage Terminal)

No list of chemicals is provided

3.14.15 United Storage & Tank Terminals Ltd (Liquid Terminal)

No list of chemicals is provided

3.15 Offshore Oil Terminal (OOT) Vadinar

KPT had commissioned off shore oil terminal facilities at Vadinar in 1978, jointly with Indian Oil Corporation, by providing single bouy mooring (SBM) system having capacity of 54 MMTPA, which was the first of its kind in India. A significant quantum of infrastructural up gradation has since been effected and excellent maritime infrastructure created for the 32 MMTPA Essar Oil Refinery at Vadinar.

- A draught of up to 33 meters at SBMs and lighterage point operations (LPO)
- Three SBMs available.
- Handling VLCCs of 300000 DWT and more.
- Providing crude oil for the refineries of Koyali (Gujarat), Mathura (Uttar Pradesh), Panipat (Haryana) and Essar Refinery, Jamnagar (Gujarat)
- 2nd SBM was commissioned in the year 1998.

- 3rd SBM at Vadinar is for importing crude for the oil refinery of Essar Oil.
- Simultaneous handling of three VLCCs possible at the SBMs.
- Vast crude tankage facility.
- Two 35 tone and two 50 tone state of art BP SRP pull back tugs are available for smooth and simultaneous shipping operations on the SBMs and product jetty.
- One oil and debris recovery tug for oil pollution control has been acquired and stationed at Vadinar.
- Excellent infrastructure and tranquil waters facilitate transshipment operations even during the monsoon.

4 IDENTIFICATION OF EMERGENCIES

4.1 Overall Methodology

In order to undertake this study TELOS has used ALOHA (Aerial Locations of Hazardous Atmospheres) a computer program designed especially for use by people responding to chemical releases, as well as for emergency planning and training. ALOHA models key hazards — toxicity, flammability, thermal radiation (heat), and overpressure (explosion blast force) — related to chemical releases that result in toxic gas dispersions, fires, and /or explosions.

4.1.1 Dispersion Modeling

ALOHA air dispersion model is intended to be used to estimate the areas near a short-duration chemical release where key hazards—toxicity, flammability, thermal radiation, or overpressure—may exceed user-specified Levels of Concern (LOCs).

(Note: If the released chemical is not flammable, toxicity is the only air dispersion hazard modeled in ALOHA.)

ALOHA is not intended for use with radioactive chemical releases, nor is ALOHA intended to be used for permitting of stack gas or modeling chronic, low-level ("fugitive") emissions. Other models are designed to address larger scale and/or air quality issues (Turner and Bender 1986). Since most first responders do not have dispersion modeling backgrounds, ALOHA has been designed to require input data that are either easily obtained or estimated at the scene of an accident. ALOHA's on-screen help can assist you in choosing inputs.

4.1.1.1 What is Dispersion

Dispersion is a term used by modelers to include advection (moving) and diffusion (spreading). A dispersing vapor cloud will generally move (advent) in a downwind direction and spread (diffuse) in a crosswind and vertical direction (crosswind is the direction perpendicular to the wind). A cloud of gas that is denser or heavier than air (called a heavy gas) can also spread upwind to a small extent.

ALOHA can model the dispersion of a cloud of pollutant gas in the atmosphere and display a diagram that shows an overhead view of the regions, or threat zones, in which it predicts that key hazard levels (LOCs) will be exceeded. This diagram is called a threat zone plot. To obtain a threat zone estimate, you must first choose at least one LOC. (ALOHA will suggest default LOCs, and you may keep those or choose up to three other LOCs.) For toxic gas dispersion scenarios, an LOC is a threshold concentration of the gas at ground level—usually the concentration above which a hazard is believed to exist. The type of LOC will depend on the scenario. For each LOC you choose, ALOHA estimates a threat zone where the hazard is predicted to exceed that LOC at some time after a release begins. These zones are displayed on a single threat zone plot. If three LOCs are chosen, ALOHA will display the threat zones in red, orange, and yellow. When you use ALOHA's default LOCs, the red zone represents the worst hazard.

There are two separate dispersion models in ALOHA: **Gaussian & Heavy Gas**.

4.1.1.2 Gaussian Model:

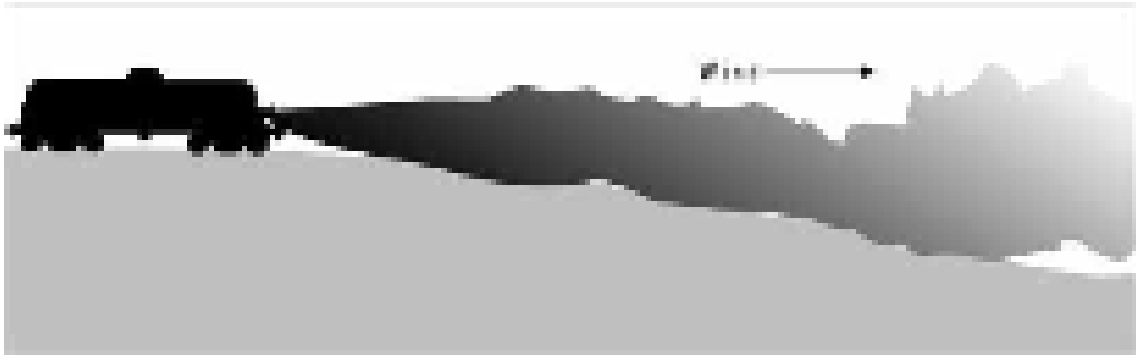
ALOHA uses the Gaussian model to predict how gases that are about as buoyant as air will disperse in the atmosphere. Such neutrally buoyant gases have about the same density as air. According to this model, wind and atmospheric turbulence are the forces that move the molecules of a released gas through the air, so as an escaped cloud is blown downwind, "turbulent mixing" causes it to spread out in the crosswind and upward directions. According to the Gaussian model, a graph of gas concentration within any crosswind slice of a moving pollutant cloud looks like a bell-shaped curve, high in the center (where concentration is highest) and lower on the sides (where concentration is lower), At the point of a release, the pollutant gas concentration is very high, and the gas has not diffused very far in the crosswind and upward directions, so a graph of concentration in a crosswind slice of the cloud close to the source looks like a spike. As the pollutant cloud drifts farther downwind, it spreads out and the "bell shape" becomes wider and flatter.

Gaussian distribution (left) & Gaussian Spread (right)

4.1.1.3 Heavy gases:

When a gas that is heavier than air is released, it initially behaves very differently from a neutrally buoyant gas. The heavy gas will first "slump," or sink, because it is heavier than the surrounding air. As the gas cloud moves downwind, gravity makes it spread; this can cause some of the vapor to travel upwind of its release point. Farther downwind, as the cloud becomes more diluted and its density approaches that of air, it begins behaving like a neutrally buoyant gas. This takes place when the concentration of heavy gas in the surrounding air drops below about 1 percent (10,000 parts per million). For many small releases, this will occur in the first few yards (meters). For large releases, this may happen much further downwind.

Cloud spread as a result of gravity.



The heavy gas dispersion calculations that are used in ALOHA are based on those used in the DEGADIS model (Spicer and Havens 1989), one of several well-known heavy gas models. This model was selected because of its general acceptance and the extensive testing that was carried out by its authors.

4.1.1.4 Classification of Heavy Gases:

A gas that has a molecular weight greater than that of air (the average molecular weight of air is about 29 kilograms per kilomole) will form a heavy gas cloud if enough gas is released. Gases that are lighter than air at room temperature, but that are stored in a cryogenic (low temperature) state, can also form heavy gas clouds. If the density of a gas cloud is substantially greater than the density of the air (the density of air is about 1.1 kilograms per cubic meter), ALOHA considers the gas to be heavy.

4.1.2 Fires & Explosions

ALOHA version 5.4, can model fire and explosion scenarios as well as toxic gas dispersion scenarios. This section provides information about fires and explosions, and then explains how to model fires and explosions in ALOHA.

ALOHA allows to model chemical releases from four types of sources: Direct, Puddle, Tank, and Gas Pipeline.

- **Direct**: chemical release directly into the atmosphere (bypassing ALOHA's source calculations).
- **Puddle**: chemical has formed a liquid pool.
- **Tank**: chemical is escaping from a storage tank.
- **Gas Pipeline**: chemical is escaping from a ruptured gas pipeline.

ALOHA Sources & Scenarios

[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]		[illegible]	

4.1.2.1 Fire

A fire is a complex chain reaction where a fuel combines with oxygen to generate heat, smoke, and light. Most chemicals fires will be triggered by one of the following ignition sources: sparks, static electricity, heat, or flames from another fire. Additionally, if a chemical is above its auto ignition temperature it will spontaneously catch on fire without an external ignition source.

There are several properties that measure how readily—that is, how easily—a chemical will catch on fire. Here we'll discuss three of these properties: volatility, flash point, and flammability limits. Volatility is a measure of how easily a chemical evaporates. A flammable liquid must begin to evaporate—forming a vapor above the liquid—before it can burn. The more volatile a chemical, the faster it evaporates and the quicker a flammable vapor cloud is formed. The flash point is the lowest temperature where a flammable liquid will evaporate enough to catch on fire if an ignition source is present. The lower the flash point, the easier it is for a fire to start. Flammability limits, called the Lower Explosive Limit (LEL) and the Upper Explosive Limit (UEL), are the boundaries of the flammable region of a vapor cloud. These limits are percentages that represent the concentration of the fuel—that is, the chemical—vapor in the air. If the chemical vapor comes into contact with an ignition source, it will burn only if its fuel-air concentration is between the LEL and the UEL. To some extent, these properties are interrelated—chemicals that are highly volatile and have a low flash point will usually also have a low LEL.

Once the chemical catches on fire, three things need to be present to keep the fire going: fuel (the chemical), oxygen, and heat. This is often referred to as the fuel triangle. If any one of those components is eliminated, then the fire will stop burning.

Like other reactions, a fire can also generate byproducts—smoke, soot, ash, and new chemicals formed in the reaction. Some of these reaction byproducts can be hazardous themselves. While ALOHA cannot model all the complex processes that happen in a fire (like the generation and distribution of byproducts), it can predict the area where the heat radiated by the fire—called thermal radiation—could be harmful.

Thermal radiation is the primary hazard associated with fires. However, it is also important to consider the hazards associated with any secondary fires and explosions that may occur.

4.1.2.2 Thermal Radiation Levels of Concern:

A Thermal Radiation Level of Concern (LOC) is a threshold level of thermal radiation, usually the level above which a hazard may exist. When you run a fire scenario, ALOHA will suggest three default LOC values. ALOHA uses three threshold values (measured in kilowatts per square meter and denoted as kW/m2) to create the default threat zones:

- Red: 10 kW/m^2 (potentially lethal within 60 sec);
- Orange: 5 kW/m^2 (second-degree burns within 60 sec); and
- Yellow: 2 kW/m^2 (pain within 60 sec).

The thermal radiation effects that people experience depend upon the length of time they are exposed to a specific thermal radiation level. Longer exposure durations, even at a lower thermal radiation level, can produce serious physiological effects. The threat zones displayed by ALOHA represent thermal radiation levels; the accompanying text indicates the effects on people who are exposed to those thermal radiation levels but are able to seek shelter within one minute.

ALOHA's default thermal radiation values are based on a review of several widely accepted sources for this topic (e.g., American Institute of Chemical Engineers 1994, Federal Emergency Management Agency et al. 1988, and Lees 2001).

Thermal Radiation Burn Injury Criteria.

Radiation Intensity (kW/m^2)	Time for Severe Pain (S)	Time for 2nd Degree Burns (S)
1	115	663
2	45	187
3	27	92
4	18	57
5	13	40
6	11	30
8	7	20
10	5	14
12	4	11

Note: The durations that correspond to effects like pain or second-degree burns can vary considerably, depending on circumstances. The effects above were observed on bare skin that was exposed directly to the thermal radiation. Some types of clothing can serve as a protective barrier against thermal radiation and can affect the exposure duration. However, exposure duration should be kept to a minimum, even at low levels of thermal radiation.

4.1.3 Overpressure

A major hazard associated with any explosion is overpressure. Overpressure, also called a blast wave, refers to the sudden onset of a pressure wave after an explosion. This pressure wave is caused by the energy released in the initial explosion—the bigger the initial explosion, the more damaging the pressure wave. Pressure waves are nearly instantaneous, traveling at the speed of sound.

Although a pressure wave may sound less dangerous than a fire or hazardous fragments, it can be just as damaging and just as deadly. The pressure wave radiates outward like a giant burst of air, crashing into anything in its path (generating hazardous fragments). If the pressure wave has enough power behind it, it can lift people off the ground and throw them up against nearby buildings or trees. Additionally, blast waves can damage buildings or even knock them flat—often injuring or killing the people inside them. The sudden change in pressure can also affect pressure-sensitive organs like the ears and lungs. The damaging effects of the overpressure will be greatest near the source of the explosion and lessen as you move farther from the source.

ALOHA predicts an explosion's effects, assess the surroundings at the explosion site as you interpret ALOHA's threat zone plot. Large objects (like trees and buildings) in the path of the pressure wave can affect its strength and direction of travel. For example, if many buildings surround the explosion site, expect the actual overpressure threat zone to be somewhat smaller than ALOHA predicts. But at the same time, more hazardous fragments could be generated as the blast causes structural damage to those buildings.

4.1.3.1 Overpressure Levels of Concern

An Overpressure Level of Concern (LOC) is a threshold level of pressure from a blast wave, usually the pressure above which a hazard may exist. When you run a vapor cloud explosion scenario, ALOHA will suggest three default LOC values. ALOHA uses three threshold values to create the default threat zones:

- Red: 8.0 psi (destruction of buildings);
- Orange: 3.5 psi (serious injury likely); and
- Yellow: 1.0 psi (shatters glass).

ALOHA's default overpressure values are based on a review of several widely accepted sources for this topic (e.g., American Institute of Chemical Engineers 1994, Federal Emergency Management Agency etal. 1988, and Lees 2001).

Explosion Overpressure Damage Estimates

Overpressure* (psig)	Expected Damage
0.04	Loud noise (143 dB), sonic boom glass failure
0.13	Typical pressure for glass failure
0.40	Limited minor structural damage
0.70-1.0	Windows usually shattered; some window frame damage
0.73	Minor damage to house structures
1.0	Partial demolition of houses, made uninhabitable
1.0-2.0	Corrugated metal panels fail and buckle. Heavy wood panels blown in
1.0-2.0	Range for slight to serious laceration injuries from flying glass and other missiles
2.0	Partial collapse of walls and roofs of houses
2.0-3.0	Non-reinforced concrete or cinder block walls shattered
2.4-12.2	Range for 1-99% medium injuries among exposed populations
2.4	99% destruction of house brickwork
3.0	Steel frame building distorted and pulled away from foundation
5.0	Wooden utility poles snapped
5.0-7.0	Nearly complete destruction of houses
7.0	Loaded train cars overturned
9.0	Loaded train box cars demolished
10.0	Probable total building destruction
14.5-29.0	Range for the 1-99% fatalities among exposed populations due to direct blast effects

* These are peak pressures formed in excess of normal atmospheric pressure by blast and shock waves

4.2 Effect at different Heat Radiations & Overpressure

4.2.1 Emergency Response Planning Guidelines (ERPGs)

ERPGs were developed as planning guidelines, to anticipate human adverse health effects caused by exposure to toxic chemicals.

The ERPGs are three-tiered guidelines with one common denominator: a 1-hour exposure period. The tiers are defined as follows:

Interpreting ERPG:

The ERPG guidelines do not protect everyone. Hypersensitive individuals would suffer adverse reactions to concentrations far below those suggested in the guidelines.

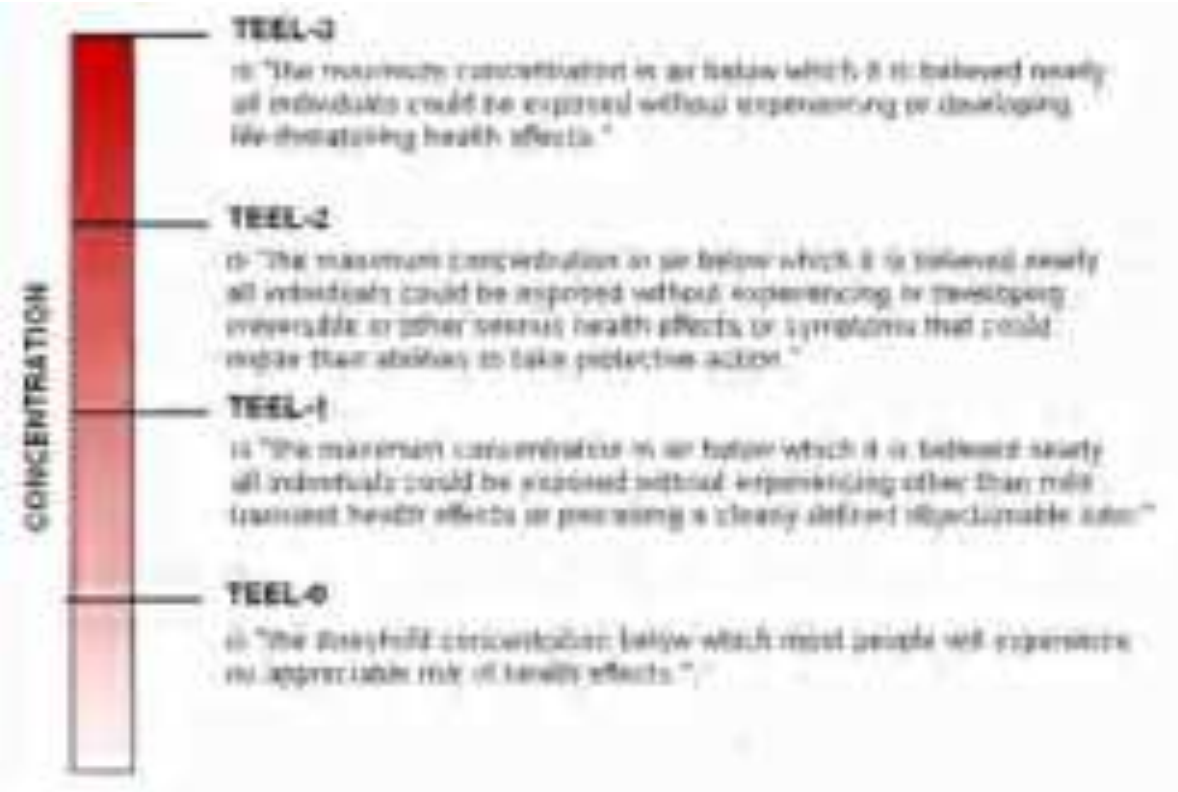
The guidelines are focused on one period of time: 1 hour. Exposure in the field may be longer or shorter. However, the ERPG committee strongly advises against trying to extrapolate ERPG values to longer periods of time.

ERPGs do not contain safety factors usually incorporated into exposure guidelines such as the TLV. Rather, they estimate how the general public would react to chemical exposure. Just below the ERPG-1, for example, most people would detect the chemical and may experience temporary mild effects. Just below the ERPG-3, on the other hand, it is estimated that the effects would be severe, although not life-threatening. The TLV, on the other hand, incorporates a safety factor to prevent ill effects to exposed workers.

4.2.2 Temporary Emergency Exposure Limit (TEEL)

TEELs are temporary levels of concern designed to be used as toxic exposure limits for chemicals for which Acute Exposure Guideline Levels (AEGLs) or Emergency Response Planning Guidelines (ERPGs) have not yet been defined. Like AEGLs and ERPGs, they are designed to represent the predicted response of members of the general public to different concentrations of a chemical during an incident.

Each TEEL includes four tiers, defined as follows:



4.3 Various emergencies that may be expected at the port area

- Leak / Spill and fire and explosion at the chemical jetties of hazardous chemicals.
- Medical Injury
- Sabotage
- Civil disturbance
- Hostage situation
- Severe Weather
- Earthquake
- Accidents in the channel.

4.4 Leak / Spill and Fire & Explosion of Hazardous Chemicals at the Jetties

- Consequence analysis of impact distances for selected maximum credible loss scenarios of some selected chemicals handled at the chemical berths.
- The distance worked are indicative and to be used as a guide line.

4.5 Important assumptions considered for the Study

1. Representative chemicals have been chosen at each jetty. The distance shown in the table / map are applicable to any jetty (1 to 6) where the same chemical could be handled.

   If the port is ready to handle the indicated distances for the chosen chemicals, then it can handle any other chemical emergency also under any weather conditions except storm / cyclone etc.

2. Wind speed 10m/sec from SW at 3 meter height.
3. Ground roughness – Open / Concrete
4. Cloud cover – Partial (5 Tenths)
5. Ambient Temperature – 40 degree C Average
6. Atmospheric stability Class "C"
7. Relative Humidity – 50%
8. Leak of 1000 litres of chemical
9. State of chemical at the time of leak – Liquid
10. Source: Direct Source
11. Source: Evaporating Puddle
    - Downwind toxic effects
    - Vapour cloud flash fire
    - Overpressure from vapour cloud explosion
12. Source: Burning Puddle
    - Thermal Radiation
13. Puddle diameter Average – 10 M
14. Puddle volume 1000 Litres.

4.6 Maximum Credible Loss Scenarios

The Maximum Credible Loss Scenarios (MCLS) give the possible failure scenarios, which takes into account the maximum inventory that can get released at the time of such a failure considering the intervention time based on safety systems provided at the facility.

The most hazardous chemicals taken into consideration for the study are:

Berth No: 1 – LPG & Toluene
Berth No: 2 – Benzene, ACN & Aniline
Berth No: 3 – Methanol, 1,3 Butadiene & Acetone
Berth No: 4 – VCM & Propylene
Berth No: 5 – Ammonia & HSD
Berth No: 6 – Motor Spirit & SKO

4.7 Impact Distances for MCLS under study

4.7.1 Jetty No – 1 Instantaneous Release / Evaporation Puddle / Burning Puddle for LPG

Chemical		Dispersion Distances			LEL Distances		Overpressure Distances			Pool Fire Heat Radiation Distance for		
		TEEL - 3 33000 ppm	TEEL - 2 17000 ppm	TEEL - 1 5500 ppm	60%	10%	8 psi	3.5 psi	1.0 psi	10.0kW/m²	5.0kW/m²	2.0kW/m²
		m	m	m	m	m	m	m	m	m	m	m
Jetty One	LPG (Instantaneous Release)	31	46	88	68	204	LOC not exceeded	48	61	-----	------	-----
Jetty One	LPG (Evaporation Puddle)	13	24	54	35	130	LOC not exceeded	21	42	-----	------	-----
Jetty One	LPG (Burning Puddle)	-----	------	-----	-----	------	-----	-----	------	34	42	57

- Emergency equipment should be placed more than 60 meters away from the unloading hoses / source of leak to prevent damage to them due to over pressures.
- All fire fighting operation should be carried out from a 57 meter distance from the unloading hose, unless fire suits and close proximity suits are used by the fire fighting personnel.
- Whatever is the emergency (fire) at the berth, the sprinklers / water curtain at the berth edge should be activated.
- All persons not directly connected with the operation should be moved beyond 88 meters from the fire / leak
- There should be no source of ignition in the chemical jetty (1 to 6) areas.
- The complete chemical jetty complex is a flame proof zone at all times.

4.7.2 Jetty No – 1 Instantaneous Release / Evaporation Puddle / Burning Puddle for **TOLUENE**

Chemical		Dispersion Distances			LEL Distances		Overpressure Distances			Pool Fire Heat Radiation Distance For		
		ERPG - 3 1000 ppm	ERPG – 2 300 ppm	ERPG – 1 50 ppm	60%	10%	8 psi	3.5 psi	1.0 psi	10.0kW/m²	5.0kW/m²	2.0kW/m²
		m	m	m	m	m	m	m	m	m	m	m
Jetty One	**TOLUENE** (Instantaneous Release)	208	395	1.0Km	71	233	LOC not exceeded	52	72	-----	------	-----
Jetty One	**TOLUENE** (Evaporation Puddle)	< 10	21	73	< 10	< 10	No part of the cloud was above the LEL	No part of the cloud was above the LEL	No part of the cloud was above the LEL	-----	------	-----
Jetty One	**TOLUENE** (Burning Puddle)	-----	------	-----	-----	------	-----	-----	------	29	35	47

- All emergency equipment should be placed more than 72 meters away from the source of leak.
- Fire fighting should be carried out from a distance of more than 47 meter unless fire suits / fire proximity suits are worn by the fire fighting personnel.
- All persons not directly connected with the emergency operation should be moved more than 1 km away from the source of leak.
- All other fire fighting precautions should be adhered to.

4.7.3 Jetty No – 2 Instantaneous Release / Evaporation Puddle / Burning Puddle for **ACRYLONITRILE (ACN)**

Chemical		Dispersion Distances			LEL Distances		Overpressure Distances			Pool Fire Heat Radiation Distance For		
		ERPG - 3 75 ppm	ERPG - 2 35 ppm	ERPG – 1 10 ppm	60%	10%	8 psi	3.5 psi	1.0 psi	10.0kW/m²	5.0kW/m²	2.0kW/m²
		m	m	m	m	m	m	m	m	m	m	m
Jetty Two	ACN (Instantaneous Release)	1.0 Km	1.5 Km	2.8 Km	62	211	LOC not exceeded	41	61	-----	------	-----
	ACN (Evaporation Puddle)	49	76	148	< 10	< 10	No part of the cloud was above the LEL	No part of the cloud was above the LEL	No part of the cloud was above the LEL	-----	------	-----
	ACN (Burning Puddle)	-----	------	-----	-----	------	-----	-----	------	19	23	30

- In case of an emergency involving Acrylonitrile in the form of a major leak with or without a fire, all fire fighters handling the emergency must wear Breathing apparatus, in addition to the usual fire suits.
- All persons not connected with the emergency operation should move beyond 2.8Km distance.
- All supporting personnel must be ready with BA sets.
- The nearby shanty should be evacuated.
- All security staff must have respiratory protection.
- All persons handling the emergency should be sent to the Kandla Port Hospital for checking for CAN poisoning.

4.7.4 Jetty No – 2 Instantaneous Release / Evaporation Puddle / Burning Puddle for **ANILINE**

Chemical		Dispersion Distances			LEL Distances		Overpressure Distances			Pool Fire Heat Radiation Distance For		
		TEEL – 3 20 ppm	TEEL – 2 12 ppm	TEEL – 1 8 ppm	60%	10%	8 psi	3.5 psi	1.0 psi	10.0kW/m²	5.0kW/m²	2.0kW/m²
		m	m	m	m	m	m	m	m	m	m	m
Jetty Two	**ANILINE** (Instantaneous Release)	1.8 Km	2.3 Km	2.7 Km	72	237	LOC not exceeded	53	73	-----	------	-----
	ANILINE (Evaporation Puddle)	12	20	29	< 10	< 10	No part of the cloud was above the LEL	No part of the cloud was above the LEL	No part of the cloud was above the LEL	-----	------	-----
	ANILINE (Burning Puddle)	-----	------	-----	-----	------	-----	-----	------	20	23	31

- All persons handling the emergency must wear full protection suits to avoid skin contact. BA should be worn by the persons handling the emergency.
- The adjoining shanty should be evacuated.
- Persons handling the emergency should check up if their nails, lips, earlobes have turned blue. If so, immediately move them to Kandla Port hospital.

4.7.5 Jetty No – 2 Instantaneous Release / Evaporation Puddle / Burning Puddle for **BENZENE**

Chemical		Dispersion Distances			LEL Distances		Overpressure Distances			Pool Fire Heat Radiation Distance For		
		ERPG - 3 1000 ppm	ERPG - 2 150 ppm	ERPG -1 50 ppm	60%	10%	8 psi	3.5 psi	1.0 psi	10.0kW/m²	5.0kW/m²	2.0kW/m²
		m	m	m	m	m	m	m	m	m	m	m
Jetty Two	**BENZENE** (Instantaneous Release)	228	625	1.1 Km	80	265	LOC not exceeded	61	76	-----	------	-----
Jetty Two	**BENZENE** (Evaporation Puddle)	23	81	145	< 10	20	No part of the cloud was above the LEL	No part of the cloud was above the LEL	No part of the cloud was above the LEL	-----	------	-----
Jetty Two	**BENZENE** (Burning Puddle)	-----	------	-----	-----	------	-----	-----	------	29	35	47

- A Benzene fire gives out dense black smoke which could reduce the visibility. All fire fighters must wear a chemical protection suit while handling the emergency, wear BA.
- All those not connected with the emergency handling should move beyond 1.1 km up wind.
- Initial fire fighting should be from a distance of 47 meter, unless fire suits, proximity suits are worn. All security staff must have respiratory protection.
- All persons handling the emergency should be sent to the Kandla Port hospital for urine test to check for Benzene poisoning.

4.7.6 Jetty No – 3 Instantaneous Release / Evaporation Puddle / Burning Puddle for 1:3, BUTADIENE

Chemical		Dispersion Distances			LEL Distances		Overpressure Distances			Pool Fire Heat Radiation Distance For		
		ERPG - 3 5000 ppm	ERPG - 2 200 ppm	ERPG - 1 10 ppm	60%	10%	8 psi	3.5 psi	1.0 psi	10.0kW/m²	5.0kW/m²	2.0kW/m²
		m	m	m	m	m	m	m	m	m	m	m
Jetty Three	1:3, BUTADIENE (Instantaneous Release)	92	524	2.4 Km	62	206	LOC not exceeded	48	63	-----	------	-----
	1:3, BUTADIENE (Evaporation Puddle)	22	157	736	13	53	LOC not exceeded	< 10	21	-----	------	-----
	1:3, BUTADIENE (Burning Puddle)	-----	------	-----	-----	------	-----	-----	------	34	42	57

- Initial fire fighting should be from a distance of more than 57 meters. The fire fighters should wear BA sets and chemical protection suits.
- The shanty should be evacuated beyond 2.4 Km distance.

4.7.7 Jetty No – 3 Instantaneous Release / Evaporation Puddle / Burning Puddle for **ACETONE**

Chemical		Dispersion Distances			LEL Distances		Overpressure Distances			Pool Fire Heat Radiation Distance For		
		TEEL - 3 5700 ppm	TEEL - 2 3200 ppm	TEEL - 1 200 ppm	60%	10%	8 psi	3.5 psi	1.0 psi	10.0kW/m²	5.0kW/m²	2.0kW/m²
		m	m	m	m	m	m	m	m	m	m	m
Jetty Three	**ACETONE** (Instantaneous Release)	97	134	591	56	190	LOC not exceeded	40	56	-----	------	-----
Jetty Three	**ACETONE** (Evaporation Puddle)	10	17	111	< 10	22	No part of the cloud was above the LEL	No part of the cloud was above the LEL	No part of the cloud was above the LEL	-----	------	-----
Jetty Three	**ACETONE** (Burning Puddle)	-----	------	-----	-----	------	-----	-----	------	20	24	32

- Fire fighters should note that acetone and methanol fires are non luminescent and there could be a tendency to go nearer to the puddle /pool on fire. This should be done by fire fighters fully equipped with fire suits / proximity suits. Acetone / Methanol are water soluble, which is advantageous for fire fighting.

4.7.8 Jetty No – 3 Instantaneous Release / Evaporation Puddle / Burning Puddle for **METHANOL**

Chemical		Dispersion Distances			LEL Distances		Overpressure Distances			Pool Fire Heat Radiation Distance		
		ERPG - 3 5000 ppm	ERPG - 2 1000 ppm	ERPG-1 200 ppm	60%	10%	8 psi	3.5 psi	1.0 psi	10.0kW/m²	5.0kW/m²	2.0kW/m²
		m	m	m	m	m	m	m	m	m	m	m
Jetty Three	**METHANOL** (Instantaneous Release)	178	431	1.0 Km	49	190	LOC not exceeded	LOC not exceeded	33	-----	------	-----
Jetty Three	**METHANOL** (Evaporation Puddle)	< 10	33	89	< 10	< 10	No part of the cloud was above the LEL	No part of the cloud was above the LEL	No part of the cloud was above the LEL	-----	------	-----
Jetty Three	**METHANOL** (Burning Puddle)	-----	------	-----	-----	------	-----	-----	------	11	12	15

- Fire fighters should note that acetone and methanol fires are non luminescent and there could be a tendency to go nearer to the puddle /pool on fire. This should be done by fire fighters fully equipped with fire suits / proximity suits. Acetone / Methanol are water soluble, which is advantageous for fire fighting.

4.7.9 Jetty No – 4 Instantaneous Release / Evaporation Puddle / Burning Puddle for **PROPYLENE**

Chemical		Dispersion Distances			LEL Distances		Overpressure Distances			Pool Fire Heat Radiation Distance For		
		TEEL - 3 20000 ppm	TEEL-2 10000 ppm	TEEL -1 1500 ppm	60%	10%	8 psi	3.5 psi	1.0 psi	10.0kW/m²	5.0kW/m²	2.0kW/m²
		m	m	m	m	m	m	m	m	m	m	m
Jetty Four	**PROPYLENE** (Instantaneous Release)	51	80	233	74	253	LOC not exceeded	52	66	-----	------	-----
Jetty Four	**PROPYLENE** (Evaporation Puddle)	30	53	163	51	194	LOC not exceeded	29	52	-----	------	-----
Jetty Four	**PROPYLENE** (Burning Puddle)	-----	------	-----	-----	------	-----	-----	------	33	41	55

- All emergency handling should be from a distance of more than 66 meters unless full fire suits / proximity suit is worn.
- All personnel not directly connected with the emergency should be moved beyond 233 meters form the leak area.

4.7.10 Jetty No – 4 Instantaneous Release / Evaporation Puddle / Burning Puddle for **VINYL CHLORIDE (VCM)**

Chemical		Dispersion Distances			LEL Distances		Overpressure Distances			Pool Fire Heat Radiation Distance		
		ERPG - 3 5000 ppm	ERPG - 2 1000 ppm	ERPG - 1 200 ppm	60%	10%	8 psi	3.5 psi	1.0 psi	10.0kW/m²	5.0kW/m²	2.0kW/m²
		m	m	m	m	m	m	m	m	m	m	m
Jetty Four	VCM (Instantaneous Release)	47	108	376	45	152	LOC not exceeded	30	48	-----	------	-----
	VCM (Evaporation Puddle)	< 10	15	52	< 10	23	No part of the cloud was above the LEL	No part of the cloud was above the LEL	No part of the cloud was above the LEL	-----	------	-----
	VCM (Burning Puddle)	-----	------	-----	-----	------	-----	-----	------	< 10	< 10	< 10

- VCM is highly toxic, hence all persons handling the emergency involving VCM should wear full respiratory protection (BA sets) and handle the emergency from a distance of more than 48 meters.
- Nearby shanty should be put on the alert for evacuation in case emergency evacuation is needed.
- All persons handling the emergency should be sent to the Kandla Port hospital for VCM poisoning check up.

4.7.11 Jetty No – 5 Instantaneous Release / Evaporation Puddle / Burning Puddle for **AMMONIA**

Chemical		Dispersion Distances			LEL Distances		Overpressure Distances			Pool Fire Heat Radiation Distance For		
		AEGL - 3 1100 ppm	AEGL - 2 160 ppm	AEGL - 1 30 ppm	60%	10%	8 psi	3.5 psi	1.0 psi	10.0kW/m²	5.0kW/m²	2.0kW/m²
		m	m	m	m	m	m	m	m	m	m	m
Jetty Five	**AMMONIA** (Instantaneous Release)	219	589	1.4 Km	33	80	LOC not exceeded	LOC not exceeded	26	-----	------	-----
	AMMONIA (Evaporation Puddle)	96	260	617	< 10	16	No part of the cloud was above the LEL	No part of the cloud was above the LEL	No part of the cloud was above the LEL	-----	------	-----
	AMMONIA (Burning Puddle)	-----	------	-----	-----	------	-----	-----	------	< 10	11	13

- Emergencies involving Ammonia will be mostly leakage / spillage.
- Ammonia is flammable with difficulty.
- Ammonia emergencies should be handled by wearing BA sets.
- Ammonia is soluble in water, which will make it easier to handle the emergency.
- Do not direct water jet onto the liquid ammonia puddle, this could cause spurting of the liquid. Let the ammonia vapours come into the water spray / fog.

AEGLs represent threshold exposure limits for the general public and are applicable to emergency exposure periods ranging from 10 minutes to 8 hours. AEGL-2 and AEGL-3, and AEGL-1 values as appropriate will be developed for each of five exposure periods (10 and 30 minutes, 1 hour, 4 hours, and 8 hours) and will be distinguished by varying degrees of severity of toxic effects. It is believed that the recommended exposure levels are applicable to the general population including infants and children, and other individuals who may be susceptible.

The three AEGLs have been defined as follows:

AEGL-1 is the airborne concentration, expressed as parts per million or milligrams per cubic meter (ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic nonsensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.

AEGL-2 is the airborne concentration (expressed as ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.

AEGL-3 is the airborne concentration (expressed as ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death.

Airborne concentrations below the AEGL-1 represent exposure levels that can produce mild and progressively increasing but transient and nondisabling odor, taste, and sensory irritation or certain asymptomatic, nonsensory effects. With increasing airborne concentrations above each AEGL, there is a progressive increase in the likelihood of occurrence and the severity of effects described for each corresponding AEGL. Although the AEGL values represent threshold levels for the general public, including susceptible subpopulations, such as infants, children, the elderly, persons with asthma, and those with other illnesses, it is recognized that individuals, subject to unique or idiosyncratic responses, could experience the effects described at concentrations below the corresponding AEGL.

4.7.12 Jetty No – 5 Instantaneous Release / Evaporation Puddle / Burning Puddle for HSD

Chemical		Dispersion Distances			LEL Distances		Overpressure Distances			Pool Fire Heat Radiation Distance For		
		TEEL 8600 ppm	TEEL 3300 ppm	TEEL 400 ppm	60%	10%	8 psi	3.5 psi	1.0 psi	10.0kW/m²	5.0kW/m²	2.0kW/m²
		3	2	1								
		m	m	m	m	m	m	m	m	m	m	m
Jetty Five	HSD (Instantaneous Release)	59	112	370	73	240	LOC not exceeded	53	71	-----	------	-----
	HSD (Evaporation Puddle)	<10	15	85	14	48	LOC not exceeded	10	19	-----	------	-----
	HSD (Burning Puddle)	-----	------	-----	-----	------	-----	-----	------	35	42	58

- High Speed Diesel fires should be handled with care, by wearing fire suits / proximity suits.
- Foam should be used for fire fighting.

4.7.13 Jetty No – 6 Instantaneous Release / Evaporation Puddle / Burning Puddle for **MOTOR SPIRIT**

Chemical		Dispersion Distances			LEL Distances		Overpressure Distances			Pool Fire Heat Radiation Distance		
		TEEL - 3 1500 ppm	TEEL - 2 610 ppm	TEEL - 1 610 ppm	60%	10%	8 psi	3.5 psi	1.0 psi	10.0kW/m²	5.0kW/m²	2.0kW/m²
		m	m	m	m	m	m	m	m	m	m	m
Jetty Six	**MOTOR SPIRIT** (Instantaneous Release)	159	258	258	68	227	LOC not exceeded	51	66	-----	------	-----
Jetty Six	**MOTOR SPIRIT** (Evaporation Puddle)	51	85	85	16	70	LOC not exceeded	11	24	-----	------	-----
Jetty Six	**MOTOR SPIRIT** (Burning Puddle)	-----	------	-----	-----	------	-----	-----	------	37	45	61

- Motor spirit fires should be handled with care, by wearing fire suits / proximity suits.
- Foam should be used for fire fighting.

4.7.14 Jetty No – 6 Instantaneous Release / Evaporation Puddle / Burning Puddle for **SKO**

Chemical		Dispersion Distances			LEL Distances		Overpressure Distances			Pool Fire Heat Radiation Distance For		
		TEEL – 3 1250 ppm	TEEL – 2 1000 ppm	TEEL - 1 600 ppm	60%	10%	8 psi	3.5 psi	1.0 psi	10.0kW/m²	5.0kW/m²	2.0kW/m²
		m	m	m	m	m	m	m	m	m	m	m
Jetty Six	**SKO** (Instantaneous Release)	141	159	209	74	239	LOC not exceeded	54	73	-----	------	-----
	SKO (Evaporation Puddle)	< 10	< 10	< 10	< 10	< 10	No part of the cloud was above the LEL	No part of the cloud was above the LEL	No part of the cloud was above the LEL	-----	------	-----
	SKO (Burning Puddle)	-----	------	-----	-----	------	-----	-----	------	28	35	48

- SKO fires should be handled with care, by wearing fire suits / proximity suits.
- Foam should be used for fire fighting.

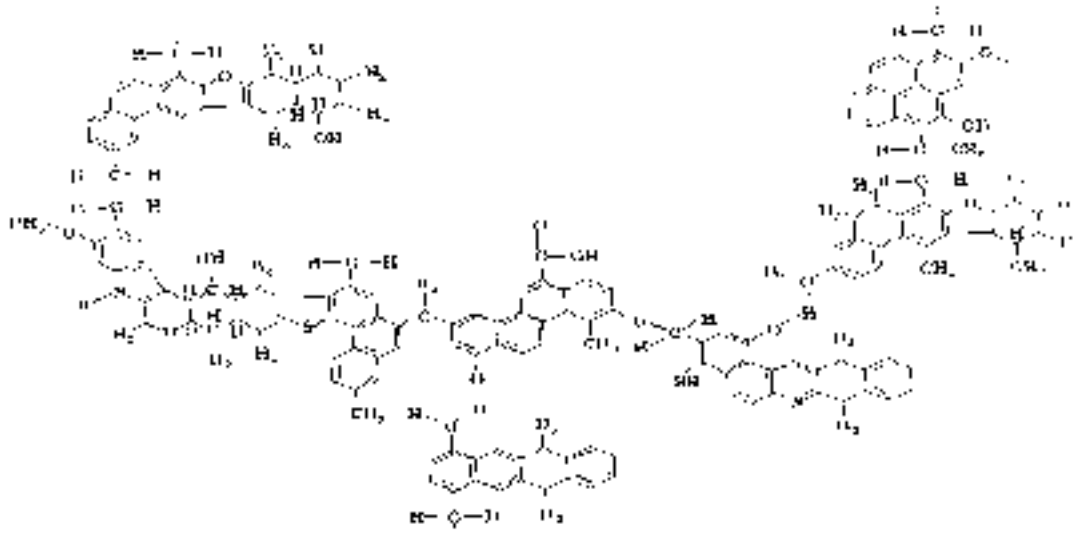
4.8 Coal Storage at Open Yard

4.8.1 General Characteristics of Coal

Coal is a fossil fuel extracted from the ground by underground mining or open pit mining. It is a readily combustible, black or brownish – black sedimentary rock. It is composed primarily of carbon along with assorted other elements.

Carbon forms more than 50% by weight and more than 70% by volume of coal.

Coal usually contains a considerable amount of incidental moisture, which is the water trapped within the coal in between the coal particles. The structure of a coal molecule is represented as follows:



Methane gas is another component of coal. Methane in coal is dangerous as it can cause explosion and may cause the coal to spontaneously combust.

4.8.2 Effects of Coal Burning

Combustion of coal, like any other compound containing carbon, produces CO_2, along with minor amount of SO_2.

Coal can be set on fire by spontaneous combustion

4.8.3 Spontaneous Combustion in Coal

The risk from fire exists where significant amounts of coal are in use of storage. Coal is a combustible material, making it susceptible to a variety of ignition scenarios. One of the most frequent and serious causes of coal fires is spontaneous combustion, which has been responsible for a number of incidents within the department in recent years.

Preventing spontaneous combustion coal fires involves attention to many different factors. Among the most critical are the type, age and composition of coal, how it is stored and how it is used. Given the right kind of coal, oxygen, and a certain temperature and moisture content, coal will burn by itself.

Spontaneous combustion has long been recognized as a fire hazard in stored coal. Spontaneous combustion fires usually begin as "hot spots" deep within the reserve of coal. The hot spots appear when coal absorbs oxygen from the air. Heat generated by the oxidation can initiate the fire.

Such fires can be very stubborn to extinguish because of the amount of coal involved (often hundreds of tons) and the difficulty of getting to the seat of the problem. Moreover, coal in either the smouldering of flaming stage may produce copious amounts of methane and carbon monoxide gases. In addition to their toxicity, these gases are highly explosive in certain concentrations, and can further complicate efforts to fight this type of coal fire.

Even the most universal fire fighting substance, water, cannot be used indiscriminately, because of the remote possibility of a steam explosion; it is advisable that water be applied carefully and from a safe distance. Certain chemicals such as carbon dioxide or nitrogen may mitigate fire effects, but their use has had mixed success from a DOE (Department of Energy) perspective. The above information suggests that coal fires require awareness and prior planning to extinguish efficiently, completely, and safely.

4.8.4 Causes of Spontaneous Coal Fires

The following general factors have been mentioned as contributing causes:

- Coal handling procedures allowed for long-time retention of coal, which increases the possibility of heating
- New coal added on top of old coal created segregation of particle sizes, which is a major cause of heating
- Too few temperature probes installed in the coal bunker resulted in an excessive period of time before the fire was detected.
- Failure of equipment needed to fight the fire
- Ineffective capability and use of carbon dioxide fire suppression system
- Delay in the application of water

4.8.4.1 Preventing Spontaneous Combustion in Stored Coal

High quantities of coal are stored in bunkers, silos, hoppers and open air stockpiles. How susceptible such stocks of coal are to fire from spontaneous combustion depends on a number of factors, from how new the coal is to how it is piled.

4.8.5 Recommendations for Coal Storage

- Storing coal with low sulphur content is helpful. Sulphur compounds in coal liberate considerable heat as they oxidize.

- Air circulating within a coal pile should be restricted as it contributes to heating; compacting helps seal air out.

- Moisture in coal contributes to spontaneous heating because it assists the oxidation process. Moisture content should be limited to 3 %; sulphur

content should be limited to 1 %, "as mined." Coal having high moisture content should be segregated and used as quickly as possible. Efforts should be made to keep stored coal from being exposed to moisture.

- Following the "First in, First out" rule of using stock reduces the chance for hot spots by helping preclude heat build up for portions of stock which remain undisturbed for a long term. The design of coal storage bins is important in this regard.
- A high ambient temperature aids the spontaneous heating process. Remove coal as quickly as possible. The longer large coal piles are allowed to sit, the more time the spontaneous process has, to work.
- The shape and composition of open stock piles can help prevent fires. Dumping coal into a big pile can lead to problems. Rather, coal should be packed in horizontal layers (opinions range from 1 ½' to 3' high) which are then levelled by scraping and compacted by rolling. This method helps distribute the coal evenly and thus avoids breakage and segregation if fine coal. Segregation of coal particles by size should be avoided, as it may allow more air to enter the pile and subsequent heating of finer sizes.
- The height of the coal pile/stock is also important; limit un - layered, un - compacted high grade coal to a height of 15' maximum height.
- Properly inspect, test and maintain installed fire protection equipment.
- Maintain an updated pre-fire plan and encourage regular visits to coal facilities by the site or local emergency response force.

4.8.6 Roll Packing

Roll packing helps to exclude O_2 and thus to prevent fires by discouraging spontaneous combustion. Coal is distributed by a grab bucket or by other means in a uniform layer. The layer is then levelled by scraping and compacted by rolling. Distributing the coal evenly avoids breakage and segregation of the coal. The firm packing helps shed water.

4.8.7 Checking Temperature

Steam rising from a pile or the odour of burning coal is an indication of spontaneous heating, but an earlier or more reliable indication is obtained by checking the temperature/ hot spots/CO detection.

Rise of temperature can be noted by use of thermocouples. Hot spots can be detected by use of IR coal fire monitors. CO detectors can indicate that coal combustion has started.

4.9 Risk Analysis for Coal Fires in Storage Yard Berth 14

Data used for calculation of impact distance for coal fires. Type of coal – Bituminous (Medium Volatile)

Emissivity Constant (ε)	=	0.9 for Bituminous Coal
Stefan Boatmen constant	=	5.6×10^{-8} KW/m^{2}K^4

4.9.1 Formula used for Calculation of Impact Distance (D) = $\sqrt{FQ/4\Pi K}$

Where D	=	Distance from flame centre to receiving point.
Where F	=	Fraction of heat radiation = 0.15 (Conservative)
Where Q	=	Total Heat Generated /Emitted by Coal
Where K	=	Thermal Radiation level

Maximum temperature attained by flame of Coal T_f = 900DegC = 1173K

Ambient surrounding temperature T_a= 27DegC to 35DegC = 300K – 308K

$Q = \sigma A \varepsilon (T_f^4 - T_a^4)$
$\sigma = 5.68 \times 10^{-8}$ kW/m2K4

$T_f^4 = (1173)^4$ K
$T_a^4 = (300)^4$ K

For active coal burning area = 10m^2

$Q = 5.6 \times 10^{-8} \times 0.9 \times 10 (1173^4 - 300^4)$

Q = 950 kW

For Heat radiation 4 kW/m^2 impact distance D

D = $\sqrt{(950 \times 0.15)/(4 \times 3.14 \times 4)}$ = 1.68 = 1.7m

For Heat radiation 12.5 kW/m^2 impact distance D

D = $\sqrt{(950 \times 0.15)/(4 \times 3.14 \times 12.5)}$ = 0.9527 = 1 m

For Heat radiation 37.5 kW/m^2 impact distance D

D = $\sqrt{(950 \times 0.15)/(4 \times 3.14 \times 37.5)}$ = 0.55m

For active coal burning area – 100 m^2

Q = 5.6 x 10-8 x 0.9 x 100 ($1173^4 - 300^4$)
= 9500 kW/m2

For Heat radiation 4 kW/m2 impact distance D

D = $\sqrt{(9500 \times 0.15)/(4 \times 3.14 \times 4)}$ = 5.32 m

For Heat radiation 12.5 KW/m2 impact distance D

D = $\sqrt{(9500 \times 0.15)/(4 \times 3.14 \times 12.5)}$ = 3.012 m

For Heat radiations 37.5 KW/m2 impact distance D

D = $\sqrt{(9500 \times 0.15)/(4 \times 3.14 \times 37.5)}$ = 1.74 m

The Damage Effects Due to Thermal Radiation of Varying Intensity

Incident Radiation Intensity (kW/m^2)	Type of Damage
37.5	Sufficient to cause damage to process equipment unless the equipment is fully thermally fire protected (Insulation, fire proofing, sprinkler protection etc)
12.5	Minimum energy required for piloted ignition of wood, melting plastic tubing, etc.
4.5	Sufficient to cause pain to personnel if unable to reach within 20 seconds, blistering of skin (1st degree burns) is likely.

4.9.2 Summary:

Heat Radiation Impact distance for	Active Burning Coal Area	
	10 m^2	100 m^2
4 kW/m^2	1.7 m	5.3 m
12.5 kW/m^2	1.0 m	3.0 m
37.5 kW/m^2	0.5 m	1.74 m

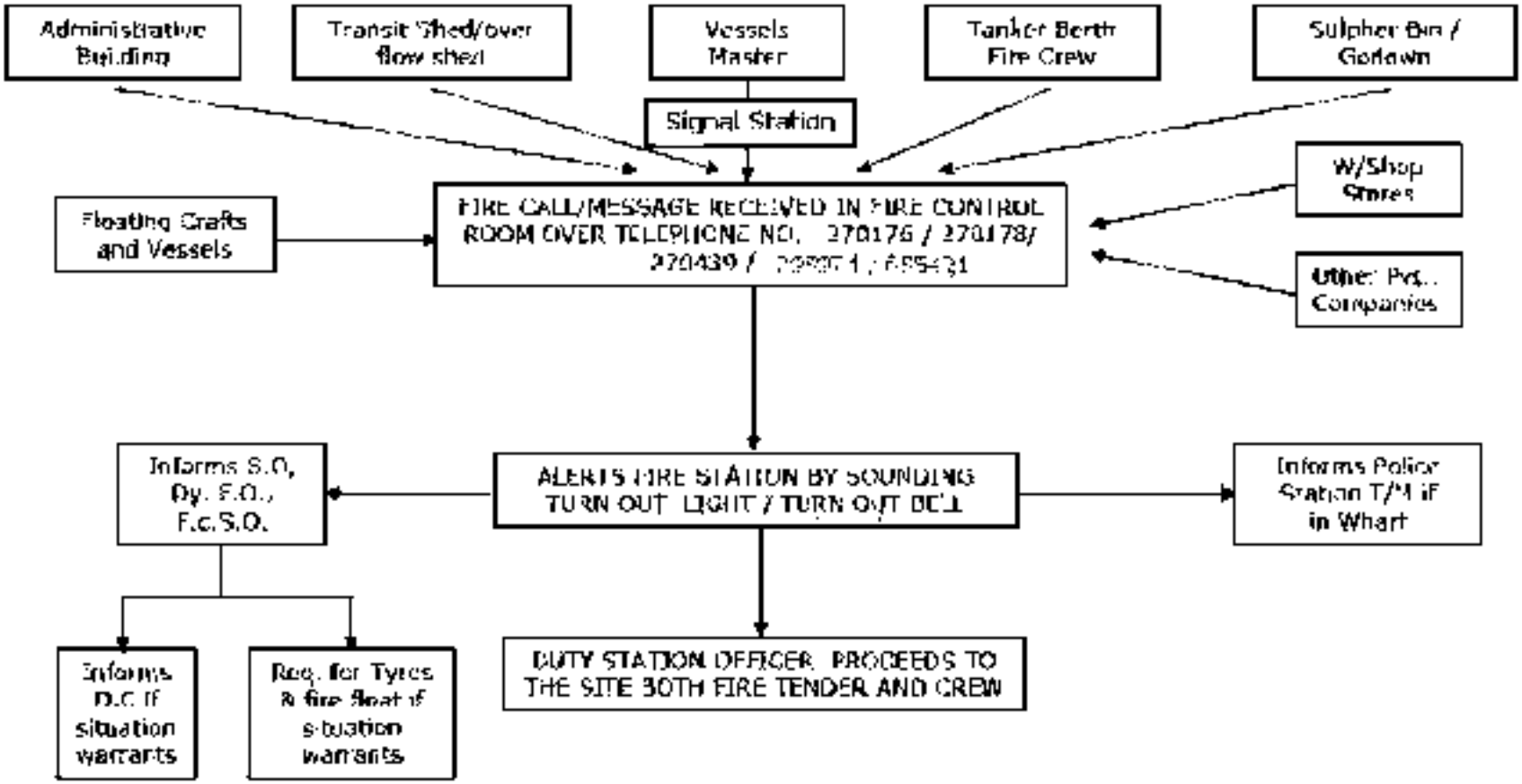
Assuming that 100m^2 surface area of the coal stack is smouldering **no person should approach the stock within 6 m distance**.

All fire fighting should be done from more than **5.3 m away** from the affected

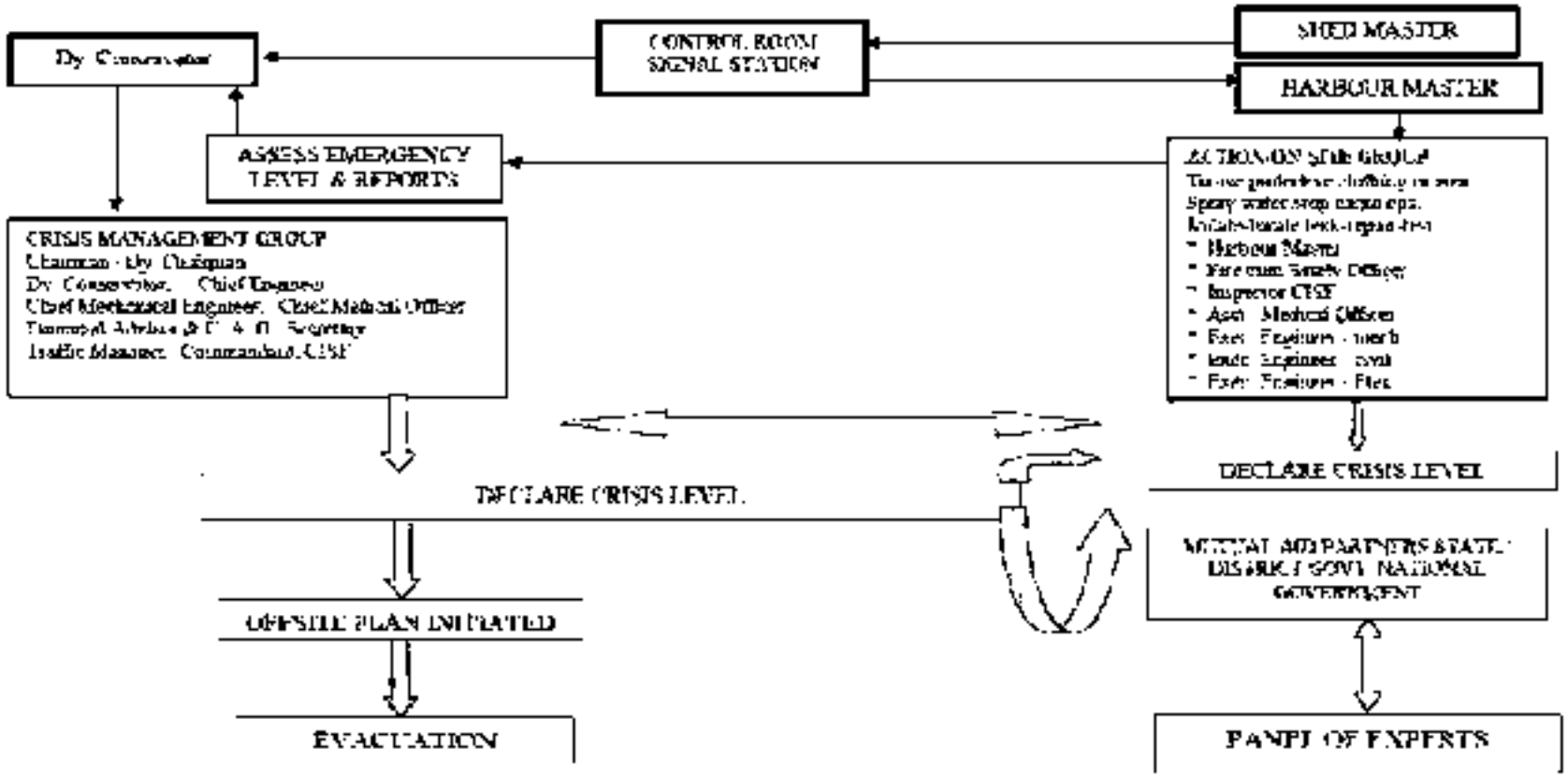
coal stack unless the fire fighter is fully clothed with fire protective clothing and respiratory protection

Please note that CO could also be emitted during a coal fire due to incomplete combustion. Hence adequate respiratory protection should be used like canister gas mask or Self Contained Breathing Apparatus –SCBA

4.10 Fire & Explosion Response Plan



4.11 Fire & Toxic Leakage



PROCESS

(1) Master or informer raises alarm
(2) Informs control room at the Fire Station
(3) Advises D.C. and H.M. and Action Group
(4) Action group commences in fire protective clothing in area
-Spray water-stop engines/isolate – locate leak-report test
(5) Declare crisis level
(6) Crisis level endorsement by crisis management group
(7) If crisis level declared in greater
(8) Mutual aid partners contacted and district emergency plan initiated
(9) If necessary evacuation commenced partial or full

4.12 Details of Fire Fighting Equipment available at Kandla Port

4.12.1 Fire Water Tender – 6 Nos

Water Tank Capacity: 6000 liters. (Discharge Capacity 2000 liters at 10kg/cm^2 & 300 liters at 40kg/cm^2).

Fire Monitor Discharge capacity 2750 lpm at 7kg/cm2 with effective throw/Jet of minimum 45 meters.

Fire Fighting Equipments:

- RRL Hose 15mtrs X 63mm (ID)
- Foam AFFF 3%
- Various type of Branches
- Hose Fittings
- Small Gears
- Personnel Protective equipment (PPE)
- Additional Foam Fighting System
- Communication System
- Public Address system
- Extension Ladder

4.12.2 Foam Fire Tender – 3 Nos

Water Tank Capacity: 5000 liters. (Discharge Capacity 2000 liters at 10kg/cm^2 & 300 liters at 40kg/cm^2).

Foam Tank Capacity: 1000 liters.

Fire Monitor Discharge capacity 2750 lpm at 7kg/cm^2 with effective throw/Jet of minimum 45 meters.

Additional CO_2 Extinguishing System.

Fire Fighting Equipments:

- RRL Hose 15mtrs X 63mm (ID)
- Foam AFFF 3%
- Various type of Branches
- Hose Fittings
- Small Gears
- Personnel Protective equipment (PPE)
- Additional Foam Fighting System
- Communication System
- Public Address system
- Extension Ladder

4.12.3 Multi Purpose Fire Tender – 1 No

Water Tank Capacity: 5000 liters. (Discharge Capacity 2000 liters at 10kg/cm^2 & 300 liters at 40kg/cm^2).

Foam Tank Capacity: 1000 liters.

Fire Monitor Discharge capacity 2750 lpm at 7kg/cm^2 with effective throw /Jet of minimum 45 meters.

Additional CO_2 Extinguishing System.

Additional Dry Chemical Powder Extinguishing System.

Fire Equipments:

- RRL Hose 15mtrs X 63mm (ID)
- Foam AFFF 3%
- Various type Branches
- Hose Fittings
- Small Gears
- Personnel Protective equipment (PPE)
- Addition Foam Fighting System
- Communication System
- Public Address system
- Extension Ladder

4.12.4 Dry Chemical Powder Fire Tender – 1 No

2Nos. Dry Chemical Powder Cylinder Capacity: 1000 Kgs. each cylinder.

Fire Monitor Discharge capacity 2750 lpm at 7kg/cm^2 with effective throw / Jet of minimum 45 meters.

Fire Equipments:

- Various type of Branches
- Small Gears
- Personnel Protective equipment (PPE)
- Communication System
- Public Address system

4.12.5 Tank Lorry - 01 No.

- Tank Capacity 12,000 liters.
- Anti Pollution Scheme.

4.12.6 Fire Jeep – 01 No.

Pump Discharge Capacity 1800 liters at 7kg/cm^2.

Fire Fighting Equipments:

- RRL Hose 15mtrs X 63mm (ID)
- Various type of Branches
- Hose Fittings
- Small Gears

- Personnel Protective equipment (PPE)
- Communication System
- Public Address system
- Extension Ladder

4.12.7 Safety Jeep – 01 No.

For proper Coordination, Inspection, in around the Port (Oil & Chemical Tank Farm & Administrative Works).

Fire Fighting Equipments:

- Small Gears
- Personnel Protective equipment (PPE)
- Communication System
- Public Address system

4.12.8 Ambulance – 01 No.

For Transportation of Injured Ship Official, Ship Crews and Victims.

4.13 Station wise Manpower Brake Up (Manned Round The Clock)

4.13.1 Emergency Response Centre / Old Kandla Fire Station (Liquid Cargo Jetty)

- Fire cum Safety Officer – 01
- Deputy Fire Officer – 01
- Station Officers – 02 Nos
- Leading Fireman – 02 Nos
- Pump Operator cum Driver – 03 Nos
- Fireman – 08 Nos
- Auto Diesel Mechanic – 01
- Junior Clerk – 01

Oil Jetty No. 1 (LPG Jetty)

- Leading Fireman – 01
- Pump Operator cum Driver – 01
- Fireman – 04 Nos

Oil Jetty No. 2

- Leading Fireman – 01
- Fireman – 04 Nos

Oil Jetty No. 3

- Leading Fireman – 01
- Fireman – 04 Nos

Oil Jetty No. 4

- Leading Fireman – 01
- Pump Operator cum Driver – 01
- Fireman – 04 Nos

Oil Jetty No. 5 (IFFCO Jetty)

- Leading Fireman – 01
- Pump Operator cum Driver – 01
- Fireman – 04 Nos

While LPG Tanker is discharging the LPG at Oil Jetty No.1, a Station Officer shall be in charge till the unberthing of LPG Vessel.

Above Fire Crews will be posted at Oil Jetties depending upon the Nature of Risk Cargo Handled.

4.13.2 Tilak Fire Station (Dry Cargo Jetty).

- Station Officers – 01 No
- Leading Fireman – 01 No
- Pump Operator cum Driver – 02 Nos
- Fireman – 04 Nos

For Running & Maintenance of First Aid, Fire Equipments installed at various work places of Kandla Port.

- Leading Fireman – 01 No
- Fireman – 02 Nos

4.13.3 Azad Fire Station (Dry Cargo Jetty).

- Station Officers – 02 Nos
- Leading Fireman – 01 No
- Pump Operator cum Driver – 02 Nos
- Fireman – 04 Nos

4.14 Fire fighting facility at Chemical / Oil Handling Berths

4.14.1 Oil Jetty No: 1

Fixed foam / water remote controlled monitors mounted on towers at each end of each berth.

There are three vertical turbine pumps each of 500m3/hr capacity. One each of Electrical Fire Water Pumps, Diesel Engine Fire water pumps, Electrical flushing pumps.

Jetty one LPG side – 12 DCP – 5Kg Fire Extinguishers, 2 DCP – 150 Kg Trolley mounted fire extinguishers.

4 Fire suits, 2 BA sets with 2 spare respirable air cylinders.

Fire equipment Room:

- Foam / DCP – 15 Nos fire extinguishers
- Helmets – 5 Nos
- Hose length (15 meters) 10 Nos
- Manual Siren – 1No
- Gum Boots – 6 Pairs
- Ropes
- Foam compound 1000 Liters
- Hose fittings
- Branch Pipes
- Fire Axe
- Safety shower – 1 No
- Water curtains
- Fire suits – 2 Nos
- Canister gas mask – 1 No
- Telephone
- Mobile foam trolley – 100 Liters

4.14.2 Oil Jetty No: 2

Fixed foam / water remote controlled monitors mounted on towers at each end of each berth.

There are two vertical turbine pumps each of 800m^3/hr capacity, two jockey pumps of 25m^3/hr capacity, two foam pumps each of 22m^3/hr capacity, two foam /water remote controlled tower monitors, and six jumbo curtains installed at the jetty face.

Fire equipment Room:

- Foam /DCP – 10 Nos each fire extinguishers
- Helmets – 6 Nos
- Fire Hoses - 10 Nos
- BA set – 1No
- Gum Boots – 6 Pairs
- Foam making branch pipes – 2 Nos
- Female coupling –8 Nos
- Jet branch pipes –5 Nos
- Fire suits -2 Nos
- Foam compound - 50 x 30 Liters
- Chemical Suits- 2 Nos
- Telephone – 1 No
- Fire Axe- 1No
- DCP Fire extinguishers – 10 Nos
- Foam Fire extinguishers – 10 Nos
- Fire Buckets – 10 Nos
- Oil Dispersant – 10 x 20 Liters

- Rubber hand gloves – 6 Nos
- Hose length – 15 meters (10 Nos)

4.14.3 Oil Jetty No: 3, 4 & 5

In Oil Jetty No: 3, there are two foam pumps, with foam tank, 2 remote controlled tower monitors for foam / water spray, 2 sets of jumbo curtains at jetty face, one flame detection system, one 50KW DG set and control console.

Oil Jetty No: 4, there are three vertical turbine pumps each of 500m^3/hr capacity, 2 foam pumps with foam tank, 2 remote control tower monitors of capacity 3000 liters per minute of water, 3 jumbo curtains at jetty face, 50 KW DG set and control console.

Oil Jetty No: 5, there are two fire water pumps each of 270m^3/hr capacity, (One electrical driven pump, and one diesel engine pump each).

Fire equipment Room:

- Fire buckets – 8 Nos
- Manual Fire Sirens – 1 No
- Foam branch pipes – 4 Nos
- Mechanical foam generator – 2Nos
- Foam compound – 1000 Liters
- BA set – 1 No
- Gum Boots – 6 Pairs
- Helmets – 6 Nos
- Hose length (15 Meters) – 10 Nos
- DCP fire extinguishers – 10 Nos
- Foam fire extinguishers – 5 Nos
- Fire suits – 2 Nos
- Dispersant chemicals - 6 x 20 Lets
- Double female couplings – 8 Nos
- Male coupling – 2 Nos
- Diffuser – 2 Nos
- Water Curtain – 1 No
- Jet Branch Pipe – 2Nos
- Canister Gas Masks – 1 No
- Portable foam / water monitor – 1 No
- DCP Unit – 2 x 150 Kg
- Mobile foam generator
- Safety Shower – 1No

4.14.4 Oil Jetty No: 6

- 2 – Nos Diesel engine fire water pumps 820m^3/hour each.
- 1 – HP Jockey pump electrical 80m^3/hour
- Fire blankets (water jel)
- Smoke detectors in fire pump house

- Hand tool set
- Water curtains nozzles – 2 Nos
- AFFF foam
- DCP fire extinguishers – 6 Nos
- Trolley mounted DCP fire extinguishers – 4 Nos
- CO_2 fire extinguishers – 6 Nos
- Foam fire extinguishers – 6 Nos

4.15 General Fire fighting guidelines at the Oil Jetty

1. Stop all loading / unloading operations and close valves.
2. All fire fighters will be apprised of the chemicals and POL products normally handled at the jetties. A set of MSDS is available at the fire station.
3. As a general rule all fire fighting will be carried out from a distance of 60 meter (Average heat radiation experience of 2kw/m^2). If the fire fighters are required to go closer to the fire then fire suits / close proximity suit must be worn. If necessary, water cover could be provided to the fire fighters going closer to the fire.
4. The water curtain along the edge of the berth will be activated for fire / leak / spill emergency at the berth.

   Fire float Agni Shanti, and any available tug should be immediately put on alert.
5. All emergency equipment should be placed beyond the over pressure distance of about 60 meters (Average overpressure distance for 1.0 psi experience) to avoid damage to them.
6. The remote water / foam monitor should be operated to control the fire at the jetty. If properly used the fire will be immediately controlled.
7. All persons not connected with handling the emergency should be moved beyond the TEEL – 1 / ERPG – 1 level distance which is an average distance of 1 Km. But if toxic chemical release takes place then the people from the shanty should be moved beyond 3 Km distance of the fire.
8. All security staff (CISF) should also have access to respiratory protection as they may not be able to leave their post.
9. External help should be obtained as soon as it is felt that the emergency is grave.
10. CISF guards will keep note of all incoming aid equipment.
11. After the emergency is over the Deputy Conservator / Harbour Master will assign a senior management team to verify that there is no longer a threat of further fire / leak / spill, to assess damage and initiate repairs

as needed.

12. Any emergency at the chemical jetties or at the dry cargo berths will be informed to the Deputy Conservator / Harbour Master, who will activate the DMP if necessary.

4.16 General guidelines in case of Toxic Chemical spill / leak

1. Stop all loading / unloading operations and close valves.
2. All emergency operation should be carried out from up wind direction. This may always not be possible. All persons handling a chemical leak / spill should wear chemical protection suit and respiratory protection like gas mask / BA sets.
3. Fire float "Agni Santi" and any available tug should be put on alert or pressed into operation.
4. Deputy Conservator / Harbour Master should be informed of a chemical spill however small it may be.
5. CISF should have access to respiratory protection as they may not be able to leave their post.
6. In case of a major chemical leak / spill the neighbouring shanty should be evacuated especially if chemicals like, Acrylonitrile, Benzene, Aniline, 1:3 Butadiene, Vinyl Chloride, Styrene has spilled.
7. Attempts could be made to salvage the spilled chemical or dispersant could be applied to the spill.
8. The chief fire officer should be kept informed of the chemicals being loaded / unloaded at the port chemical berths on a daily basis.

   Important fire fighting methods and spill handling methods of the concerned chemicals should be then informed to the fire fighters. They should also be apprised of the health effects and water solubility of the concerned chemicals.

5 IDENTIFICATION OF EMERGENCIES AT THE OIL & CHEMICAL FACILITIES AROUND THE KANDLA PORT

5.1 Impact Distances

Under the Risk Assessment Study for the Kandla Port Trust carried out by Tata AIG Risk Management Services Ltd in the year 1999, various failure scenarios have been identified for different facilities around the port and these have been simulated using Phast / Safeti software. These failure scenarios have been categorized into Maximum Credible Loss Scenarios (MCLS) and Worst Case Scenarios (WCS).

These failures can be due to number of reasons like material failure, human error. The failures could also be on account of natural disasters like earthquake, flood etc or they could be due to external factors like missile attack or terrorist attack. On failure due to any account mentioned above and depending on the extent of damage, there can be partial or total loss of confinement of hazardous materials handled in the port.

5.2 Maximum Credible Loss Scenarios (MCLS) considered for the study

5.2.1 Scenario 1 – Butadiene Sphere of United Storage and Tank Terminals Ltd.

There are 4 Butadiene Spheres in the terminal. We have considered the 1000 M.T. sphere for the study. Butadiene is stored at 3 to 4 Degree C and pressure in the sphere is maintained at 0.8 bar. The temperature of Butadiene is controlled by brine chillers cooled by Freon refrigeration system. The probability of BLEVE is very remote, considering there are two compressors and DG set is provided to take care of full power load of terminal in case of power failure. However, for Consequence Analysis study, we have considered BLEVE of 1000 M.T. Butadiene Sphere. It is assumed that the catastrophic rupture of the sphere takes place at a pressure of 25 bar.

Initial temperature (K) : 395.
Initial pressure (bar (g)) : 25.0

5.2.1.1 Radiation Effects: Bleeve / Fire Ball

Sr. No.	Radiation levels (Kw/sq m)	Distance in meters	
		5m/s C	2m/s D
1.	4	1558	1558
2.	12.5	919	919
3.	37.5	526	526

5.2.1.2 Explosion Effects

Sr. No.	Over pressure		Distance in meters	
	BAR(g)	PSI (g)	5.0m/s;C	2.0m/s; D
1.	0.0207	0.3	3246	3246
2.	0.1379	2	841	841
3.	0.2068	3	650	650

Comments:

1. In case of BLEVE a radius of 526 m. could be subjected to heat radiation, intensity of 37.5 kw/m^2. This would affect the facilities of Synthetics and chemicals, Indo Nippon, Kesar Enterprises, Bayer ABS & Chemicals and Resins. A portion of IFFCO facility (boundary) would also be subject to 37.5 KW per m^2 radiation intensity. This could cause fires in the neighbouring areas and this is likely to lead to domino effect. Employees within a radius of 1.5 km. from the sphere would suffer burn injuries.

2. Structural damage is likely within a radius of 650 m. from the sphere. This would damage nearby tanks, buildings and is likely to lead to domino effect which could aggravate the emergency. Upto a distance of 3.2 k.m there would be window glass breakage.

3. The possibility of BLEVE is less likely as the Horton spheres are maintained at low temperatures and at low temperature. There is also a standby DG set to take care of 100% electrical load of the terminal. The spheres are protected by water spray ring system along with a hydrant system.

5.2.2 Scenario 2 - Phenol storage of United Storage and Tank Terminals Ltd.

In the United storage terminal there is a phenol storage tank. In the event of bottom nozzle rupture or a large overflow from the tank, phenol would spill out and the contents would be within the dyke.

5.2.2.1 Dispersion Distance for PHenol

Sr. No.	Concentration of interest ppm	Dispersion Distance in meters	
		5.0m/s;C	2.0m/s; D
1.	100	103	90

5.2.2.2 Radiation Effects – Pool Fire

Sr. No.	Radiation levels (Kw/sq m)	Distance in meters	
		5.0m/s;C	2.0m/s; D
1.	4	32	32
2.	12.5	25	22
3.	37.5	12	12

Comments:

Phenol has IDLH of 100 ppm concentration and the vapours are toxic. Toxic vapour of 100 ppm. Concentration would disperse upto 90 to 103 meters in the downward direction. This scenario may have a moderate off site implication due to toxic vapours.

5.2.3 Scenario 3 - Toluene storage of United Storage and Tank Terminals Ltd.

It is assumed that the tank has a diameter of 15 m. and dyke dia of 30 meters. In case of bottom nozzle failure of large overflow toluene would accumulate in the dyke. In case, the pool encounters the source of ignition, a pool fire would result.

5.2.3.1 Dispersion Distance for Toluene

Sr. No.	Concentration of interest Vol %	Distance in meters	
		5.0m/s;C	2.0m/s; D
1.	1.2 (LEL)	63	72

5.2.3.2 Radiation Effects – Pool Fire

Sr. No.	Radiation levels (Kw/sq m)	Distance in meters	
		5.0m/s;C	2.0m/s; D
1.	4	59	44
2.	12.5	25	22
3.	37.5	20	19

5.2.3.3 Flash Fire

Sr. No.	Distance (m)	Distance in meters (1/2 LEL Distance)	
		5.0m/s;C	2.0m/s; D
1.	Furthest extent (m) for flash fire	111	121

Comments:

In case of a pool fire, the radiation effect is likely to be contained within the site. A flash fire distance is approximately 120 m. This means that a flammable cloud could cause a flash fire due to source of ignition within 120 m. in the downward direction. The flash fire would result in a pool fire.

The terminal has its own independent fire protection and fire fighting system which can reduce the affected distance by immediate actions like spray of foam compound over the pool formed in the dyke to prevent ignition and reduce the rate of evaporation.

5.2.4 Scenario 4 – Acrylonitrile storage of Bayer ABS

Acrylonitrile polymerises in the presence of light and at high temperature. If

polymerization takes place in the tank, it could explode resulting in large release of Acrylonitrile. Acrylonitrile could also be released in the event of bottom nozzle failure of tank or overflow into the dyke.

5.2.4.1 Dispersion Distance for Acrylonitrile

Sr. No.	Concentration of interest ppm	Dispersion distance in meters	
		5.0m/s;C	2.0m/s; D
1.	4 (IDLH)	4026	12000

5.2.4.2 Radiation Effects – Pool Fire

Sr. No.	Radiation levels (kW/sq m)	Distance in meters	
		5.0m/s;C	2.0m/s; D
1.	4	80	85
2.	12.5	57	53
3.	37.5	42	32

5.2.4.3 Flash Fire

Sr. No.	Distance (m)	Distance in meters (1/2 LEL Distance)	
		5.0m/s;C	2.0m/s; D
1.	Furthest extent (m) for flash fire	118	125

<u>Comments:</u>

1. Acrylonitrile has boiling point of 77Degree C and IDLH 4 ppm concentration. However, it should be noted that on polymerization and in fire condition, Acrylonitrile would decompose to release hydrogen cyanide and NOx.

2. The dispersion distance for 4 ppm concentration of Acrylonitrile vapours could be 12 kms if the wind speed is 2 m/sec and atmospheric stability D. However, this distance could be reduced if timely action is taken.

3. Bayer ABS maintains a good safety code of practice. They have conducted various safety studies and have a good maintenance system. Moreover the emergency management plan is well prepared and rehearsed in house. The standard of housekeeping in the terminal is good. The personnel working in the terminal have a good knowledge of the actions to be taken in the event of an emergency.

5.2.5 Scenario 5 - Styrene storage of Bayer ABS

Bayer ABS has a 1210 KL styrene tank. Styrene can undergo violent polymerization above 65 degree C, which could be explosive. It is assumed that the tank diameter is 12.5 m. and bund is 22.5 x 22.5 m^2. In case of bottom nozzle failure, overflow, shell rupture, the material would accumulate in the dyke and if it would

encounter the source of ignition, a pool fire would result.

5.2.5.1 Radiation Effects

Sr. No.	Radiation levels (Kw/sq m)	Distance in meters	
		5.0m/s;C	2.0m/s; D
1.	4	52	43
2.	12.5	26	21
3.	37.5	23	17

Comments:

1. The radiation effect would be restricted to the site and is not likely to have off site implication. However, on polymerization and fire condition, styrene generates enormous quantity of soot and splinter could fly off. This could affect neighboring areas.
2. The high safety standards maintained and observed at site would go a long way in preventing catastrophic scenarios.

5.2.6 Scenario 6 - Benzene storage of Indo Nippon

In Indo Nippon terminal Benzene is stored in an 1800 KL tank. Pool fire scenario has been considered for the tank assuming tank diameter as 12 m. and dyke dia as 25 m.

5.2.6.1 Dispersion Distance for Benzene

Sr. No.	Concentration of interest Vol%	Dispersion Distance in meters	
		5.0m/s;C	2.0m/s; D
1.	1.3	119	120

5.2.6.2 Radiation Effects: Pool Fire

Sr. No.	Radiation levels (Kw/sq m)	Distance in meters	
		5.0m/s;C	2.0m/s; D
1.	4	55	42
2.	12.5	23	20
3.	37.5	20	16

5.2.6.3 Flash Fire

Sr. No.	Distance (m)	Distance in meters	
		5.0m/s;C	2.0m/s; D
1.	Furthest extent (m) for flash fire	175	175

Comments

In case of pool fire radiation effect would be restricted to site.

5.2.7 Scenario 7 - Methanol storage of Indo Nippon

Methanol is stored in 2500 KL tank, dyke dia is assumed as 30 m. And tank dia as 15 m.

5.2.7.1 Dispersion Distance for Methanol

Sr. No.	Concentration of interest Vol%	Distance in meters	
		5.0m/s;C	2.0m/s; D
1.	6	36	47

5.2.7.2 Radiation Effects: Pool Fire

Sr. No.	Radiation levels (Kw/sq m)	Distance in meters	
		5.0m/s;C	2.0m/s; D
1.	4	66	73
2.	12.5	48	48
3.	37.5	37	34

5.2.7.3 Flash Fire

Sr. No.	Dispersion (m)	Dispersion Distance in meters	
		5.0m/s;C	2.0m/s; D
1.	Furthest extent (m) for flash fire	172	83

5.2.7.4 Explosion Effects – Late Ignition

Sr. No.	Over pressure		Distance in meters	
	BAR(g)	PSI (g)	5.0m/s;C	2.0m/s; D
1.	0.0207	0.3	110	137
2.	0.1379	2	80	95
3.	0.2068	3	78	91

Comments:

1. In case of pool fire, the radiation effect would be restricted to the site.
2. Methanol has a low boiling point i.e. (65oC.), hence if timely action is not taken, a large amount of Methanol would vaporize and unconfined vapour cloud would be formed which if it encounters a source of ignition would explode.
3. In case of unconfined vapour cloud explosion there may be a moderate

implication on the surrounding facilities (Synthetics & chemicals and J R Enterprises).

5.2.8 Scenario 8 - Refrigerated Butadiene storage tank of Synthetics and chemicals

There are two atmospheric storage tanks of Butadiene having capacity of 2000 MT each. The storage temperature is maintained at minimum 8oC. Ammonia is used as refrigerant. The tank is double walled tank, catastrophic rupture of the tank is improbable. It is assumed that if the roof of the tank fails and a pool fire has taken place whose diameter equals the diameter of the tank.

5.2.8.1 Radiation Effects: Pool Fire

Sr. No.	Radiation levels (Kw/sq m)	Distance in meters	
		5.0m/s;C	2.0m/s; D
1.	4	46	74
2.	12.5	41	41
3.	37.5	33	19

5.2.8.2 Flash Fire

Sr. No.	Distance (m)	Distance in meters	
		5.0m/s;C	2.0m/s; D
1.	Furthest extent (m) for flash fire	97	4

Comments:

The radiation distance would be contained within the site.

5.2.9 Scenario 9 - IFFCO Ammonia Sphere

IFFCO has refrigerant ammonia storage tanks. There are two 1500 m/tons Horton Spheres. In case of external fire, the sphere would be heated up. The external fire would cause the shell above the liquid level to get weakened.

5.2.9.1 Dispersion Distance for Ammonia

Sr. No.	Concentration of interest ppm	Distance in meters	
		5.0m/s;C	2.0m/s; D
1.	500 (IDLH)	10440	9908

Comments:

1. A toxic ammonia cloud of IDLH concentration (500 ppm would disperse upto 10 km. in the downward direction.
2. Considering that ammonia is highly soluble in water and it is a light gas, the severity of the scenario could be greatly reduced by timely action. I.e.

application of water spray to ammonia cloud.

3. The ammonia storages are well protected. The company has its own fire and safety department with fire engines and fire fighting personnel on duty round the clock. The company has a good preventive maintenance programme. Safety training is given to all employees.

5.2.10 Scenario 10- Phenol storage of Kesar Enterprises

Kesar Enterprises terminal phenol is stored in a 566 KL steam jacketed tank. In case of overflow or bottom nozzle failure, phenol would accumulate in the dyke.

5.2.10.1 Dispersion Distance for Phenol

Sr. No.	Concentration of interest ppm.	Distance in meters	
		5.0m/s;C	2.0m/s; D
1.	100 (IDLH)	103	90

5.2.10.2 Radiation Effects: Pool Fire

Sr. No.	Radiation levels (kW/sq m)	Distance in meters	
		5.0m/s;C	2.0m/s; D
1.	4	32	32
2.	12.5	25	22
3.	37.5	12	12

Comments:

1. Phenol vapour of IDLH 100 ppm would disburse upto 131 to 197 m. in downward direction.This may have a moderate off-site implication.

5.2.11 Scenario 11 - Acrylonitrile storage of Kesar enterprises.

In Kesar terminal, Acrylonitrile is stored in a 2526 KL tank. Acrylonitrile polymerises in the presence of light and at high temperature. In case of polymerization, the distances affected could be as follows.

5.2.11.1 Dispersion Distance for Acrylonitrile

Sr. No.	Concentration of interest ppm	Distance in meters	
		5.0m/s;C	2.0m/s; D
1.	4	4075	12150

5.2.11.2 Radiation Effects: Pool Fire

Sr. No.	Radiation levels (kW/sq m)	Distance in meters	
		5.0m/s;C	2.0m/s; D
1.	4	91	96

2.	12.5	65	58
3.	37.5	46	35

5.2.11.3 Flash Fire

Sr. No.	Distance (m)	Distance in meters	
		5.0m/s;C	2.0m/s; D
1.	Furthest extent (m) for flash fire	119	126

Comments

1. The dispersion distance for Acrylonitrile for a cloud of 4 ppm concentration is approximately 12 km in the downwind direction, if the wind speed is 2 m/s at atmospheric stability is D. However, this would be greatly reduced if timely action is taken.
2. The polymerization products include Hydrogen Cyanide and Nox.

5.2.12 Scenario 12 - Aniline storage - JK Synthetics Terminal

Aniline is stored in the JK Terminal. The tank diameter is considered 12m and dyke diameter as 25m.

5.2.12.1 Dispersion Distance for Aniline

Sr. No.	Concentration of interest ppm	Distance in meters	
		5.0m/s;C	2.0m/s; D
1.	100	92	177

Comments:

1. In case of overflow of tank or bottom nozzle rupture aniline would accumulate in the dyke.
2. Aniline has an IDLH value of 100 ppm. Toxic vapour of aniline would disperse upto 177 m. in the downwind direction, if the wind speed is 2m/sec. an atmospheric stability D.
3. The rate of evaporation could be reduced by blanketing with water.

5.2.13 Scenario 13 - BLEVE of LPG road tanker

LPG Road Tankers are filled up at the IOCL terminal. In case of over pressurization of the bullets a BLEVE could take place. Over pressurization could take place because of external fire. In case of an accident of the road tanker on the road, LPG would spill out and could result in an unconfined vapour cloud explosion. One 10 ton LPG road tanker has been considered for the study.

5.2.13.1 Radiation Effects – Bleeve / Fireball

Sr. No.	Radiation levels (Kw/sq m)	Distance in meters	
		5m/sC	2m/s D
1.	4	345	345
2.	12.5	196	196
3.	37.5	108	108

5.2.13.2 Explosion Effects

Sr. No.	Over pressure		Distance in meters	
	BAR(g)	PSI (g)	5.0m/s;C	2.0m/s; D
1.	0.0207	0.3	707	707
2.	0.1379	2	183	183
3.	0.2068	3	141	141

5.2.14 Scenario 14 - Naphtha storage of BPCL

In case of a dyke fire or tank roof fire of a naphtha storage tank in BPCL terminal the damage distances would be as follows.

Sr No	Commodity	Scenario	Wind Speed (M/S)	Damage Distance for Pool fire(Meters)		
				4 kW/m 2	12.5 kW/m2	37.5 kW/m2
1.	Naphtha	Dyke fire	3	205	71	31
2.	Naphtha	Tank Roof Fire	3	188	65	29

5.2.15 Scenario 15 - Catastrophic rupture of 15000 MT cryogenic LPG tank of IOCL

The possibility of catastrophic rupture of the cryogenic LPG tank is very remote. However in case of such a scenario the damage distances would be as follows.

5.2.15.1 Explosion Effects

Sr. No.	Over pressure		Distance in meters	
	BAR(g)	PSI (g)	5.0m/s;C	2.0m/s; D
1.	0.0207	0.3	316	302
2.	0.1379	2	169	176
3.	0.2068	3	157	166

5.2.16 Scenario 16 - Catastrophic rupture of ammonia road tanker

In case of catastrophic rupture of ammonia road tanker the damage distances would be as follows.

5.2.16.1 Dispersion Distance for Ammonia

Sr. No.	Concentration of interest ppm	Dispersion Distance in meters	
		5.0m/s;C	2.0m/s; D
1.	500	1866	1592

5.2.17 Scenario 17 - Leak from Acrylonitrile road tanker

In case of leak from one compartment (Capacity 3 tons) from an Acrylonitrile road tanker, the affected distances would be as follows.

5.2.17.1 Dispersion Distance for Acrylonitrile

Sr. No.	Concentration of interest ppm	Dispersion Distance in meters	
		5.0m/s;C	2.0m/s; D
1.	400	574	1508

6 TOXIC HAZARD RANKING FOR HAZARDOUS CHEMICALS HANDLED AT PORT PREMISES

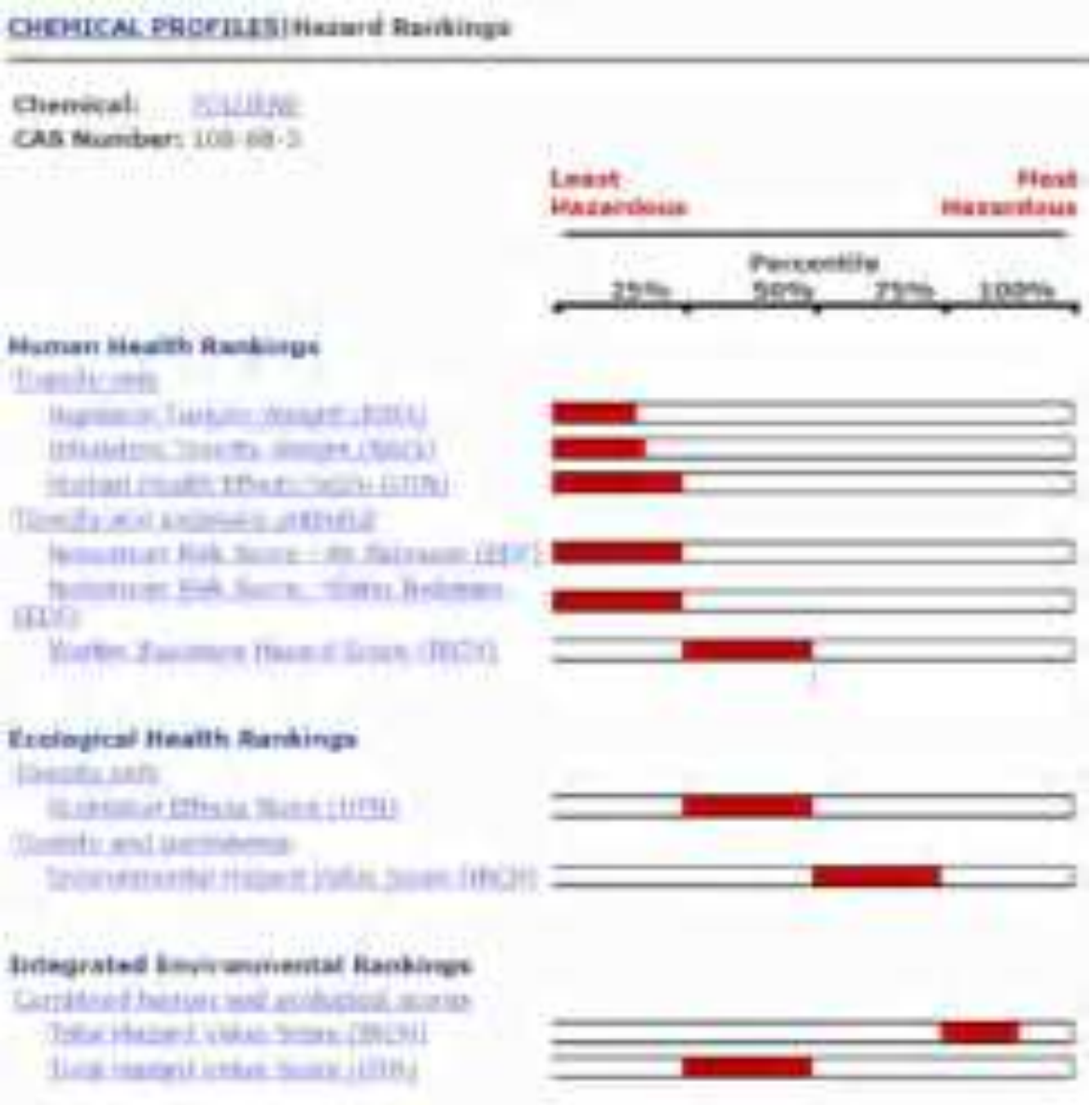
6.1 Hazard Ranking

6.1.1 Propane

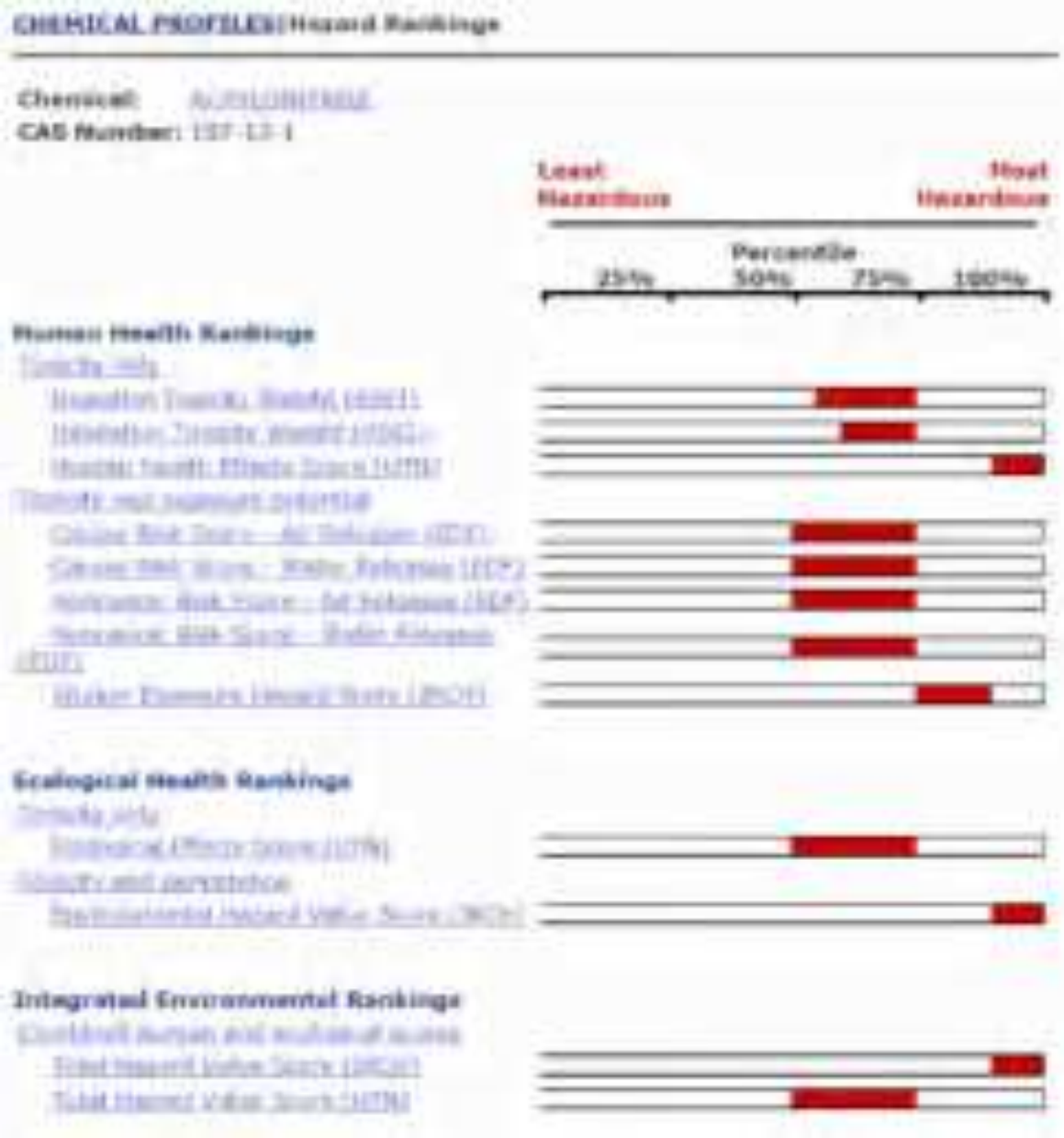
6.1.2 Butane

CHEMICAL PROFILES | Hazard Rankings
Chemical:
CAS Number:
Least Hazardous
Most Hazardous
Percentile
25%
50%
75%
100%
Human Health Rankings
Ecological Health Rankings
Integrated Environmental Rankings

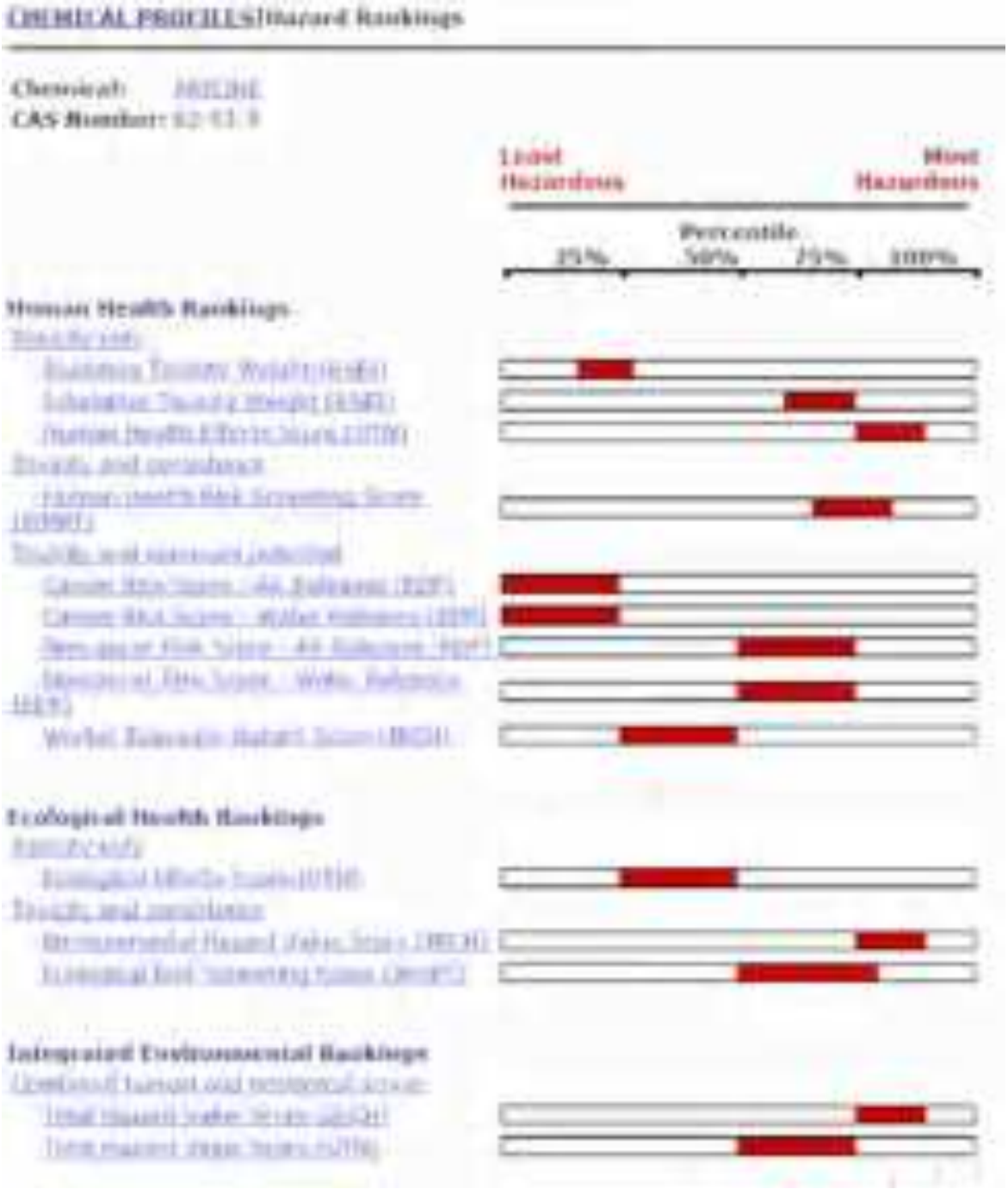
6.1.3 Toluene


CHEMICAL PROFILES | Hazard Rankings
Chemical:
CAS Number:
Least Hazardous
Most Hazardous
Percentile
25%
50%
75%
100%
Human Health Rankings
Ecological Health Rankings
Integrated Environmental Rankings

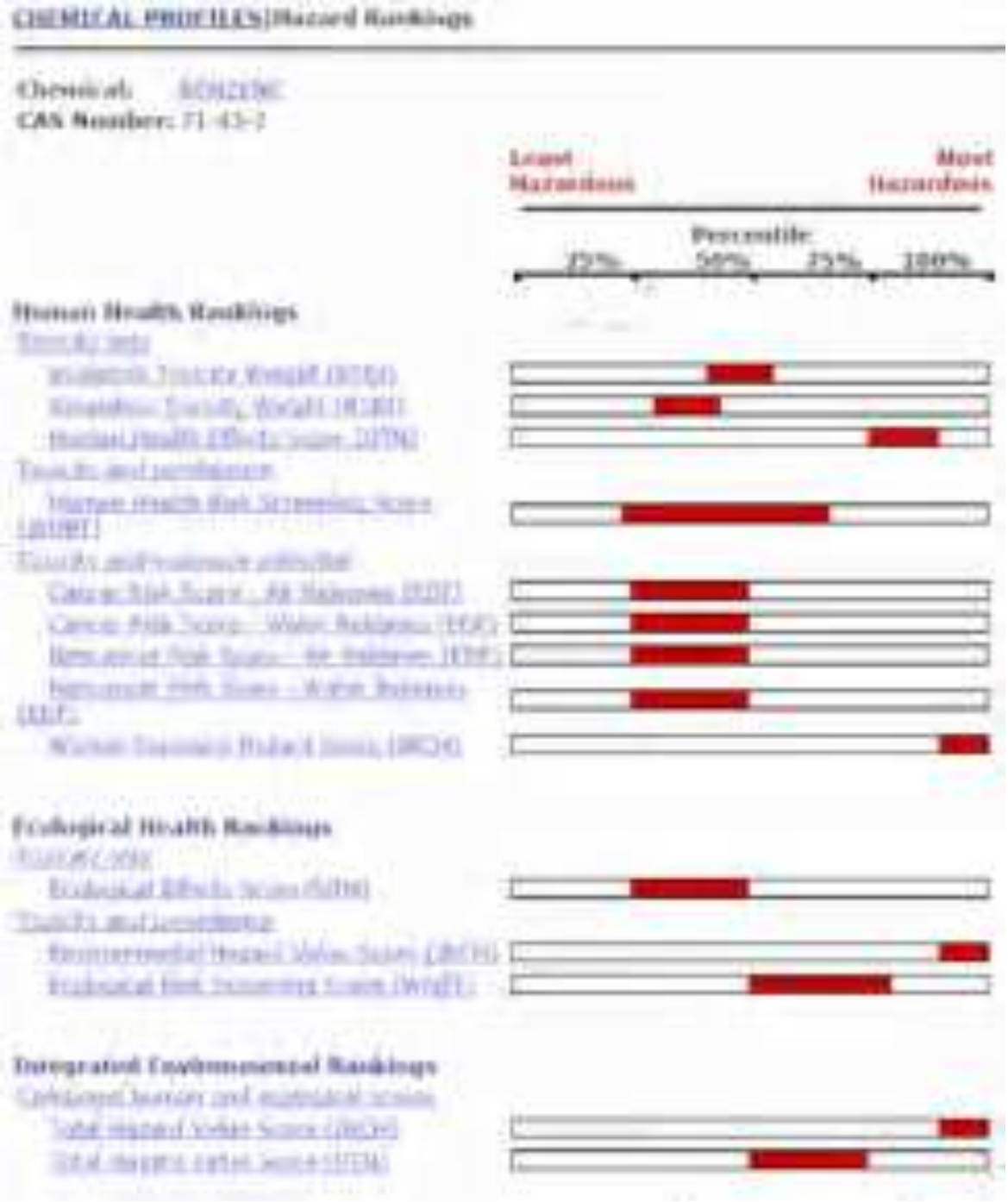
6.1.4 Acrylonitrile



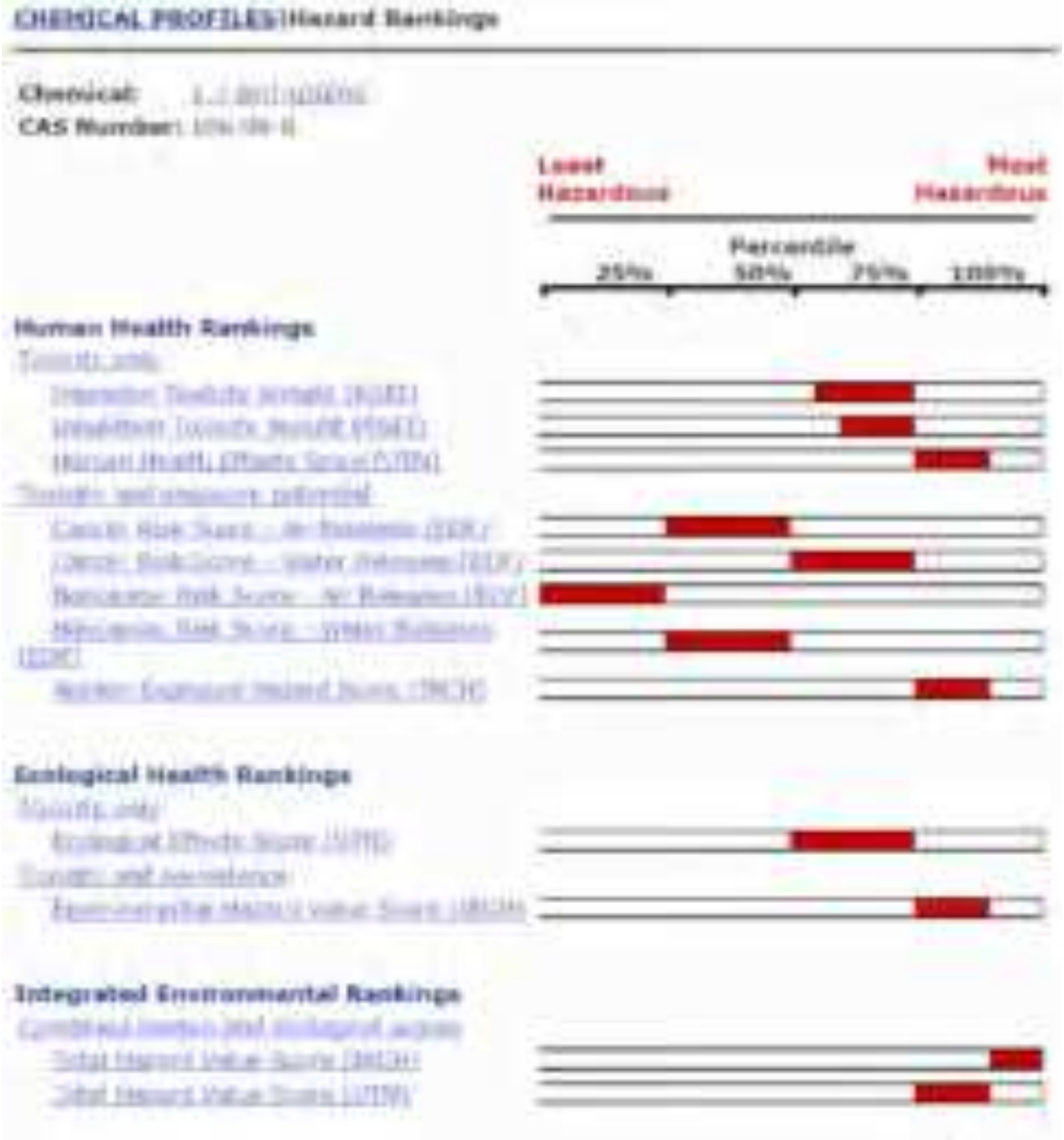
6.1.5 Aniline


CHEMICAL PROFILES Hazard Rankings
Least Hazardous
Most Hazardous
Percentile
25%
50%
75%
100%
Human Health Rankings
Ecological Health Rankings
Integrated Environmental Rankings

6.1.6 Benzene


Least Hazardous
Most Hazardous
Percentile:
25%
50%
75%
100%
Human Health Rankings
Ecological Health Rankings
Integrated Environmental Rankings

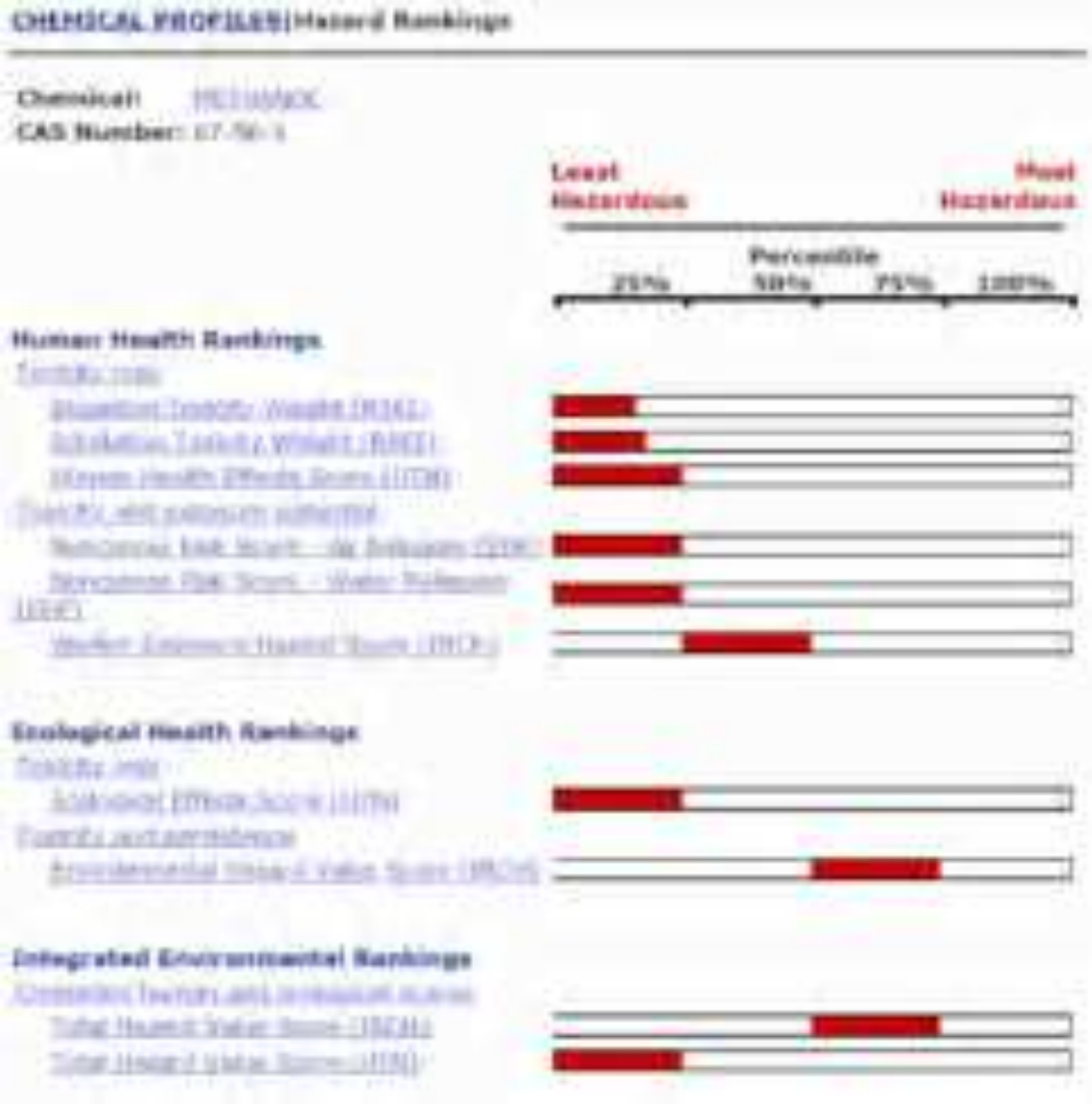
6.1.7 1: 3, Butadiene



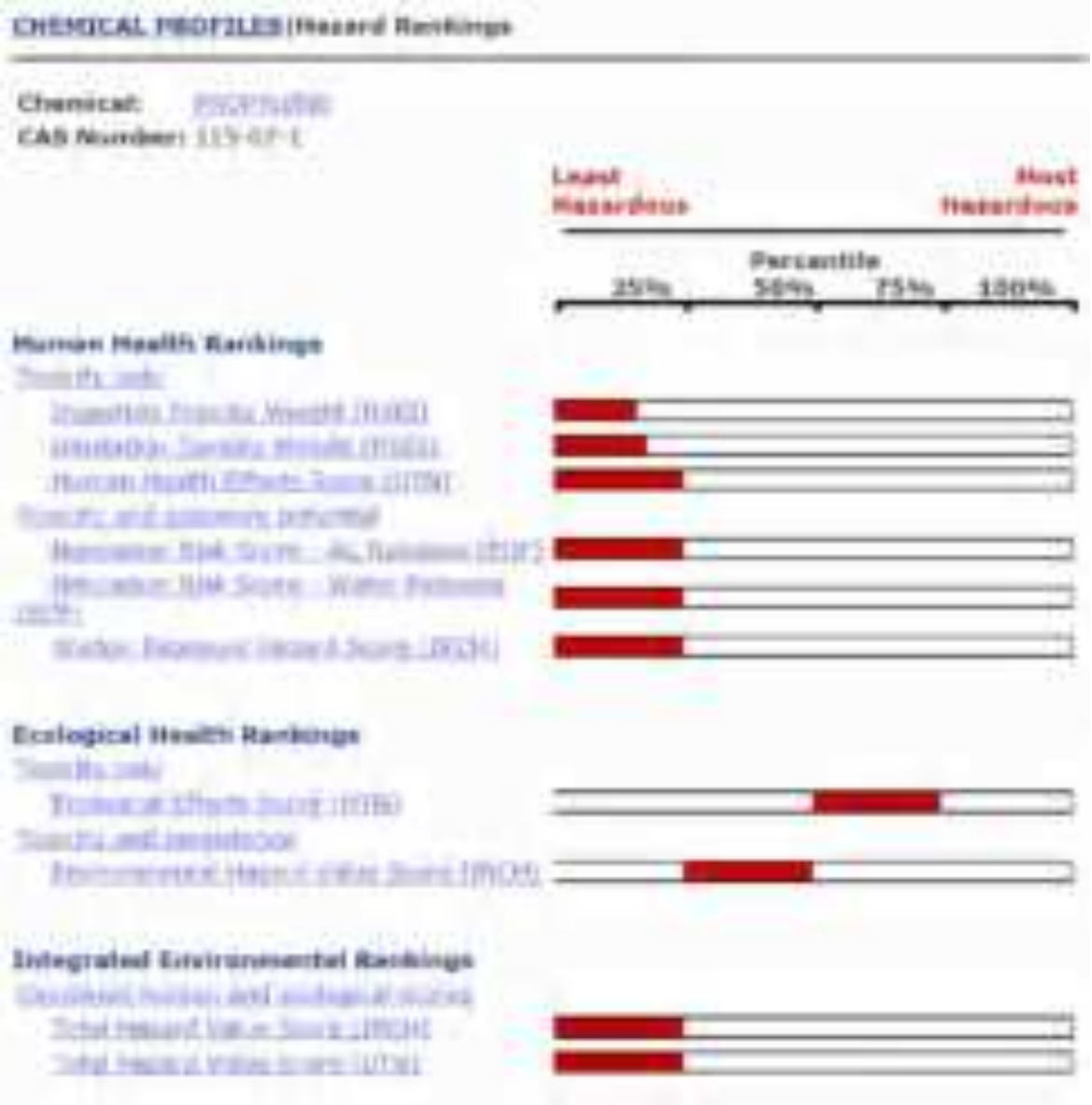
6.1.8 Acetone

CHEMICAL PROFILES | Hazard Rankings
Chemical:
CAS Number:
Least Hazardous
Most Hazardous
Percentile
25%
50%
75%
100%
Human Health Rankings
Ecological Health Rankings
Integrated Environmental Rankings

6.1.9 Methanol

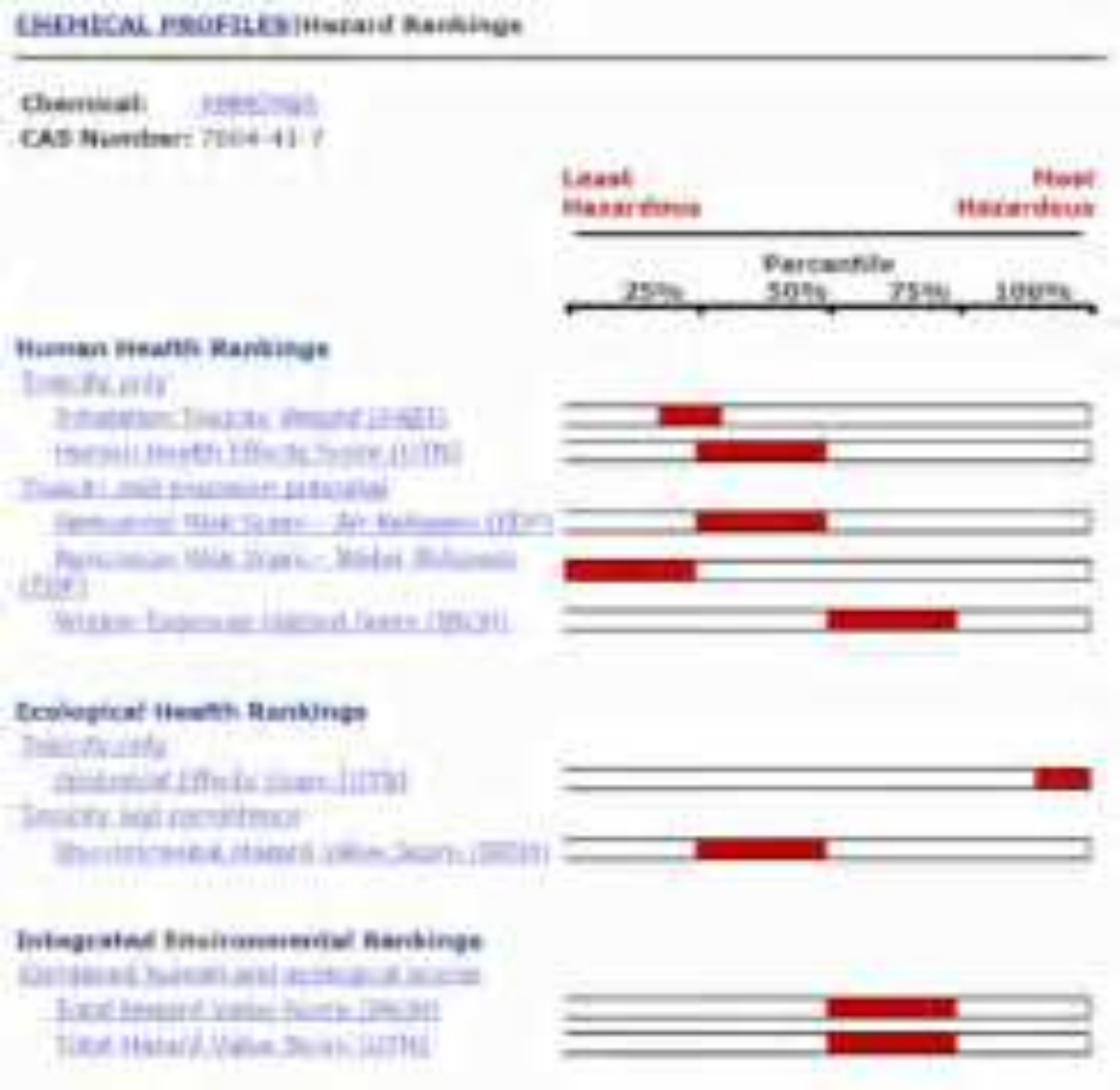


6.1.10 Propylene

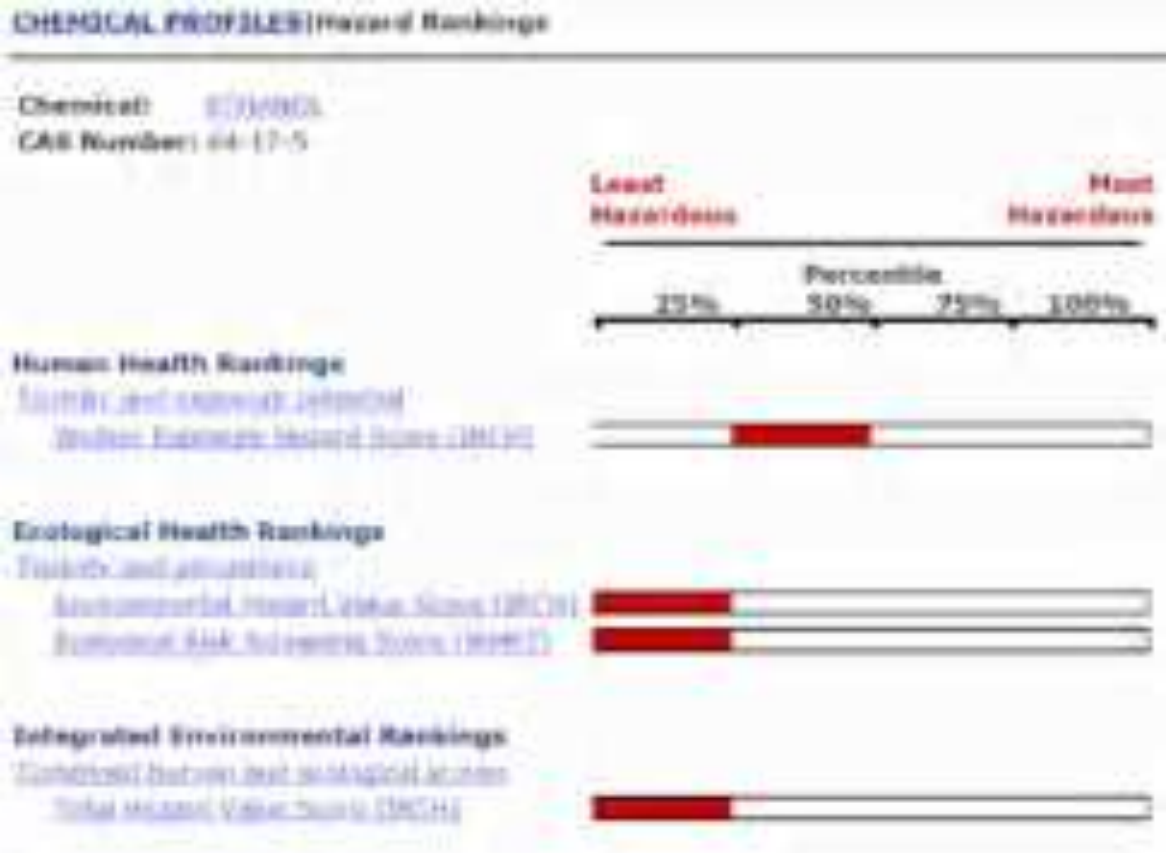


6.1.11 Vinyl Chloride

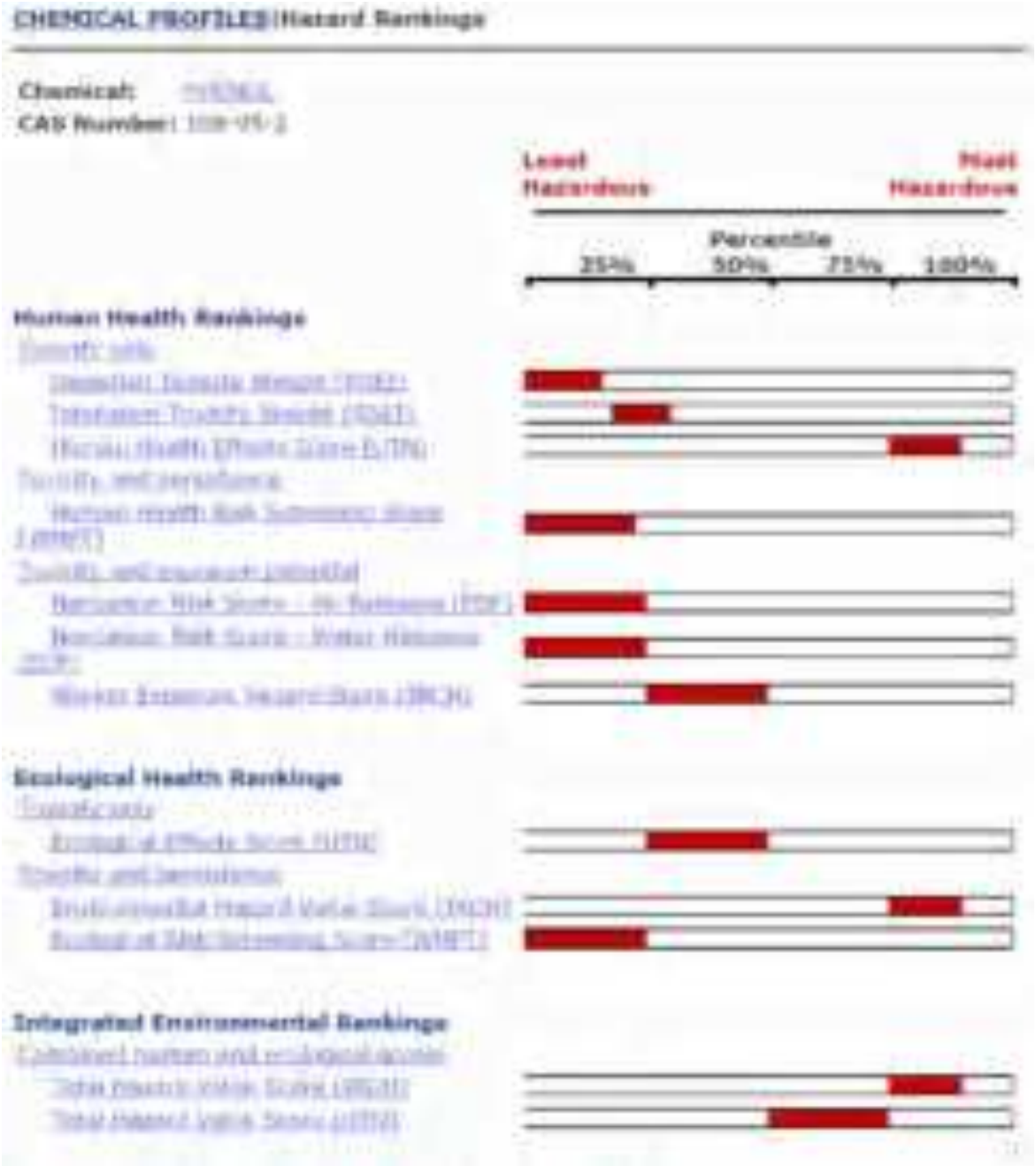
6.1.12 Ammonia



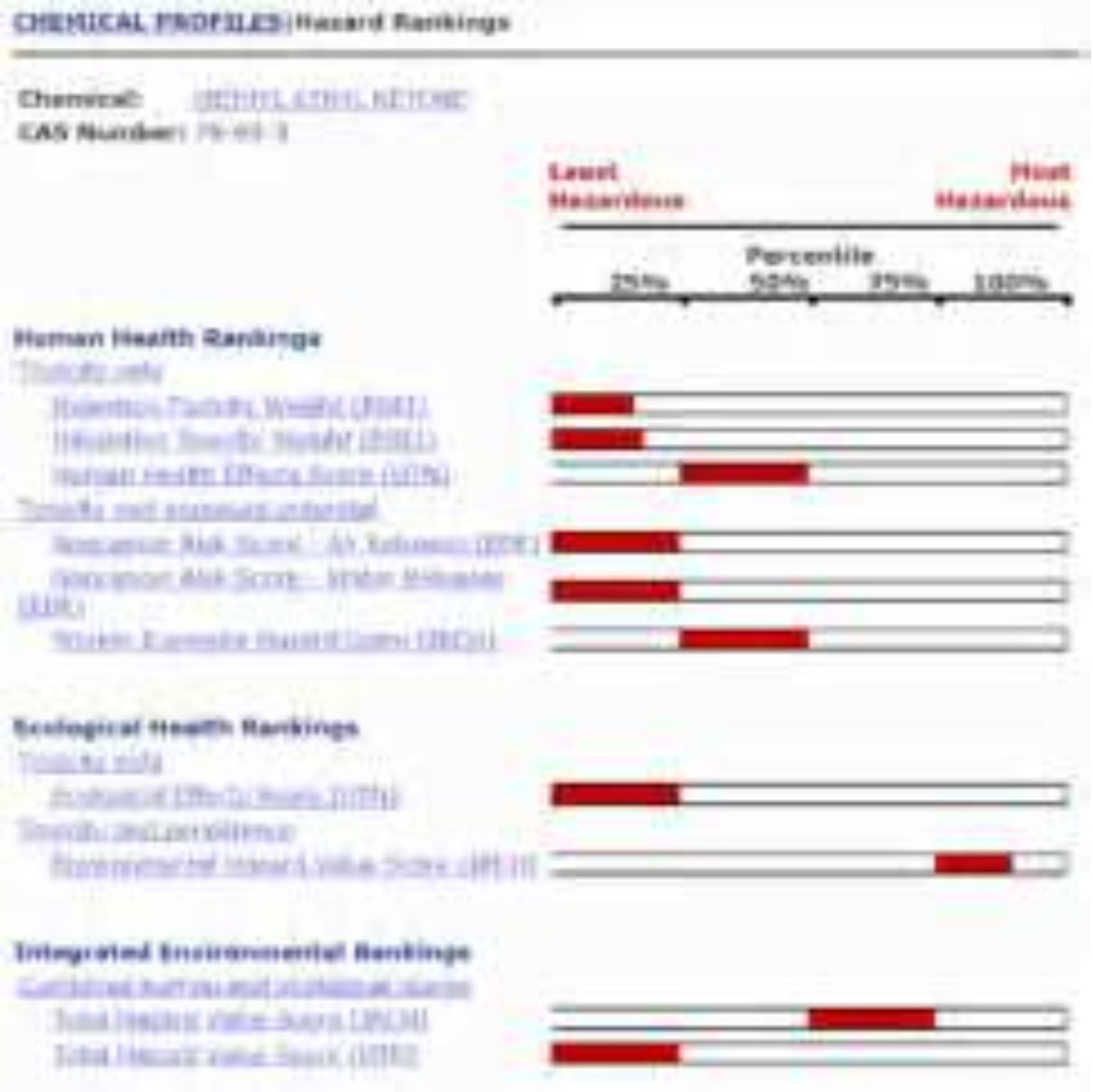
6.1.13 Ethanol



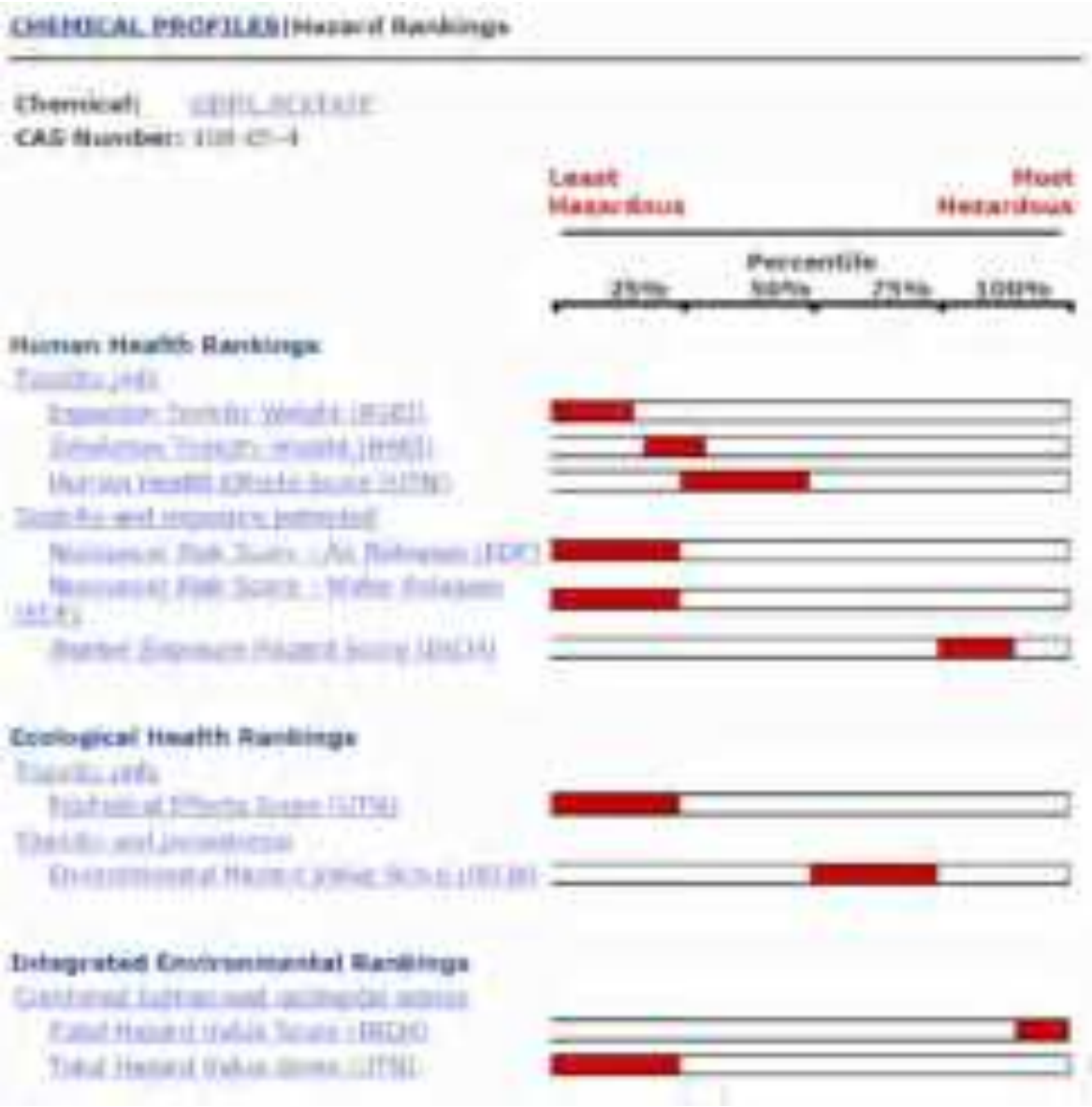
6.1.14 Phenol


CHEMICAL PROFILES | Hazard Rankings
Chemical:
CAS Number:
Least Hazardous
Most Hazardous
Percentile
25%
50%
75%
100%
Human Health Rankings
Ecological Health Rankings
Integrated Environmental Rankings

6.1.15 Methyl Ethyl Ketone



6.1.16 Vinyl Acetate

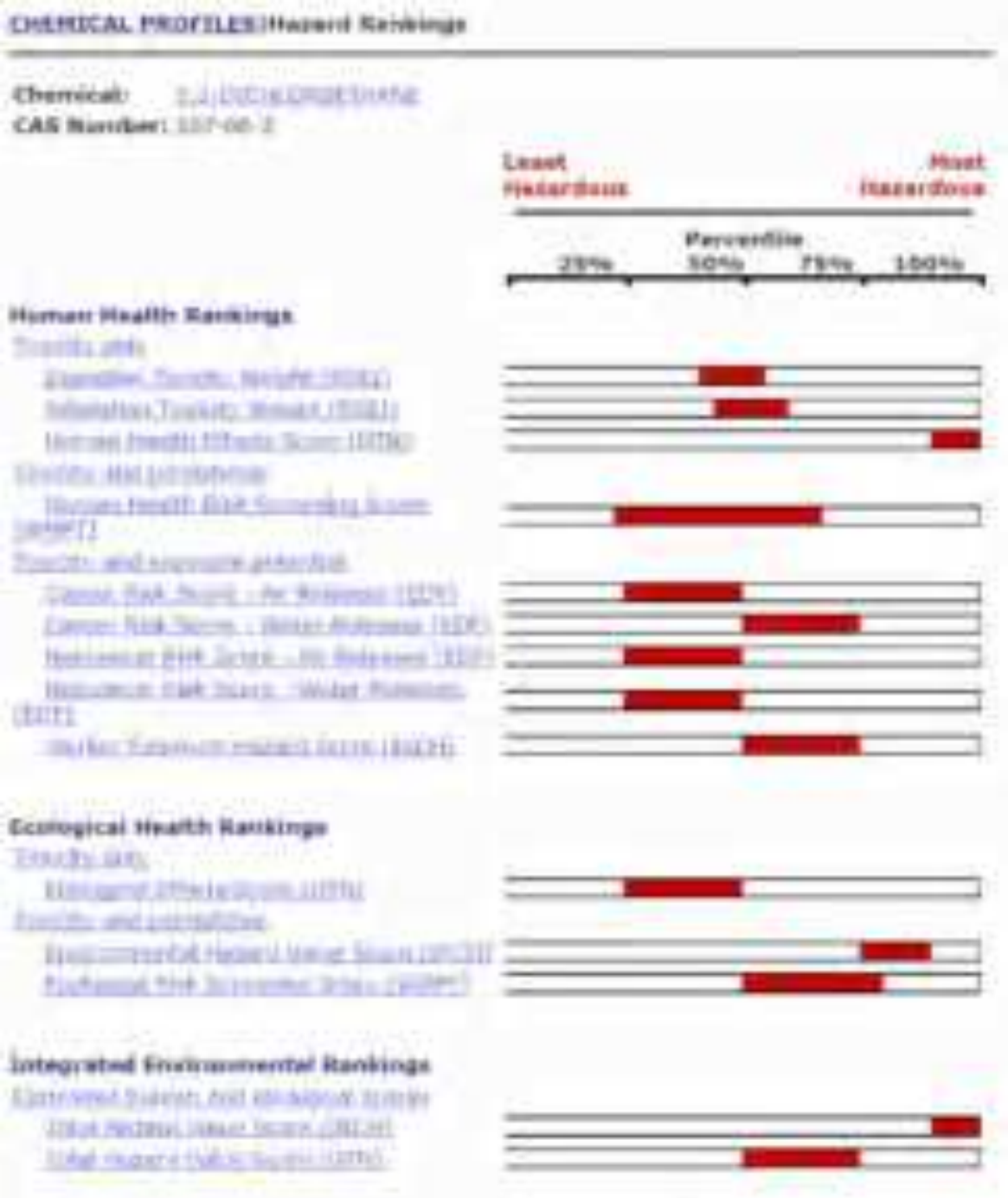


6.1.17 Caustic Soda

6.1.18 Acetic Acid

6.1.19 Nonene

6.1.20 Ethyl Di Chloride (EDC)



Reference: http://www.scorecard.org/chemical-profiles/hazard-indicators

7 SABOTAGE & CIVIL DISTURBANCE

Access to the Kandla Port is controlled by walls / fence. The entrances are manned by CISF guards.

If a civil disturbance or sabotage threatens or actually damages the port property – the Harbour Master will communicate with local civil authorities or will request immediate assistance from police, coast guard, navy / air force.

7.1 Bomb Emergency Management

In the event of receiving a bomb threat by telephone call, the following should be asked and noted for relaying it to the army/air force/navy:

In view of the high priority given to Ports, they have high risk of becoming targets of the terrorist groups. Therefore the possibility of receiving bomb threats cannot be ruled out. The golden rule is consider all bomb threats as genuine and act accordingly keeping in mind the safety of the people in the Port and the property.

The objective is:

a) To avoid/minimize any loss or damage to lives and property
b) To eliminate panic and build up confidence.
c) To be prepared for proper handling of any critical situation.

7.2 Immediate actions:

a) Bomb threats may be received in writing email, SMS or may be received on phone.
b) When the call is received on phone, keep the caller on the line as long as possible. Request him to repeat the message, listen carefully as every word spoken by the person has to be recorded mentally and penned down.
c) If the caller does not indicate the location of the bomb or the time of possible detonation, it is advisable to try to ask him for this information.
d) Inform the caller that the port area is occupied and the detonation of a bomb would result in death or serious injury to many innocent persons.
e) Pay particular attention to peculiar background noises such as motors running, background music and any other noise which may give a clue as to from where the call is being made.
f) Listen closely to the voice (male, female), voice quality (calm, excited), accents and speech impediments. Immediately after the caller hangs up report should be made to the security officer on duty about all the above details.
g) Fill up the bomb threat call details in the format as given below.
h) Call all identified personnel (As indicated for any emergency)
i) As soon as an emergency is envisaged /occurs the Emergency chief or his alternate shall promptly communicate the information by a telephone or any other quickest mode of communication to the Inspector of Police, highest administrative officer, fire brigade and the nearby installations. The

information should include the location of the installation and the degree of emergency (anticipated, eminent or actual).

7.3 Bomb Threat Report Form

7.3.1 Actions on Receiving Bomb Threat Call

1. Do not put down receiver or cut off caller
2. Put on tape-recorder
3. Alert nearest colleague
4. Keep Form and pen ready to fill
5. Note time and duration correctly
6. Obtain as much information as possible
7. Keep caller engaged in conversation as long as possible

   (Apologise for bad line, ask him to speak up etc.)

Time of call..... Date..... Exact words of caller.....

Was any one called for by name or designation () Yes () No. If so, who?

7.3.2 Questions to Ask Caller

1. Who is calling from where?
2. When is the bomb set to go off?
3. Where is the bomb placed?
4. What kind of bomb is it?
5. How does it look like?
6. Why are you doing this?
7. Whom do you represent?
8. How do you know so much about the bomb?
9. How can we get rid of the bomb?
10. Do you know that the bomb will kill innocent people?

7.3.3 Details of Caller

- Sex: () Male () Female Approximate age: .....years.
- Origin of call: () inside plant, () outside local, () outside long distance.
- Voice characteristic: () fast, () slow, () stutter, () distinct, () disguised, () educated, () uneducated, () loud, () soft.
- Language used ....., accent ....., manner: ()calm, ()angry, ()emotional, ()laughing, ()deliberate, ()normal, ()abnormal, ()other
- Is voice familiar? () yes, () no.
- Background sound: ()street, ()telephone booth, ()airport, () railway station, ()residence, ()cannot identify, ()others

CISF Commandant/Officer informed at: Name of the person receiving call ..... signature.....

(Keep these forms with all Telephone Operators/All designations having direct line?)

7.4 Responsibility of the CISF Commandant / Officer of Kandla port

a) Advise the Emergency chief (Chairman/Dy. Chairman/Dy. Conservator/Harbour Master) and keep him appraised of the actions being taken.
b) Immediately make elaborate preparations near the threatened area for
   - Fire fighting
   - Casualty handling
   - Rescue operations
   - Search operations
c) Prepare for partial/total evacuation if required. Emergency chief or his alternate will authorize these activities.
d) Designate the team for bomb search. Initiate search operations with Fire and safety/security officers if time is available.

7.5 Action Plan

Two situations are possible.

a) When no time limit is given.
b) When bomb threat call has time limit specified.

As soon as the call is received the concerned area-in-charge will make fire fighting/first aid preparations immediately.

1. In the first case if there is no time limit specified for bomb explosion, as soon as the Emergency chief gives a clearance the following action should be initiated.

   - Emergency shutdown of the Port sections likely to be affected.
   - Evacuation of the employees and visitors to safer locations.
   - Bomb search taking all the precautions.

7.5.1 Action plan when time limit is specified:

In such case the concerned officers should search the area along with safety and security officers.

7.5.2 Search procedures:

- Search must be conducted by employees of the concerned department since they are familiar with the area and would be in a better position to notice a foreign object faster.
- Two teams could be formed to search various parts of the area. Stand quietly for some moments to listen for any clockwork device before starting the search.
- As far as practical do not cause any disturbance in the environment till the search is over.
- Do not go into dark rooms and turn on lights. Use a flashlight instead.
- If any foreign or suspicious object is located, do not move or touch it. The removal/disarming of a bomb must be left to professionals. Report the location and description of the object immediately to the emergency control

centre/Security gate.

- If possible place sand bags or mattresses around the bomb. Do not cover it.
- Identify the danger area and block it off with clear zone of at least 100 meter.

7.6 Important Telephone Nos of Police Authorities

Name and Designation of Officer	Telephone Nos. (Office)	Telephone Nos. (Residence)
Supdt. of Police (West), Bhuj Mob: 9978405073 Supdt. of Police (East) Gandhidham Mob: 9978405690	02832-250444 02832-227934	250850
I/c Add. Supdt. of Police Bhuj	253505	227333
Police Control Room, Bhuj	253593 / 250960	Fax – 250427
Dy. Supdt. Of Police, Anjar	02836-243254	242596
Dy. Supdt. Of Police - Bhachau	02837-224040	224020
Bhachau Police Station	02837-224036	
Anjar Police Station	02836 - 242517	
Gandhidham Police Station	A 100/232500/ 229513 B 233752	
Kandla Police Station	270527	
Adipur Police Station	260615	
Air Commander, Jamnagar	0288-2720003 -009	
Commandant, BSF, GIM	223845	
Air Force Commander, Bhuj	(02832)244005-10	
Army, Bhuj, C.O 128 AD Regmt	229239,229942	

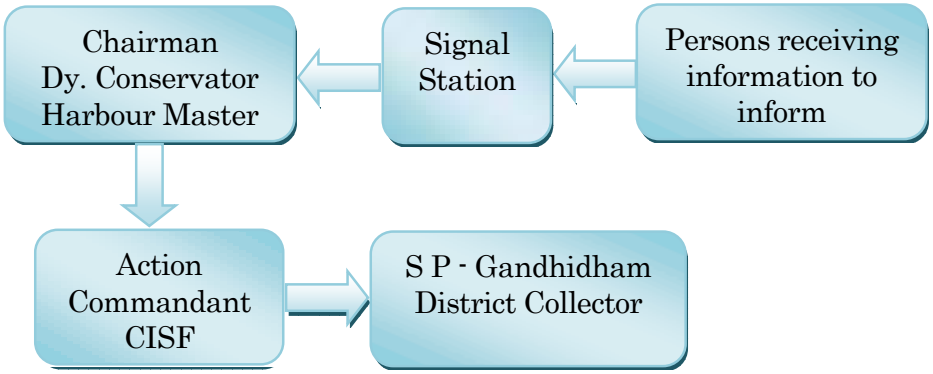
7.7 Contact Telephone Nos of CISF Officials

S. No	Designation	Present incumbent	Contact Telephone Numbers		
			Office	Res	Mobile
01	Commandant	K.K. Dutta	271037	229140	9825227282
02	Dy. Commandant	R.P. Kaushik	271036	220192	9825227045
03	Asst. Commandant	M. Kannaian	270440	271041	8000954482
04	Control Room		271040		
05	North Gate		270440		
06.	West Gate – I		271039		
07.	West Gate II		270876		

7.8 Contact Telephone Nos of Bomb Detection & Disposal Squad

Sr. No	Area	Telephone
01	Rajkot	0281 – 245777
02	Ahmadabad	079 – 2210019

8 HOSTAGE SITUATION



8.1 Commandant CISF Responsibilities

- Apprise - Chairman, Deputy Chairman, Deputy Conservator, Harbour Master of contemplated action.
- Prepare threatened area for fire fighting, casualty handling, search and rescue operations
- Inform Police and requisition help with regard to negotiators/snipers, etc.
- CISF to cordon off area and deny access to persons hampering operations especially media and onlookers.
- Buy time for negotiators to arrive or for formalizing proper plan of action.
- Police/CISF shall assess the situation and based on the assessment, Chairman may permit operation deemed fit to free hostages.

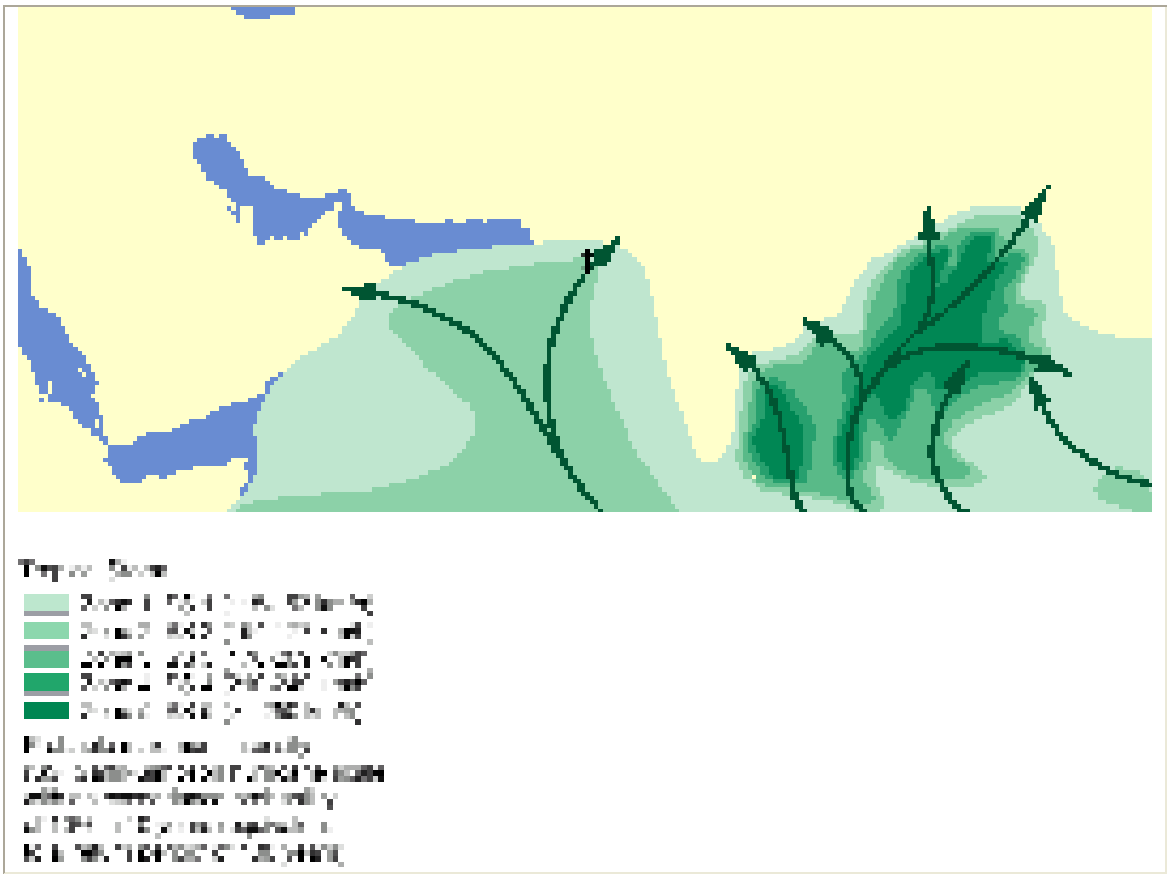
9 SEVERE WEATHER SITUATION

9.1 Act of God Perils

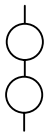
9.1.1 Storms / Cyclone

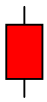
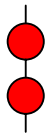
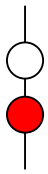
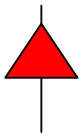
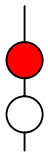
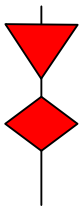
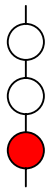
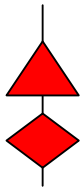
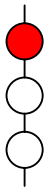
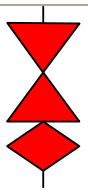
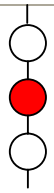
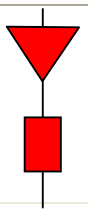
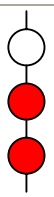
Even though Kandla is within the cyclone area of storms originating in the Arabian Sea and those that enter across the Indian Peninsula from the Bay of Bengal, cyclones are not as severe or frequent as in the Bay of Bengal. Historically, there has been major cyclone in the region in the year 1998.

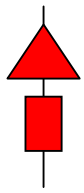
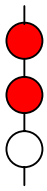
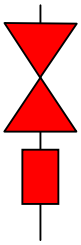
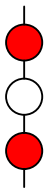
Hence the exposure to this peril is High.



9.1.1.1 Cyclone Alarms (11Levels)

Signal No.	Symbol Day	Symbol Night	Type of Warning	Description
I			Cautionary	There is a region of squally weather in which a storm may be forming.

II			Warning	A storm has formed.
III			Cautionary	Port is threatened by squally weather.
IV			Warning	The Port is threatened by storm, but it does not appear that the danger is as yet sufficiently great justifying extreme measures of precautions.
V			Danger	The Port will experience severe weather from a storm of slight or moderate intensity that is expected to cross the coast to the south of the port.
VI			Danger	The Port will experience severe weather from a storm of slight or moderate intensity that is expected to cross the coast to the north of the port.
VII			Danger	The Port will experience severe weather from a storm of slight or moderate intensity that is expected to cross over or near to the port.
VIII			Great danger	The Port will experience severe weather from a storm of great intensity that is expected to cross to the south of the port.

IX			Great danger	The Port will experience severe weather from a storm of great intensity that is expected to cross the coast to the north of the port.
X			Great danger	The Port will experience severe weather from a storm of great intensity that is expected to cross over or near to the port.
XI			Failure of communication	Failure of Communication with Meteorological head quarters has broken down and the local officer considers that there is danger of bad weather.

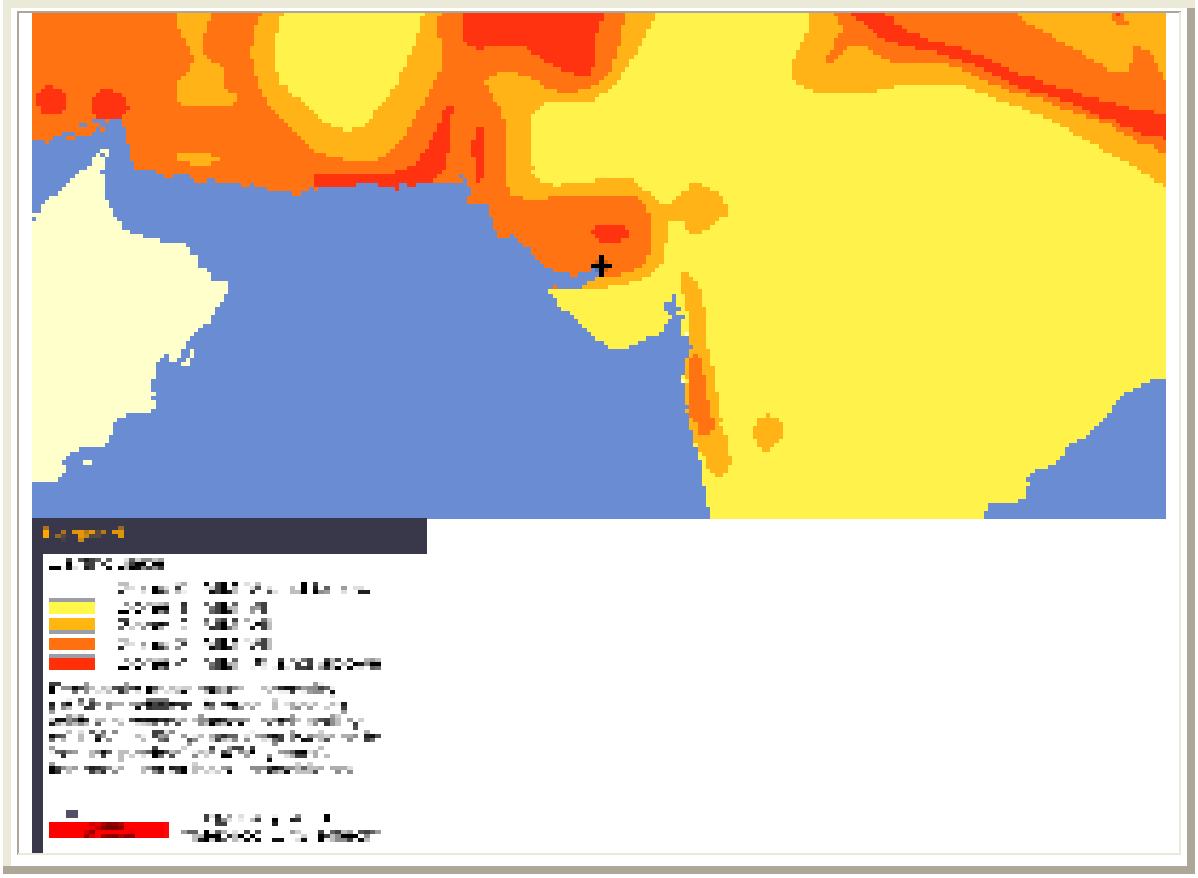
Red Light,

White Light

9.1.2 Earthquake

As per Munich Re world map for Natural hazards the Gandhidham region comes under the Zone III of the earthquake classification as per Indian Standards which is relatively high. However, seismic experts have opined that the Indian land mass is being constantly compressed between the sea and Himalayas and thus the developed stresses are being released in the form of earthquakes in the least expected areas.

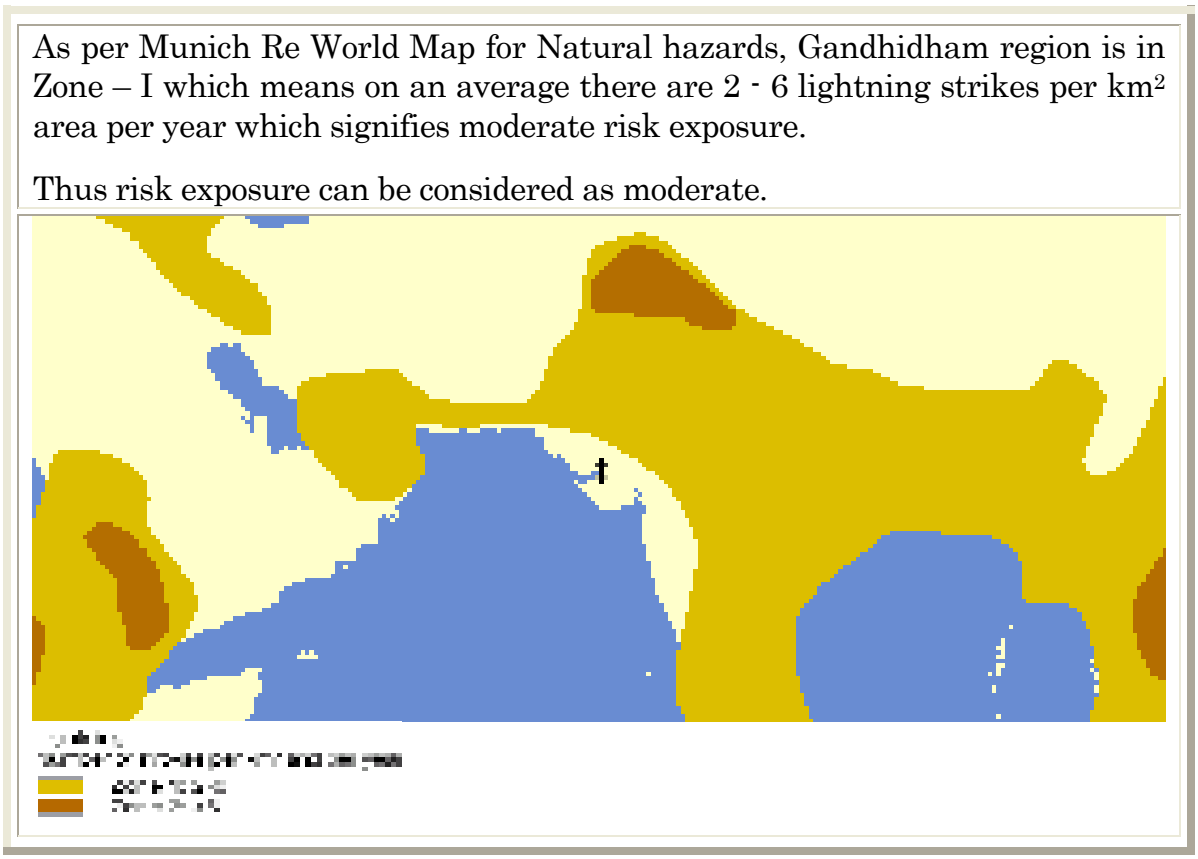
Thus taking the dynamic seismic scenario in to consideration risk exposure can be considered as High.



9.1.3 Lightning

As per Munich Re World Map for Natural hazards, Gandhidham region is in Zone – I which means on an average there are 2 - 6 lightning strikes per km^2 area per year which signifies moderate risk exposure.

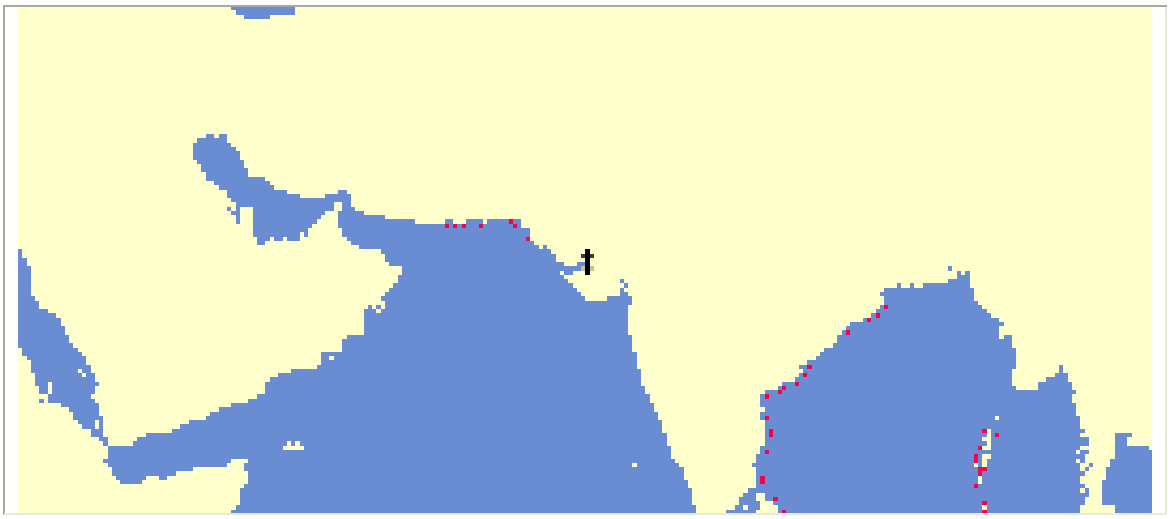
Thus risk exposure can be considered as moderate.



9.1.4 Tsunami

Tsunami is large submarine earthquake or large submarine landslides, which are often triggered by earthquakes, and volcanic eruption in the sea or on the coast. The waves spread out in all directions and at great speed, which increases with the depth of water. In great ocean basins the average speed is about 700km/h.

Thus risk exposure can be considered as moderate.



When severe weather is predicated or threatened preparation is made by site personnel.

The most probable severe weather events at the Kandla Port will involve High winds, Heavy rains, Cyclone, Storm, Tsunami, and Lightning & Earthquake.

There is a possibility of surface water accumulation and ingress into buildings and equipment. In addition the above severe hazard conditions can create significant personnel hazards loss of power.

9.2 Internal Action Plan in case of Cyclone / Flood & Any other Natural Calamity

As soon as the message on anticipated cyclone/flood/natural calamity is received from the State Government Authority/Indian Meteorological Department/Cyclone Warning Centre/Indian Navy, etc. by any official of the Port Trust, the same shall immediately be informed to the Deputy Conservator (Nodal Officer), who in turn shall get such message confirmed from the above sources and apprise the Chairman and Dy. Chairman accordingly. On approval of Chairman, the Action Plan as stipulated hereunder shall be put into operation for which the Deputy Conservator shall inform all the officers-in-charge of the Control Rooms as well as the Heads of Departments, including Chief Operation Manager, OOT, and Vadinar about the decision of the Chairman as per **Point No: 9.2.1.**

9.2.1 Particulars of the Action Plan Committee Members

Sl No	Name	Designation	Telephone Nos.			
			Office	Residence.	Fax	Mobile
1	Mr. P.D. Vaghela	Chairman	233001 234601	233002	235982	9825327760
2	Mr.M.A. Bhaskarachar	Dy. Chairman	234121 236323	234113 236346	236323	9825227037
3		FA&CAO	220047	228819	233174	9825227914
4	Mr. R S Singh	Deputy FA&CAO	220543	239250		9825351107
5	Mr.N.B.V Ramana Rao	Sr. DD(EDP)	239623	234116		9825505620
6	Capt. B. Tewari	Secretary	233172 220146	231939	233172	9825227035
7	Mr. Muralidharan.V	Dy. Secy (G)	221375	236990		9825505969
8	Mr. Md. Feroz Hussain	Sr. Dy. Secy (P)	231854	234730		9825227480
9	Mr. Joy Mathew	A. Secy (G)	221679	234691		
10	Mr. B.H. Gehani	OSD-Estate	223912	235683		9825225963
11	Mr. Y K Singh	S.L.O.	223828	228584		9825227079
12	Mr. H C Vankatesh	Traffic Manager	270625 270246	235100	270475	9825227076
13	Mr. M. S. Balani	Sr. Dy Traffic Manager	270270	263006		9825227047
14	Capt. H. K. Sibal	Deputy Conservator	233585 220235	232806	233585	9825227043
15	Capt. T Srinivas	Harbour Master	270201	234427		9825232982
16	Mr. M.R.Tilakan	Dy.Hydl. Engr	270277	227927		9825227201
17	Mr. I D Bhagchandani	Flotilla Supdt.	270280	220805		9825289204
18	Mr. A. J. Maheshwari	FCSO	270176 270178	238238	270176	9825227041
19	Mr. R. Murugadoss	Chief Engineer	233192	228777	220050	9825227243
20	Mr. B. G. Somaiya	Supdt Engineer (P)	233569			9825325390
21	Mr. M. N. Tewani	Exe Eng (R)	236165	222056		9825706255
22	Mr.C. M. Manwar	SE (PL)	220013	229164		9825225962
23	Mr. N. M. Parmar	SE (H)	270429	252624		9825227046
24	Mr.B. Rajendra Prasad	Exe Eng (D)	220038	232880		9725338260
25	Mr. Niteen Borwankar	CME	270632 270184	222866	270184	9825226944
26	Shri S. K. Das	Addl. CME	270426			9825235196
27	Mr. A. Ganeshan	SE (E)	270209	229345		9825227048
28	Mr. L N Punjwani	SE (M)	270354	265781		9726188222

29	Dr. C. M. Joshi	CMO	225767 220072	234598		9825505795
30	Dr A K Tilwani	Sr Dy CMO	220072	221161		9825236167
31	Dr S B Suryavanshi	AMO	220072	233099		9687606995
32	Dr. Mahesh Bapat	A.M.O	220072	228167		
33	Mr. K.K. Dutta	Com. CISF	271037	229140		9825227282

Based on the past experience, after detailed discussions and experience sharing process, the actions suggested in the plan have to be taken immediately by the concerned staff members/officials as shown against their names/Designations as soon as the warning of cyclone or any other natural calamity is issued. All staff members/officials should know that they shall come into action on their own as soon as the warning is issued, without waiting for any further instructions. Failure on the part of any employees/officials to carry out the earmarked action plan shall attract severe consequences, which all must note.

9.3 Control Room

There shall be three control rooms, one at Kandla at Seva-Sadan-III, and second one at AO Building, Gandhidham and third at A O Building, Off Shore Oil Terminal, and Vadinar. The Control Room at Kandla shall be under the direct supervision Harbour Master, whereas Dy. Secy. (G) will be the overall in charge of the control room at A O Building, Gandhidham. XEN (M&E) will be the overall in charge of control room at Vadinar. They shall rush to the respective control rooms as soon as the action plan is put into force. The officials named in the duty roaster of various departments elsewhere in this Action Plan shall also report to the respective HODs for coordination and to perform duties as may be assigned by the higher authorities. The overall in charge should draw up roster of the said employees and assign duties for the coming five days. The staff should report to the respective control rooms. The Radio Radar Technician will remain in control room to attend all communication equipments.

9.3.1 Duty Roster for Staff of General Administrative Department

01	Mr. Pulli S. Rao, Steno	220416		
02	Mr. Umesh Lalwani, Assistant	220010	261803	9426737761
03	Mr. Purshotam B., Assistant	220010	263833	
04	Mr. N.K. Raba, Senior Clerk	220010	228623	9426737760
05	Mr. Jacob Thomas, Sr. Clerk	220010		
06	Mr. Kalpeshsingh Rao, Senior Clerk	220010		9427407370
07	Mr. Kamalesh S Bajaj, Senior Clerk	220010		9825241998
08	Mr. Haresh Gulrajani, Junior Clerk	220010	225813	
09	Mr. R.V.Jadeja, LWA	270872		

9.3.2 List of Duty Roster of Marine Department (Ministerial Staff)

Sr No	Name	Office	Residence / Mobile
01	Mr.V. S. Chavate	221971	233396
02	Mr. AR Jadeja, Signal Supdt	270549	232551
03	Mr. JK. Chavda, D.A	270427	222848
04	Mr. P. Srinivasan, Sr. Steno	220235	233470
05	Mr. Narshi Maheshwari Assistant	221971	9925317584
06	Mr. AK Patel, Assistant	221971	
07	Mr. Rajesh Vinayak, Sr. Clerk	270427	9099115556
08	Mr. Sunjay Saluja, Messenger	221971	235390
09	Mr. Hiralal Motwani, Marine Khalasi	221971	263755

9.3.3 Pilots

Sr No	Name	Residence	Mobile
01	Capt. S. K. Pathak	231310	9825803499
02	Capt. D. C. Bhatt	235653	9879603641
03	Capt. A K Sharma	238154	9879603642
04	Capt.Vipul M. Madan	238154	9879603643

9.3.4 List of Telephone Nos & Address of DC, HM & Pilots

Sr No	Name of Officer / Pilots	Address of Gandhidham Res	Tel Nos: Cell / Landline	W/off or Remarks
01	Capt H K Sibal, DC	A – 4, Gopalpuri	9825227043 232806	Sunday
02	Capt T Srinivas HM	B – 3, Gopalpuri	9825232982	Sunday
03	Capt S K Pathak Pilot	C – 32, Gopalpuri	9825803499 231310	Saturday
04	Capt D C Bhatt. Pilot	C – 38, Gopalpuri	9879603641 235653	Monday
05	Capt A K Sharma Pilot	C – 40, Gopalpuri	9879603642 238154	Sunday
06	Capt V Madan, Pilot	C – 31, Gopalpuri	9879603643 221478	Thursday
07	Capt Ashok Modi Contract Pilot	Plot 120, Sec. 3, Opp Syrian Church	9825172975 234950	
08	Capt Bharat Modi Pilot on call	Plot 111, Sec. 3, Opp Syrian Church	9825140889 238627	
09	Capt Prakash, Contract Pilot	C – 49, Gopalpuri	9099674149 236647	
10	Capt Genius Raj, Contract Pilot	C – 52, Gopalpuri	9726097129 232826	
11	Capt Vinod Ranjan, Contract Pilot	C – 53, Gopalpuri	9726097126	

12	Capt A Mishra, Contract Pilot	C – 60, Gopalpuri	9099694747 229914	
13	Capt M Kumar, Contract Pilot	C– 51, Gopalpuri	9726097127	
14	Capt Pradeep, Contract Pilot	Gopalpuri Guest House	9586150784	
15	Capt R P Singh, Contract Pilot	Gopalpuri Guest House	9586152050	
16	Capt D S Katoch, Contract Pilot	Gopalpuri Guest House	9727817020	

9.3.5 Contract / Empanelled Pilots

Sr No	Name	Mobile
01	Capt. A C Modi	9825172975
02	Capt. B C Modi	9825140889
03	Capt. Arvind Kumar Mishra	9099694747
04	Capt. Manmohan Kumar	9726097127
05	Capt. Genuis Raj	9726097129

9.3.6 List of Duty Roster of Mechanical Engineering Department

Name of Officer	Designation	Office	Resi.	Mobile
Mr.Niteen Borwankar	CME	270632	222866	9825226944
Mr. S.K. Das	Addl. CME	270426	242036	9825235196
Mr. M.Y. Chacko	PA to CME	270184	238813	9913582859
Mr. A. Ganeshan	SE(Electrical)	270209	229345	9825227048
Mr. L.N. Punjwani	SE (M)	270354	265781	9726188222
Mr. J K Verma	Dy M M	234114	222771	9825227255
Mr. P S Pathan	XEN(E)	270469	229038	9427205563
Mr. V.I Vazirani	XEN(DD) I/C	270285	220182	9375357125
Mr. B J Solanki	AXEN(M)	270285	240010	9825340169
Mr. A K Marathe	Asstt. Engr (M)	234199		9427201492
Mr. Haridas Nair	AXEN	270165	235458	9426730306
Mr. D. K. Hazara	AXEN (E)		227185	9427436025
Mr. S.M. Gor	AE(E)	270322	226460	9879630888
	Office Supdt	270245		
Mrs. Sunita Bajaj	Div. Accountant	270245		9925547755
Mr. Anthony Varghese	Div. Accountant	270342		
Mr. Anil Panikar	Steno	270184	236833	9427437804
Mr. Pradeep Pandey	Junior Clerk	270245		9426277390
Mr. A.K. Sharma	AE(E)	270469		9913200232
Mr. B.S. Sharma	AE(E)	270458	240966	
Mr. Dana Manohar	AE(M)	270010	295536	9427719184
Mr. Rajesh Roat	AE(M)	270370	225182	9825692785

Mr. R. Padmanabhan	JE(M)	270127	225162	9428032272
Mr. Mohan Dhanji	Head Clerk	270342		9428897954
Mr. Vinod Sondhra	Head Clerk	270498		9979323157
Mr. Yuvraj	Div. Accountant	270498		9428316341
Mr. D.K. Hanakadia	Head Clerk	270484		
Mr. Vasu Tilwani	Div. Accountant	270484		9429426734

9.3.7 List of Duty Roster of Civil Engineering Department

Name of Officer	Designation	Office	Resi.	Mobile
Mr. R Murugadoss	Chief Engr	233192	228777	9825227243
Mr. B.G. Somaiya	Supdt. Engr.(P)	233569	--	9825325390
Mr. M K Khushalani	Supdt. Engr.(C)	270787	260964	9825227038
Mr. D. D. Somaiya	Supdt. Engineer (Const)	270419	252856	9825227203
Mr. M H Makati	PA To CE (T)	220016	237513	--
Mr. Ravi Maheshwari	P.A. To CE	220050	222550	9426737553
Mr. N M Parmar	Supdt Engineer (Harbour)	270429	252624	9825227046
Mr. M. N. Tewani	Exe. Engr (R)	236165	222056	9825706255
Mr. B Rajendra Prasad	Exe. Engineer (Design)	220038	232880	9725338260
Mr. B.H. Gehani	Ex.Engr (TD)	223912	235683	9427205610
Mr. Suresh Kumar	Dy.Secretary(E)	221758	236086	9825227044
Mr. J.K. Chauhan	Asst.Estate Manager	221598	237512	

9.4 Kandla Control Room

Designation	Office	Residence	Fax No	Mobile
Harbour Master	270201	234427	270624	9825232982
Inspector (RI),CISF	271038	271035	------	-----
R.R. Technician	270165		270165	9727870346

9.5 A.O. Building, Control Room (Gandhidham)

Designation	Office	Residence	Fax No	Mobile
Dy. Secretary (G)	221375	236990	------	9825505969

Accounts Officer (Mr. K F Shrimali)	220908	226199	-----	------
Asstt. Purchase Officer	231362	222675		

9.6 Vadinar Control Room

Designation	Office	Residence	Fax No	Mobile
	02833-256749 / 256555 / 256296		02833-256540/ 256296	9825212359 9825212360 9825148556
Exe. Engineer (E&M)	02833-256556			9825148556
A. F. S.	02833-256269	02833-256517		
Pilot in Station				

The overall in charge of the Control Rooms shall ensure the presence of the staff, to which various duties have been assigned. They should attend the meetings as and when called. In case of absence of the staff, the matter should be informed to the disciplinary authority, who shall take disciplinary action against the erring employees.

9.7 The Control Room shall have the following Facilities

Control Room	Telephone Nos	Fax No	VHF
Kandla	02836 – 270549/270194	02836-270624	8,10,12,16
Gandhidham	02836 – 238055/239055	02836-239055	------
Vadinar	02833 - 256749/256555	02833-256540	12, 16, 8, 10

The above facilities will remain as permanent assets of the Control Rooms. The overall in charge for setting up of Control Room at Kandla will be Dy. Conservator and Secretary for A. O. Building, Gandhidham. They should ensure setting up the Control Rooms at the respective places within two hours of warning and the matter reported to Chairman/Deputy Chairman.

Commandant, CISF to remain in contact with In charge of Control Room at Kandla regarding the positions of the Cyclone.

9.8 Functions of the Control Room

1. It shall remain in touch with the Indian Meteorological Department (Telephone numbers given at Point No: 11.8.1) and also offices and officials as at **Point No: 9.8.2, 9.8.3, 9.8.4**, **9.8.5 & 9.8.6** on need basis.

9.8.1 Important Telephone Numbers of Indian Meteorological Department

Designation	Address	Office	Resi.	Fax
Director General	Mausam Bhavan, Lodi Road, New Delhi.	011-24611842	011-24633692	011-24611792
D.D.G.M. (C.W)	-do -	011-24611068		011-24619167
D.D.G.M. (WF)	Met Office, Simla Office, Pune	020-25535886	020-25884104	020-24623210 25893330 25535201
D.D.G.M.	RC Colaba, Mumbai	022-22150517	22150417	
Director (ACWC)	-do-	022-22150405	022-22150452	
Director (I/c)	Met Center Ahmadabad	079-22865012 22865165		079-22865449 22865012 22861413
Met I/C	MET Centre, Ahmadabad	22861413		
Duty Officer		22865012		
Meteorologist	Ahmadabad	22861413		

Websites

www.imd.emet.in

www.imdmumbai.gov.in

9.8.2 The Telephone Numbers of Some of the VIP s

Sr. No.	Name and Designation	Fax	Telephone (Office)	Telephone (Resi)
1	District Collector, Bhuj	02832-250430	250020	250350
2	Dy. Collector, Bhuj Mob. 9825300729	02832-252704	250650	
3	Add. Collector, Bhuj Mob. 9825049360	02832-252704	252704	251348
4	Superintendent of Police, Ghandidham,	9978405690	227934	
5	Asstt. Supdt. Of Police		253405	250850
6	Dy. Collector, Anjar		243345	243363
7	Dy. S. P., Anjar		243254	242596
8	Mamlatdar, Gandhidham	9879278174	242588	243362
9	Mamlatdar, Gandhidham		250475 250270	222875 250475
10	Port Co-coordinator, OCC		234313	232808
11	Terminal Manager, IOC	234396	231871	236442

12	Air Force Commander, Jamnagar		2550245	-
13	Collector, Jamnagar		555869	554059
14	Station Commander, Air Force, Bhuj		244005 to 244010	
15	Commandant, BSF, Gandhidham		223845	
16	Smt. Nirmala Gajwani, SRC	260401	260019	260631
17	Mr. Vasan Ahir, MLA, Bhuj	9825025148		
18	Dr.Nimaben Acharya, MLA, Anjar	9825226700	220715	
19.	Civil Surgeon, GK Gen. Hospital		222850	

9.8.3 Telephone Numbers of State Ministers

Sr. No.	Name and Designation	Telephone Numbers Code – 079		
		Office	Residence	Mobile / Fax
1	Mr. Narendra Modi, Hon'ble Chief Minister, Block No.1, 5th Floor, Sachivalaya, Gandhinagar	23232611 to 19	23243721	23222020 23222101
2	Mr. Vajubhai Vala Hon'ble Finance Minister	23248007 23238072	23221233	23257616
3	Mr. Nitin Patel, Minister of Water resources & Supply.	23238076 23243389	23232491	23250120
4	Smt. Anandiben Patel, Minister for Revenue, Disaster Management, R&B.	23238077 23250115	23248460	23243331
5	Mr. Dilip Sanghani, Minister for Agri., Animal husbandry, Co-operation, Fisheries	23238152 23243506	23259728	23250124
6	Mr. Jay Narayan Vyas, Min. for Health	23238109 23243502	23222102	23250135
7	Mr. Fakirbhai Vaghela Min. for Social Justice and Empower Department	23221186 23238075	23259681	23250129
8	Mr. Mangubhai Patel, Min. for Tribal Dev & Forest & Environment	23238153 23220164	23222006	23250157
9	Mr. Narottam Patel, Panchayat, Rural Development, Food and Civil Supplies.	23250101 23238078	23259606	23250102

9.8.4 Telephone Numbers of Minister of State

Sr. No.	Name and Designation	Telephone Numbers		
		Office	Residence	Fax
	(Home)	23250231 23225920	23259661	23250235
	Mr. Saurabhai Patel, (Energy & Petrochemical)	23220694 23220655	23250625	23250215
	Mr. Purshottam Solanki, (Animal Husbandry & Fisheries)	23250225 23250230	23251404	23250263
	Shri Vasan Ahir (Welfare of backward Comm)	23250183 23250184	23259793	23250180

9.8.5 Telephone Numbers of Officials (State Ministry)

01	Chief Secretary, GAD	23250301	22868282	
02	Principal Secretary, GAD	23250403	22850505	
03	Addl. Chief Secretary, Port & Road Transport	23250506		
04	Principal Secretary (Industries & Mines)	23250701	23254926	
05	Principal Secretary (Labour & Employment)	23250871	26851304	
06	Addl. Chief Secretary (Home)	23250505	23254905	
07	Principal Secretary (Energy & Petro-chemicals)	23250771	23254844	
08	Principal Secretary (Finance)	23250611	23252045	
09	Principal Secretary (Revenue)	23251501	26301728	
10	Principal Secretary (Education)	23251301	26423231	
11	Chairman, GMB	23238363	23249356	
12	Commissioner Disaster Management Cell	23259502	23254900	

9.8.6 Gujarat State Disaster Management Authority Telephone Numbers of Senior Officials

Sr. No.	Name and Designation	Office	Residence	Mobile
1	Dr. P. K. Mishra, Ph.D.IAS, Chief Executive Officer, GSDMA	3259392 Fax – 3259248	3261271	9825095142
2	Mr. M.Sahu, IAS, Addl. CEO, GSDMA	3259502 Fax-3259275	6309273	9825095148

3	Mr. C.L.Meena, IAS, Addl. CEO, GSDMA	3259293 Fax-3259289 / 48	3220488	9825244543
4	Mr. V.Thiruppugazh Joint CEO, GSDMA	3259451	3235404	9825084316
5	Mr. Arvind Joshi, IAS Director (Admn.)	3259500 Fax – 3259289	3235434	9825084317
6	Mr. P. C. Purabia Chief Engineer (Procurement)	3259219	2148066	9825084320
7	Mr. J.G.Pandya Director (Emer. Comm. & Housing)	3259501	3244022	9825084318
8	Mr. R.J.Makadia Director, (Disaster Management)	3259025		9825244540
9	Mr. H.K.Patel, Director (Finance)	3259279	6752930	9824033622
10	Mr. S. M. Shah Controller of Accounts	3259278	6302219	9825244541

2. Information from the above Offices/Officers will be collected and transmitted to the overall in charge of Control Rooms/ Dy. Conservator/Harbour Master/ Traffic Manager/Senior Commandant, CISF/Chief Mechanical Engineer on hourly basis. The information should also be passed on to Secretary/Dy. Chairman/Chairman on every 03 hours.

3. Two telephones should be kept in the Control Rooms, one for receiving and the other for outward calls.

4. Each control room will enter messages in Log Books continuously and simultaneously report to the overall in charge after every one-hour. The information shall be passed on to Chairman/Deputy Chairman directly depending upon the importance. It shall be the responsibility of the Control Room Staff to ensure that timely information is passed on and timely proper monitoring done.

9.9 Continuous Monitoring Process

Immediately after the initial signal for Cyclone storm is received, the following officials shall continuously monitor the movement of Cyclone on hourly basis.

Sr. No.	Designation	Office	Fax	Residence	Mobile
1	Dy. Conservator	233585 / 220235	233585	232806	9825227043
2	Harbour Master	270201		234427	9825232982
3	Hydraulic Engineer	270338			
4	Dy. Hydraulic Engineer	270277		227927	9825227201
5	Sr. Hydrographic Surveyor	270396		238854	

6	Dy. Secretary (G)	221375		236990	9825505969
7	JE(C) Mr. Joseph Chacko			224013	9925150908

These officials shall obtain the information from the following sources and The Telephone Numbers of I.M.D. is given in (**Point No: 9.8.1**)

1. State Meteorological Control Room, Ahmadabad, Pune & Mumbai.
2. Meteorological Control Room, Delhi.
3. District Civil Defense Control Room
4. Air Force Station, Bhuj
5. Naval Base, Probandar / Vadinar
6. All India Radio, Bhuj
7. Doordarshan, Ahmadabad

The information so collected shall be maintained by making hourly log entry in a register.

9.10 Monitoring Through Internet

1. As soon as the cyclone warning Signal No. 5 or above is hoisted, the Sr. Dy. Director (EDP) should monitor it through internet and give two hourly print out to Dy. Conservator, Secretary, Chief Engineer, FA & CAO, Dy. Chairman and Chairman. Dy. Director (EDP) along with Junior Engineer (PMC) and Mr. B. Rajendra Prasad Exe. Engineer (Design) will monitor the website in the A. O. Building, Gandhidham.
2. System Analyst and Programmer Mr. Ajay Gupta, along with Dy. Hydraulic Engineer will monitor the Weather Report through Website at Kandla and Mr. Remesh Sorathia and Mr. Kishore Chawda, Scientific Asstt (MET) will assist them and send daily Bulletin to Harbour Master, Traffic Manager, Chief Mechanical Engineer, Executive Engineer (Harbour) and Senior Commandant, CISF.

The following are the website codes, through which the required information regarding the position of the Cyclone can be ascertained:

1. www.imd.ernet.in
2. www.supertyphoon.com/indian.html
3. www.npmoc.navy.mil/products
4. www.solar.ifa.hawaii.edu/tropical/tropical.html
5. www.underground.com/tropical

9.11 Inmarsat Mini – M – Terminal Kandla - 00873762092789

9.11.1 Control Room, Gandhidham

1	IDS No	762092789	-	VOICE
		762092790	-	FAX
		762092791	-	DATA

9.11.2 Control Room, Vadinar

1	IDS No	762092777	-	VOICE
		762092778	-	FAX
		762092779	-	DATA

9.12 Plotting of Information on Map

The following officers shall be deputed in the Control Room immediately on starting of the control room with relevant charts.

Sr. No.	Designation	Office	Residence	Mobile
1	Hydraulic Engineer	270338		
2	Dy. Hydraulic Engineer	270277	227927	9825227201
3	Cartographer	271058	225389	
4	Signal Supdt.	270549 / 270194	232551	9825427400 / 9825227246

The above persons shall immediately reach the Control Room and stay there till the emergency is called off. They shall plot the movement of cyclone on hourly basis and bring the position to the notice of Traffic Manager, Chief Mechanical Engineer, Dy. Conservator and Dy. Chairman/Chairman.

After scrutinizing the movement of Cyclone on the Charts, Dy. Conservator shall, in consultation with Chairman / Dy. Chairman, if required, take a decision for evacuation of ships immediately as soon as the Cyclone is in close proximity to the danger line as defined above.

All pilots should remain stand by as soon as the warning of Cyclone No. 5 level and above is received. All pilots shall be stationed at Kandla and shall not leave the port without prior permission. If it comes to the notice of the administration that any pilot has left the port and gone back to Gandhidham/Gopalpuri without prior permission till the emergency is called off, Departmental action will be taken against them.

Dy. Conservator shall station himself at Control Room at Kandla and remain continuously in touch with the pilots. The pilots should be in a position to mobilize themselves for evacuation of vessels and securing all Port crafts at shortest possible time.

ALL PILOTS SHALL REACH THE PORT IMMEDIATELY AFTER SIGNAL NO. 5

AND ABOVE IS HOISTED AND REMAIN TILL THE EMERGENCY IS CALLED OFF. THEY SHALL STAY THERE DURING NIGHT AND NOT LEAVE UNDER ANY CIRCUMSTANCES.

9.13 Leave of Pilots stand cancelled on declaration of Emergency

No leave shall be granted to Pilots from 1st May to 31st July without prior permission of DC and the pilots whether in the headquarters or outside shall rush back and reach Kandla Port at shortest possible time as soon as signal No. 5 or above is hoisted. It shall be the responsibility of pilots who are out of headquarters to remain in constant touch through newspaper, Television, Radio and to rush back to Kandla immediately without waiting for any instructions from Chairman/Dy. Chairman or Dy. Conservator's Office. Any pilot not rushing back at a reasonable time shall be held responsible and appropriate action shall be taken against him. Similarly, the Flotilla Staff and Signal Station Staff of the Marine Department will not be granted Leave without prior permission from Dy. Conservator during the said period. **(Ref: KPT – Internal Action Plan updated July 2010)**

9.13.1 Leave for Class 1 Class II Officers

All Class-I & Class-II Officers, the Technical Staff, the essential staff and other persons assigned with specific functions under this plan who wants to avail leave in the month of May, June and July should invariably submit their leave program in April every year. Secretary shall issue a circular in the first week of April every year to all the Class-I and Class-II Officers and ascertain the period for which officers would like to proceed on leave during the months of May, June and July of that year.

9.13.2 Immediate stopping of operations at the Port

All the Pilots of the Port should reach Kandla immediately in case of emergency. Any Pilot not traceable in emergency shall be liable for disciplinary action.

Dy. Conservator/Harbour Master/Pilots should be available at Kandla during emergency. (i) Removal of vessels whenever the Cyclone is located in close proximity to the danger line plotted between 65 degree E Longitude 18.2 degree N Longitude and 73 degree E Longitude 18.2 degree N Longitude. Map showing the above position is given at (Annexure XXX (to be inserted by KPT).

i. Under such a situation, the ships shall be removed during the first/next available tide. It will be the duty of Harbour Master and Dy. Conservator to ensure that the ships are removed during the first/next available tide as soon as the storm approaches in the close proximity to the danger line as defined above without seeking any further instructions from higher authorities. This action shall be taken automatically and suo-motto without any confusion and for this purpose Traffic Manager shall stop all loading and unloading operations immediately upon instructions from Dy. Conservator so as to enable him to remove the vessels in time. The removal shall be done with the help of all the available pilots plus all contract/empanelled pilots together at one go in the shortest possible time so as to ensure that all the vessels cross the bar before

the tide restriction sets in.

ii. Dy. Conservator shall ensure that all ships are moved out of the Harbour at the earliest. All pilots shall immediately report at Kandla and stay there till the Action Plan is in operation. Dy. Conservator/Harbour Master shall immediately plan removal of vessels to the OTB as soon as the Action Plan is put into operation irrespective of the signal number, which must be hoisted. If it is impossible to remove them, then all other steps should be taken to ensure safety of the vessels at the Port, as also it would not cause any damage to the Port.

iii. S E (M) shall enlist the Engine side staff of the Floating crafts to be kept stand by for shifting of crafts to safer places. He will be the in charge of manning these crafts as per the requirement.

For shipping tugs, Marine Engineer / Engineer In charge (Tugs) / Mr. S.C. Mohanty, AE (D&T) will be the in charge for manning the engine side staff for operation of the shipping tugs as per the requirement. Mr. K.C.P Rajan, Assistant Engineer (DT) and Mr. Umakar Dubey, Assistant Executive Engineer (FC) shall co-ordinate with Marine Engineer / Engineer In charge (Tugs).

iv. After the Cyclone warning Signal No. 5 or above is hoisted at the Port Traffic Manager shall ensure that the loading/unloading operations at the Port are stopped immediately, hatches closed, ships' derricks properly secured and all labourers evacuated from the port area. Public address system shall be installed at the cargo jetty area, which shall be under the charge of TM. He shall use it for necessary arrangements relating to the evacuation. Senior Commandant, CISF shall ensure that Public Address System is fitted on jeeps provided to CISF.

Traffic Manager should ensure that responsible persons make announcements in a proper way so as not to create any misunderstanding / panic.

9.14 Securing of Cranes

Chief Mechanical Engineer shall ensure that immediately the cranes are secured and properly locked after closing of loading and unloading operations from ships as per procedure and report submitted to Chairman/Dy. Chairman after the operation of this action plan.

The following officers shall constantly monitor the safety of Cranes:

Sr. No.	Designation	Office	Residence	Mobile
1	S E (M)	270354	222771	9825227255
2	S E (E)	271010	229038	9427205563

The above officials and Mr. S.M. Gor, Assistant Engineer (Elec.) shall arrange to secure all the cranes and keep them properly locked as per the procedure and send a report to the Chief Mechanical Engineer.

Executive Engineer (Dry Dock) and Mr. Manohar Dana, AE (Mech) shall arrange to secure the cranes at maintenance Jetty as well as Bunder Area.

9.14.1 Securing of all Crafts

Dy. Conservator/Harbour Master shall immediately arrange for securing all the Port Crafts at safer places so that there is no loss to the port and send a report to the Chairman/Dy. Chairman as early as possible after operation of this action plan. Flotilla Superintendent shall be overall in charge of each craft for ensuring their safety.

For parking of crafts in emergency, there places are mainly identified, viz. Bunder Basin, Launch Jetty and maintenance Jetty (As per):

1. Maximum number of crafts such as Mooring Launches, G. S. Launches, and Pilot Launches will be placed in **Bunder Basin**.
2. In the inner side of **Passenger Jetty**, one Pilot Launch and one G.S. Launch will be kept.
3. Three Tugs will be kept in the inner side of **Maintenance Jetty**.

Priority will be given to the Port Crafts for parking in the Bunder Basin and other areas. Rest of the places available in the northern side of Bunder basin area will be allotted to the self propelled barges and private crafts. Dumb barges will be allowed on the beach between maintenance jetty and oil jetty area.

Mr. Maharam Yadav, B.S. will render all possible assistance to FS, being the overall in charge of the crafts. The following flotilla staff will take care of;

1	Mr. I D Bhagchandani	F.S	Launch Jetty/Passenger Jetty
2	Mr. T. Sunil Kumar	B.S	Craft Jetty
3	Mr. R B Chauhan	AFS	Maintenance Jetty
4	Mr. SreeKumar	AFS	Bunder Basin

9.15 Private Barges / Crafts

The parties who have been given license by the Dy. Conservator to keep their barges and crafts inside the Port limit are given below:

9.15.1 List of License Holders to keep their Crafts inside the Port Area

Sl. No.	Name of Party	Name of Nodal Officer	Tele. (Office)	Tele. (Resi)
01	M/s Jaisu Shipping Co. P Ltd., Kewalramani House, Dinshaw, Bldg. Road, New Kandla	Mr.Preetam, Director, Mob. 9825226114	270538 270128 270428	260235 260224
02	M/s Gautam Freight Pvt Ltd., Plot No. 24, Sector, 10/C, GIDC Area, Gandhidham	Mr. Ramesh Singhvi, CMD	231386 232605 230345 220163	234176 230328

03	M/s Bapu's Shipping, Plot No. 32, Sec – 9 GIM	Mr. Vishal Jadeja	222002	
04	M/s Blue Ocean Sea Transport, Manali Chamber, Plot No.306, Sec 1/A GIM	Mr. Hukumat T. Bhojwani & Mr. Dushyant Patel	239143 222518 230488 239058	
05	M/s Rishi Shipping, Rishi House, Sec 1/A, Plot No. 50 Gandhidham	Mr. Manoj Mansukhani Proprietor	220843 229830 229831 223913 229517 Fax. No. 238943	
06	M/s Velji P & Sons, Deepak Complex, 2nd Floor, Plot No. 315, Ward 12/B, GIM	Mr. Sureshchandra	231545 231546	232247
07	M/s A.S. Moloobhoy & Sons, Anchor House Shivkripa Bldg, Plot No. 135, Sec 1/A, GIM	Mr. Adil Sheth M- 9375312077	326543 225060 225061 225060	
08	M/s Gudani International Pvt. Ltd, C/o Chemoil Adani Mithakali Circle, Ahmadabad.		079-25555765 25555266	

Necessary instructions shall be issued to all those people have valid license immediately. The work of informing these parties will be carried out by Office Superintendent of Dy. Conservator's Office and will personally ensure that the instructions are carried out and report to HM within two hours of the Action Plan coming into operation. The representatives of the above parties shall reach Kandla at once, failing which Dy. Conservator shall cancel the license granted to them and take over the barges/crafts of the party who violate the instructions.

9.16 Evacuation of People from Kandla Area during Emergency – Action Plan

In Kandla Area, there is Residential Habitation in the following areas:

9.16.1 Places of Habitation

9.16.1.1 Saltpan Units

Considerable numbers of Salt Workers are engaged in the following Salt Manufacturing Units.

1. Kutch Salt Works.
2. New Kandla Salt Works.
3. Vijay Salt Works.
4. Friends Salt Works.

5. United Salt Works on KPT Land.
6. United Salt Works on State Government Land.
7. Small Salt Works of State Government, Near Nakti Creek.

The approximate number of Salt Workers that are being engaged/ residing in these Salt Works will be **around 2575**.

9.16.1.2 Sirva Labour Camp

Plots in Shirva Labour Camps (Near Mosque) have been allotted by Kandla Port Trust on L&L Basis. **Population: 450 (approx).** There are also some un-authorized hutments in the area.

9.16.1.3 Sirva Railway Hutments

The Shirva Railway Hutments (alongside Main Road) is a cluster of un-authorized Hutments erected on the Railway Land: **Population 700 (approx).**

9.16.1.4 G – Type Quarters & Housing Societies

The G-Type Quarters are constructed by Kandla Port Trust in early 1950s and were allotted to some persons who were engaged in Port related activities in those days.

Kandla Port Trust has allotted land to Two Housing Societies known as Kandla Port Workers Co-operative Society and Dr. Jaynat Khatri Co-operative Housing Society in Kandla area. **Population: 1000 (approx).**

9.16.1.5 New Kandla Port Colony P & T & Customs Colonies

The KPT employees, Customs employees etc are residing in these areas.

9.16.1.6 Hutments in the Land of PGVCL

There is a cluster of unauthorized Hutments to the Northern side of wahiya creek and southern side of M/s ABS Bayers Limited and this land belongs to PGVCL. **Population: 100 (approx).**

9.16.1.7 Banna Fishermen Hutments

There are unauthorized Fisherman hutments situated on the Bank of Kandla Creek towards Southern side of NDDB Colony. **Population: 800 (approx).**

9.16.1.8 Hutments near IFFCO Plant

There is a cluster of unauthorized hutments near IFFCO Plant. **Population: 500 (approx).**

9.17 Population of Kandla

The population of Kandla Area is basically a mixture of people from various places and they can been generally divided in the following three groups;

People belonging to nearby villages like (i) Tuna (ii) Kharirohar (iii) Mithirohar (iv) Chirai and (v) Gandhidham City.

People belonging to other States like (i) Andhra Pradesh (ii) Rajasthan

(iii) Uttar Pradesh and (iv) Bihar.

People working in Government establishments residing in the colonies of their organizations.

Most of the people residing in Shirva Labour Camp, Shirva Railway Hutments and Thermal Hutments etc are engaged as Private Labours in the Port and Port related ancillary activities and petty business.

9.17.1 People of Nearby Villages

People of the Port and nearby lease areas belonging to nearby villages like (i) Tuna (ii) Kharirohar (iii) Mithirohar (iv) Chirai and (v) Gandhidham City will have to be sent back to their respective village by providing them Trucks and/or ST Bus facilities in consultation with State Govt. Agencies.

9.17.2 People of Other States

People belonging to other States like (i) Andhra Pradesh (ii) Rajasthan (iii) Uttar Pradesh and (iv) Bihar may not have any relatives or other accommodations facilities in the nearby places like Gandhidham, Adipur. Hence, they will have to be provided Temporary Shelter in the Schools/community centres as may declared as Temporary Rehabilitation Centre/ Temporary shelters by the State Govt. Authorities.

9.17.3 Action Plan for Evacuation of People from Kandla

On Hoisting of No. 5 Signal or above in Kandla Port, immediately action shall have to be initiated for evacuation of people in the following areas by the persons responsible as mentioned hereunder:-

The evacuation of the inhabitants of the following areas at Kandla is to be done as these areas are sensitive and prone to natural calamities like cyclone, high-tide and other disaster like Gas Leak, etc.

OSD(Estate) and Mr. Bhatia, Asst. Engineer (C) shall ring up all salt lease holders directing them to evacuate their people from their Kandla sites and a report thereof submitted to the Chairman/ Dy Chairman. The Dy Secretary (Estate) will be overall in-charge of the proposed action.

9.17.3.1 List of Salt Lessees

Sr. No	Name of Salt Works	Contact Person	Tel. No. Office	Tel. No. Residence
1	Asstt. Salt Commissioner, Gandhidham	Mr. Jagdish Tripathi	233670	263690
2	M/s. Kanoria Chemicals and Ind. Ltd., Plot No.220, Sector –4, Gandhidham	Mr. B. N. Singh, Mr. J. Singh Factory -	229470 0237-74433	283325 9825225841

3	Shree Krishna Salt Industries, Central Bank Compound, Gandhidham	Mr. Kantibhai Thakkar Mr. Vikash Patel Mb: 9825206214	234727 233990	235315 234089
4	M/s. Chirai Salt Works, DBZ-S-46, Jawahar Chock, Gandhidham.	Mr.Sureshbhai Mr.Parasbhai Mb: 9825225181 Mr.Mayajar	221109 221267 9826214709	234386 233081
5	M/s. Bhuveneshwari Salt Works, TCX-S-62, Gandhidham	Mr.Sreechandji Jain 9825222269	237114 235203	233605 236860
6	M/s. Dungershee Salt Works, Shop No. D-93, P.B.No.9, Gandhidham	Mr.Hiralal Parekh Mb: 9825019661 Mr. R.B.Agrawal Mb: 9825019662 Mr. Bhikhabhai (Salt Area)	222765 223440 9825225667	232767
7	M/s. Shree Laxmi Salt Allied Ind., "Shree Sadan", 207 / 12-B, Gandhidham	Mr. Rajubhai Rathi Mr. Rameshbhai Rathi Mob.: 9824214901	232167	232167 235482
8	M/s. Jyoti Salt Industries, "Sukh Sadan", Opp. Hotel President, Gandhidham	Mr.Acharya Sukhdevbhai Mr. Sukhdevbhai Acharya Mb: 9825226075	223776 221082 221089 223094	221876
9	M/s. New Kandla Salt and Chemical Co., "Maitri Bhavan", Plot No.18, Sector 8, Gandhidham	Mr. Babulalji Sanghvi 9825226091 Mr. Sukhrajbhai 98252 26011	232227 231588 234087	234325 231814 232122
10	M/s. Kutch Salt Works, New Kandla	Mr. Mitenbhai Mb: 9825225990 Mr. S.P.Giria, Works Manager, Mb: 9825228085	234659 022-22040561 22041598 270371	238633

11	M/s. Vijay Salt Works and Allied Industries, "Friends House", P.No. 50, Sector –1A, P.B.No.106, Gandhidham	Mr. Harishbhai Chaturani Mb: 9825064241 Mr. Babulal Nahata	231119 252247 223743	234856 9825228398
12	M/s. Rajesh Salt Works, "Chandan Chambers" National Highway, Plot No.18, 12/A, Gandhidham.	Mr. Kishorbhai Thakkar Mob: 9825177081 Mr. Rameshbhai Mb: 9825226026	220586 221048 222301	234387
13	M/s. Western Chemical, DBZ-S-151, Gandhidham	Mr. Naranbhai Mb: 9825226092	233185 230913	230141
14	M/s. Urvakunj Nicotine Ltd., Central Bank Compound, Plot No.31, Sector No.9, Gandhidham	Mr. Mahendrabhai Patel – 9825206214 Mr. Vikash Patel Mb: 9825226214	234727	234480
15	M/. Friends Salt Works, "Maitri Bhavan", Plot No.18, Sector No.8, Gandhidham	Mr. Babulalji Mb: 9825226015 Mr. Ashokbhai Mb: 9825226091 Mr. Sukhrajbhai Mb: 9825226011	232227 231588 234087	231646 231814
16	Smt. Savitri H.Pandya, DBZ-N-21/A, GIM	Mr. Jagdihbhai	220212 238112	255612
17	Smt. Vimlaben.H. Pandya, DBZ-N-21/A, Gandhidham	Mr. Jadishbhai Mr.Amritlal Pandya Mb: 9825225212	220212/238 112 238212 / 255612	-
18	M/s. Rajendra Salt Works, D-125, Jawahar Chowk, Gandhidham	Mr. Tarachand	-	-
19	Mr. Natwarlal Agrawal, TCX-S-75, Gandhidham	Mr. Natwarlal Mb: 9825393555	222672	231564
20	Mr. Indrumal Khubchand, C/o Gulab Salt Works, D-125, Jawahar Chowk, Gandhidham.	Mr. Tarachand	233041 234388	234937

21	Mr. Virji Khimji C/o Ajit Salt works, D-75, Gandhidham	Mr. Kirtibhai	220310	-
22	Mr. Girdharilal.S. Agrawal, Plot No.126, Ward – 12/B, Gandhidham	Mr. Girdharilal	232862	234755
23	Mr. Vijay Kumar.D. Palan & Mri Jagdish Kumar.D.	Mr. Navrotambhai Palan	220310	-
24	M/s. Satya Salt Works, DBZ-S-183, Gandhidham	Mr. Candubhai Mb: 9825225911	224055 221445	234739 234469
25	Shri Premji Gangji Soni, DBZ-S-183, Gandhidham	Mr. Mahesh Soni	221263	-
26	Smt. Geetadevi P. Chaturani Plot No.13, Sector 1, Gandhidham	Mr. Romesh / Ashwin Mr. Dayalbhai Chaturani, Mb:9825064245	221048 256713 220586 256706 Fax: 222930	-
27	Shri Rashmin A.Pandya DBZ-N-21/A, Gandhidham	Mr. Jagdish Pandya	220212 238112 238212	-
28	M/s. Neelkanth Enterprise, DBZ-S-60, Gandhidham	Mr. Shamjibhai Mb: 9825 25711	220421 220103 Fax: 223560	231485
29	Dayalal G.Chaturani Shop No.1 to 4, "Chandan Chamber" Plot No.18, Ward No.12, Gandhidham	Mr. Dayal	221048 220588	-
30	Shri Chaganlal Punamchand, DBZ-N-197, Gandhidham	Mr. Chaganlal	220545	-

Safety Officer & Librarian shall inform the Public/Private Sector Tank Farms in Kandla about the situation and advise them to shift their people out of the respective areas to safe places.

9.17.3.2 List of Private / Public Tank Farm Owners

Sr. No.	Tank Farm Owners	Persons to be contacted in case of emergency		
		Name and Position	Telephone No.	Mobile No.
1	Kesar Enterprises Ltd., Near Oil Jetty, Old Kandla (Kutch)-370210	Mr. R.K. Gupta Gen. Manager	270435 (O) 295676 (R)	9375349181
2	Kessar Enterprises Ltd, Terminal II, Plot No. 5 &6 Old Kandla	Mr. R.K. Gupta G.M	270435 (O) 270177 (O)	9375349181
3	Chemical & Resins Pvt. Ltd Terminal –I, Near Oil Jetty, Old Kandla, Kutch Terminal – II, Near West Gate, New Kandla – Kutch	Lt. Col. Pramod Kumar (Retd), GM,	270505(O) 236831(R) 270916 (O)	9825225676
4	Indo-Nippon Co. Ltd., Plot No.2, K.K.Road, Old Kandla,	Mr. R.N. Pathak Asst. Terminal Manager	270795(O) 235818(R) 270295(O)	9879571295
5	J. R. Enterprise, Plot No.3, Old Kandla,	Mr. Devendra Dadhich, Terminal In-charge	653528 (O) 257152 ®	9898238380
6	Friends Oil & Chemical Terminals Pvt. Ltd., Near Booster Pump Station, Old Kandla, Kutch	Mr.S.Ramakrishnan Terminal Manager	270987 (O) 257249 ®	9879572107

7	Indian Oil Corporation Ltd., Main Terminal, GIM Foreshore Terminal, Kandla KBPL LPG Import Plant	Mr. AK. Khanna Sr. Term. Manager Mr. KS Rao, Sr.TM Mr. PS Negi Plant Manager	233274 (O) 229002 (R) 270394 (O) 270628 (O) 270477 (O) 233359 ® 270978 (O) 236944 ®	9427216637 9426416108 9426725342
8	United Storage & Tank Ltd Near IOC Foreshore Terminals, New Kandla Gas Terminal, Plot No. 4 Old Kandla	Mr. Manoj Gor Terminal Manager Mr. G. Chudasama	270609 (O) 653525 (O) 651238 ® 653529 (O)	989850029 9904366855
9	IFFCO Kandla Unit, Kandla, Kutch	Mr. L. Murugappan, G.M.(NPK-I) Mr. Brahmbatt Manager (F & S)	270711 270352(O) 270381 (O)	982506922 9099019861
10	BPCL, KK Road, GIM	Mr. RG. Dekate Sr. Manager Operations	234313 (O) 223235 (R)	9099929634
11	HPCL KK Road, GIM	Mr. Murthy Manager (Installation)	230936 (O) 220084 (O) 233078 Ext	
12	INEOS ABS (I) Ltd Plot No. 8 Old Kandla	Mr. Vineeth Nair Dy. Manager	270087 (O) 234409 (R)	9825237029

13	Liberty Investments Pvt. Ltd., Plot No. 1 & 2, Block 'H', New Kandla	Mr. Jitendra Vaidya Terminal Manager	270151 (O) 270464 (O) 270468 (R)	9825025645
14	Avean International Pvt. Ltd., Liquid Storage Tank Terminal, Plot No. B-1, New Kandla	Mr. Bharat Rathod Terminal Manager	270537 (O)	9375310260
15	Rishi Kiran Logistics Pvt Limited, Plot No. 7, Link Road Old Kandla	Mr. RH. Pandya GM (Terminal)	270223 (O) 270443 (O)	9879104556
16	N.P.P. Pvt. Ltd., Old Kandla	Mr. MD.Nagvekar	270347 (O) 257807 ®	9825227649
17	Friends Salt Works and Allied Industries, KK Road, Old Kandla	Mr. NJ.Zinduwadia Sr. Manager Mr. HA. Mehta,S.M	270814 (O) 262698 (R) 271260 (O)	9825506361 9825506360
18	IMC Ltd, Cargo Jetty New Kandla	Mr. Anil Brahmbhat	270369(O) 653524 (O) 296079 (R)	9898126243
19	Agencies & Cargo Care Ltd., Plot No.3, New Kandla.	Mr.Shivkumar Menon, Terminal Manager	270714 (O)	9825226765
20	Dipak Estate Agency Plot No. 5-6, Block – A New Kandla	Mr. Narendra Thacker	270375 (O)	9879611243
21	Parker Agrochem Exports Ltd, Plot No. 3 –4,Block-H New Kandla	Mr. Bharat Thacker	270486 (O) 270528 (O) 231876 (R)	9825238260

22	Tejmalbhai & Co New Kandla	Mr. Ankitbhai Chandan	271330 (O) 230090 (R)	9825225101
23	Parker Agrochem Product Pvt. Ltd, Plot 7-9/A,N.Kandla	Mr. Raja Babu Dy Manager	270528 (O) 231876 (R)	9979158543
24	Mother Dairy Fruit & Vegetable Pvt. Ltd, Near Oil Jetty, Old Kandla	Mr. Saju Therattu	270654 (O) 270655 (O) 230979(R)	9974022681

Traffic Manager/ Additional Traffic Manager shall arrange to inform all the Stevedores / Agents and other Stakeholders to remove their workers from the operational areas at Kandla.

9.17.3.3 List of Stevedores in the Port

Sr. No.	Name	Address	Fax No.	Telephone Nos.	
				Office	Resi.
1	M/s. Cargo Movers	"Cargo House" BBZS-32A, Gandhidham	231687	220453 231365	261280
2	M/s. DBC & Sons (P) Ltd.	Seva Sadan-II, Room No. 303 / 304, New Kandla	270631	270503 270263 270348	-
3	M/s. A.V.Joshi & Co.	Plot No. 18, Sector-8, Maitry Bhavan, Nr. Post Office, Gandhidham – Kutch	233924	231070 232227 231588	234909
4	M/s. ACT Shipping P. Ltd	Seva Sadan-II, Room No. 206/207, New Kandla	232175	270111 270112 270015 229967	261308 231416
5	M/s. Cargo Carriers	214/215, Rishab Corner, Plot 93, Sector- 8, GIM	230030	220816 231649 230030	231694
6	M/s. Cargo Clearing Agency (Gujarat)	Plot No. 271, Ward 12-B, Gandhidham	233034	221721 220655	231452
7	M/s. Chotalal Premji Stevedores Pvt. Ltd	C-8, Shaktinagar, GIM	231509	270009	-
8	M/s. Hiralal Maganlal & Co.	C-11, GIDC Area, Gandhidham – Kutch	223914	223914 231832	223878 232430

9	M/s. New Dholera Shipping Company	Goyal Commerce Centre Building - 1, Plot No.259, Ward 12B, Gandhidham - Kutch	-	222637 232267	237284
10	M/s. J.M. Baxi & Co.	Seva Sadan – II, Room No. 301 / 306, New Kandla	270646	270630 270550 270448	260427
11	M/s. Pestonjee Bhicajee (Kutch)	Seva Sadan-II, 203, New Kandla	270650 270556	270257 270367	262914
12	M/s. OTA Kandla Pvt. Ltd.	BBZ-N-324, Gandhidham	223241	220145 270560	223241
13	M/s. Purshotamdas Jeramdas & Co.	5, Vaswani Chamber, 16, Sector-8, GIM	222850	238242 222598	220598
14	M/s. R. Tulsidas & Co.	Ahit Building , Plot No.323, Gandhidham – Kutch	232308	222717 221943	-
15	Rishi Shipping	Plot 50, Sector 1/A GIM	238943	229830 229831	
16	M/s. Vinsons	BBZ-S-25, Gandhidham – Kutch	231948	220466	222395 239460
17	Sical Logistics Ltd	403, 4th Floor, Madhuban Compex, OSLO, GIM	234416	234646 234194	
18	Parekh Marine Agency	C-8, Shaktinagar GIM	231509	229297 221158	
19	Krishna Shipping and Allied Services	Transport Nagar, NH GIM	233135	230501 223814 229085	
20	Kevar Carrier Handling & Transport	Shop 24, Tolani Chamber, Sector –8,GIM	228298	228298	
21	Trinity Shipping & Allied Industries	Trinity House, Plot 46 Sec 1/A, GIM	232060	230911 230910	
22	Velji P & Sons(P)Ltd	2nd Floor, Deepak Compex, 315, 12/B GIM	236168	231545 231546 225466	

23	Asean Marine Services	Ashit Bldg, Plot 33 Sector 1/A, GIM	232308	222717 221943 222145	
24	Rishikiran Roadlines	Kiran House, Plot 8 Sector 8, GIM	231422	231894 234108	
25	Universal Shipping Services	Hotel Sea Bird, Plot 173, Sector 1/A,GIM	235251	230663 226050 226037	
26	Seaways Shipping (P) Ltd	2nd Floor, Plot 351 Ward 12/B, GIM		226183 237147	
27	Seacrest Shipping Services Pvt. Ltd	216, 2nd Floor Om Corner, Plot 336 Ward 12/B, GIM	227028	233325	
28	Shree Maruti Shipping Services	18/21, Swaminarayan Bldg, Sector 9, GIM	234107 250690	233245 237247 250690	
29	Liladhar Pasoo Forwarders P.Ltd	Plot 4, Sector –1 KASEZ, GIM	252383 253506	252286 252297 252612	
30	Shree Radhey Shipping Company	14-16/C, GF Green Park, GIM	232967	222919 228919 238883	
31	Pearl Shipping	220, Rishab Corner, Plot 93, Sector 8 GIM	235570	225283 225284	
32	Patel Shipping Agency	Patel Avenue, Floor 2,Plot 170, Sector 1/A, GIM	231143	224024	
33	Ashirvad Shipping	18-21, Swaminarayan Bldg, Sector- 9, GIM	250690	233245 237247 222822	
34	M/s. Swaminarayan Vijay Trade Carriar	1st Floor, H-6, Op. Tejas Society, Ghatlodia, Ahmadabad	079-231983	231981, 231982	

9.17.3.4 List of Liner & Steamer Agents at Kandla Port

Sr. No.	Name	Fax No.	Tele. No.	Mobile

01	M/s ACT Shipping Ltd Mr. Harshad Gandhi	232175/ 270597	270111 270115-6 229967 231734	9825226141
02	M/s Admiral Shipping Ltd	233596	230552 232823	
03	M/s Areadia Shipping Ltd	232542	234254 223486	
04	M/s Ambica Maritime Ltd Mr. Amit Vyas	252447	252479 252349	9825225210
05	M/s APL (India) Pvt Ltd., Mr. Murli Krishnan	236361	224601/2 236357 236355	9825225753
06	M/s Arebee Star Maritime Agencies Pvt Ltd. Mr. Anil Talwar	235831	220465 235832	9824229109
07	M/s Ashit Shipping Ser. Pvt Ltd. Mr. Sanjay Thakkar	232308	221943 222717 222145	9825225698
08	M/s Atlantic Shipping Pvt Ltd	223372	230552	
09	M/s Asia Shipping Services. Mr. Mohan Karia239326	231285	234526 230954	
10	M/s Bayland Freight Systems Pvt Ltd., Mr. Danendran Gopalan	239326	225522/ 23	9825230880
11	M/s B D Vithlani Shipping Services Pvt Ltd.	234104	232220 221081	
12	M/s Cargo Conveyors Mr. Shekhar Ayachi Mob. 9825226102	233034	221460 220655	
13	M/s CCA Shipping Services Mr. K C Varghese	233034	221721 220655	9825225217
14	M/s Chowgule Brothers Mr. C R Soman	229227	278521 225051 232365	9825361782
15	M/s Coastline Services (India) Pvt Ltd.	221137	232095 222853	
16	M/s Container Marine Agency Pvt Ltd	234541	230026 220416	
17	M/s Conftreight Shipping Agency (India) Pvt Ltd. Mr. K T R Nair	-	233615 236157	
18	M/s Cresent Shipping Agency (India) Pvt Ltd Mr. Sanjay Salve.	224506	221290 221957	9825227311
19	M/s DBC Freight International	230832	230832 230639	

20	M/s DBC Sons (Gujarat) Pvt Ltd. Mr. R C Vazirani	270631	270263 270503	
21	M/s Depe Global Shipping Agency Pvt Ltd. Mr. Jaydeep Roy	232079	231528 233608 234582	9825228121
22	M/s Evershine Shipping Services. Mr. Kishan Motwani	234083	221588 237408	
23	M/s Forbes Gokak Ltd	231464	222634 235004	
24	M/s Freight Connection (India) Pvt Ltd	231357 270726	222247 222545 270727	
25	M/s GAC Shipping (India) Pvt Ltd. Mr. V C Rao	231429	231427 237244	9825225136
26	M/s Ganges Liners Pvt Ltd	233437	231608 233436	
27	M/s German Exp. Shipping Agency Pvt Ltd	236040	223269 236040	
28	M/s Goodrich Maritime Pvt Ltd	222875	222882 222883	
29	M/s G P Dave & Sons (Shipping)	234382	234288 234382	
30	M/s Greenways Shipping Agencies Pvt Ltd	232079	233608 234585	
31	M/s K. Shipping Services Pvt Ltd	233632	231933	
32	M/s Halar Ship & Freight Forwarders. Mr. Tejas Shrma	270224	270192 270568	9825212646
33	M/s Hind Shipping Agencies. Mr. Mahesh Vyas	234795	232710 235375	
34	M/s Hindustan Shipping Services. Mr. M D Sorathiya	239110	239110 222821	9824214994
35	M/s Interocean Shipping India Pvt Ltd. Mr. Suresh Tripathy	232579	235201 230589	9825225583
36	M/s Intra Trade Pvt Ltd. Mr. B P Vasavda	233295	233313 231255	9825226129
37	M/s Trades Shipping Pvt Ltd	231463	235572 233606	
38	M/s James Mackintosh Marine (A) Pvt Ltd. Mr. Satish Nair	270793	270792 270846	9825226077

39	M/s J MBaxi & Co. Mr. D P Mitra	270646	270630 270635 270525	9825225107
40	M/s Kutch Shipping Agency Pvt Ltd. Mr. Azad Khan	233339	221148 250226/ 7/8	
41	M/s Liladhar Passop Forwarders Pvt Ltd. Mr. S. Chakraborthy	252383	252297 252402 252288	9825020523
42	M/s Maersk (India) Ltd. Mr. Dinesh Joshi	231388	231387 236192 233963	9825270419
43	M/s Maheshwari Handling Agency Pvt Ltd. Mr. Chaggan Maheshwary	230575 234633	223228 230393	9825227111
44	M/s Maltrans Shipping Agencies India Pv Ltd.	230606	220147 230336 235022	
45	M/s Mathurdas N. & Sons Forwarders Ltd.	252221	252224 252350	
46	M/s Meridian Shipping Agency Pvt Ltd	230212	220305 230220	
47	M/s Mitsutor Shipping Agency Pvt Ltd	230411	220110	
48	M/s M M Shipping Services	235255	231385 238385	
49	M/s Modest Shipping Agency Pvt Ltd	-	230576	
50	M/s NLS Agency India Pvt Ltd. Mr. Sanjay Salve	232413	231318 220305	9825237311
51	M/s Orient Express Lines Ltd	230359	232186 232805	
52	M/s Orient Ship Agency Pvt Ltd. Mr. H G Digrani	233518	223430 223487	9824214801
53	M/s Oscar Shipping Agencies.	231812	226959/6 0 232123	
54	M/s Parekh Marine Agencies Pvt Ltd. Mr. Mitesh Dharamshi	231509	221409 235341	9825226557
55	M/s Patel Handling Agency (Capt. Kalra)- 9825062912	231143	224024 231004 221718	
56	M/s Patvolk (Mr. Shreekumar Nair)	231464	222624 235004	

57	M/s Pearl Shipping Agency. Capt. Kalra	231143	224024 221718	9825062912
58	M/s Penguin Shipping Agencies Pvt Ltd.	230606	230336 220147	
59	M/s Pestonjee Bhieajee (Kutch) Mr. R K Kewalramani	270650 270556	270221 270257 270367	9825226962
60	M/s Prudential Shipping Agencies Pvt Ltd. Mr. Siddharth Mishra	232911	230479 233982	9825226477
61	M/s P&R Nedlloyed India Pvt Ltd	232207	224906/7 232128	
62	M/s R T Bhojwani & Sons Mr. Gopichand Bhijwani	232423	223831 220839	9825225639
63	M/s Sahasu Shipping Services Pvt Ltd	236358	225224 237854	
64	M/s Sai Shipping Co. (P) Ltd Mr. S T Hingorani	231972	221369 231739	9825228681
65	M/s Samrat Shipping Co Pvt Ltd	232890	231983 222939	
66	M/s Samsara Shipping Pvt Ltd. Mr. Pranesh Rathod	233165	228602	9825225755
67	M/s Scorpio Shipping Agency	-	223085	
68	M/s SDS Shipping Pvt Ltd	231542	221326 221087	
69	M/s Seanay Shipping Pvt Ltd	270026	270788	
70	M/s Seabridge Maritime Agencies Pvt Ltd	231509	221409 221158	
71	M/s Seafreight Pvt Ltd	222850	233530 222393	
72	M/s Sealand Agencies India Pvt Ltd	230584	231179 230584	
73	M/s Seamar Shipping India	255563	-	
74	M/s Seatrade Shipping	234171	233810	
75	M/s Sentrans Maritime Pvt Ltd	236129	230002 220702	
76	M/s South India Corporation (Agencies) Ltd Mr. Antony	234416	221276 234646 231494	9825226256
77	M/s Spoonbill Maritime Agencies Pvt Ltd	234167	221049 222058 234454	
78	M/s Star International	231395	233948 232402	

79	M/s Taipan Shipping Pvt Ltd	236040	223269 227010	
80	M/s Taurus Shipping Services. Mr. Sukhveersingh	231266	221334 223074	9825227325
81	M/s Oceanic Shipping Agency Pvt Ltd	270631	270263 270503	
82	M/s TICC Container Line (Kandla) Pvt Ltd	237854	237854	
83	M/s Total Transport Systems Pvt Ltd	231463	222634	
84	M/s Transocean Shipping Agency Pvt Ltd	-	230832	
85	M/s Transworld Shipping Services India Pvt Ltd Mr. Sandeep Rajvanshi	231913	229824 221290	9825225733
86	M/s Trinity Shipping & All. Services Pvt Ltd Mr. Soly	222060	230911 223703	9825225245
87	M/s Unimarine Agencies (Gujarat). Mr. Jaikumar Ramdasani	224633	224631/ 32 223113	9825225216
88	M/s Unique Shipping Services Pvt Ltd	-	232729 232730	
89	M/s United Liner Agencies of India Pvt Ltd Capt Rakesh Kumar	236040	227779 223269	9825225741
90	M/s Universal Freight Systems	252383	252288 252297	
91	M/s Universal Shipping Services Mr. Anil Pillai	235251	230663 231708	9824215168
92	M/s Velhi P. Sons (Agencies) Pvt Ltd	255328	255327 231545	
93	M/s Vibhuti Shipping Pvt Ltd Mr. Vinod	236219	236719 230035 232424	9825226536
94	M/s Worldwide Cargo Care Pvt Ltd	231913	221290 221479	

9.18 Core Team

Asstt. Commandant-CISF, OSD (Estate), Ex. Engineer (Roads)-KPT, Executive Magistrate of State Govt. of Gujarat i.e. the Mamlatdar, Gandhidham and Police Inspector, Kandla shall jointly ensure evacuation of people from Kandla areas. The persons entrusted with the evacuation programme as indicated here below will have to report the progress in evacuation to the Dy. Secretary (E) who shall appraise all developments in this regard to Chairman and Dy. Chairman, KPT over telephone from time to time.

The Evacuation of People from different areas at Kandla shall be looked after by the officers named below.

9.18.1 Banna Fishermen Hutments

ACTION BY: Mr. R.D. Ahir, Junior Engineer, and CISF

9.18.2 Saltpans (Including Major & Minor)

ACTION BY: Mr. J K Chauhan, Asstt. Estate Manager, Mr. AB Pradhan, Labour Officer and CISF.

9.18.3 Sirva Camp & Sirva Railway Hutments

ACTION BY: OSD (Estate), Estate Inspector and CISF

9.18.4 G Type Quarters of Kandla Port Trust

ACTION BY: Mr. T.T. Mangtani, Assistant Engineer and CISF

9.18.5 New Kandla KPT Colonies, Customs & Hutments in PGVCL Land

ACTION BY: Mr. T.T. Mangtani, Assistant Engineer/Mr. Nemichand (Inspector-Vigilance) with CISF

9.18.6 Hutments near IFFCO Plant

ACTION BY: Mr. Rajesh Israni Junior Engineer and CISF

9.18.7 Cargo Jetty & Oil Jetty Areas

ACTION BY: Traffic Manager – Private Workers/ Shore Workers

AAO, CHD - CHD Workers

HOD/Dos - The Employees of their respective deptt.

The Traffic Manager/ Commandant CISF shall ensure that the Cargo/ Oil Jetties are completely evacuated and there is no fresh entry into the operational areas.

9.19 Public Announcement

The Public Announcement for faster evacuation is to be made by (a) CISF on behalf of Kandla Port Trust and (b) Police Inspector, Kandla Police Station in consultation with KPT officials.

9.20 Temporary Shelters

The Temporary Evacuation Centres (TEC) will be set up in the Gandhidham area in places like Schools/ Community centres etc as may be decided in consultation with the State Govt. Officials.

Executive Engineer (TD) will have to ensure the following;

Opening cleaning and providing water facility in the Temporary Shelters at Gandhidham in premises coming under the administrative jurisdiction of Kandla

Port that may be identified for the purpose by the Collector/Mamalatdar/concerned state govt. authority. The toilet blocks attached to these buildings are to be kept in usable condition.

Executive Engineer (Electrical) shall ensure providing of lights and continuous electric supply in the Temporary Shelters as mentioned above.

Mr. A B Pradhan, Labour Officer and the Head Master of BVM School will have to ensure opening of the School and shifting of school furniture as may be directed.

The requirement of amenities/ medical aid etc in the Temporary Evacuation Centres will be taken care of by the Executive Engineer(TD)/ (R), Senior Engineer (PL), XEN (E) and Dr. Mahesh Bapat/ Dr.(Mrs) Manju Tilwani of Medical Department.

9.21 Transport Facility

The Traffic Manager shall provide sufficient number of Trucks and Dumpers as may be requested by Dy. Secretary (E) for evacuation purpose.

The hired buses of KPT shall be deployed for evacuation. In case of additional requirement the Dy. Secretary (G) will co-ordinate with Mamlatdar, Gandhidham for obtaining sufficient number of ST Buses for evacuation purpose.

Secretary shall co-ordinate the above activities.

Ensuring the functioning of TELEPHONES

The name and telephone No. of the Officer Telephone Department to be contacted in case of any problem:

1. General Manager, Bhuj (O) 231201/231648 (R)

2. District Engineer, Bhuj (O) 525410

3. SDO (P), Gandhidham (O) 232453/229666 (R)

Dy. Secretary (Personnel) shall ensure that the telephone of all the Head of Departments and other responsible officers of different Departments are functioning properly by ringing personally. In case any of the telephones does not function or give satisfactory service, he shall take up the matter with the higher authorities immediately.

9.22 Traffic Movement

Commandant, CISF with the help of Police shall ensure that all incoming traffic to the Port is stopped except those which are coming for rescue operations and essential services at three places i.e. KASEZ Junction, Railway crossing and Kharirohar Road. He shall immediately erect two temporary tents and post sufficient number of personnel of CISF in coordination with Police, who shall identify which person has to be allowed. Commandant, CISF shall also ensure that those allowed do not cause any hindrance for those who are supposed to function as per the Internal Action Plan.

9.23 Staff Attendance

From experience it is observed that several times many officials do not turn up for work under one or the other pretext. This would be viewed very seriously. Immediately on operationalising this Action Plan, even if, it is a Public Holiday, the following staff shall report for duty. (Ref: KPT Internal Action Plan – Updated July 2010)

All Operational Staff particularly those of Floating craft Section and Power Supply Section.

All Head of Departments and all Class-I & Class-II Officers shall be present in their office timings. Besides, a list of very essential officers, who will be required to be present even beyond the normal duty hours, as and when required, shall be prepared.

All P.A.s/Stenographers/Peons of Head of Departments and Deputies.

All Office Superintendents/Superintendents (Accounts)

All Head Clerks and Divisional Accountants.

The above officials shall be present in the office, unless otherwise directed.

The Staff attendance on days when the Action Plan is in the operation shall be collected from P.A. to HODs and compiled by Asstt. Secretary (G). The daily position will be reported to Chairman/Dy. Chairman every day with separate list of absentees. Assistant Secretary (G) should ensure presence of staff by following the required action.

All Head of Departments may hold a meeting with Class-I, & Class-II and staffs and explain their functions as per the provisions of Action Plan during the Natural Calamity and submit a Compliance Report to Chairman/Dy. Chairman on priority basis.

The following officers will ensure timely supply of Drinking Water/Food Packets to the staff during the operation of the Action PLAN:

Asstt. Executive Engineer - For the staff of Traffic/Mech./Civil
(Mr. K J Todarmal & P T Bhallara) Engineering Department

Mr. P K Pandey, AFS - For the Flotilla Staff

Company Commander, CISF - CISF

Mr. K Varghese - For Fire Brigade Staff

The above officers shall be responsible for placing order for procurement of Food Packets. They should ensure that there is no shortage on this account. They shall come in to action on their own. They are also responsible for placing advance order, preparation of food packets, transportation, and distribution in time and report compliance to Secretary for the previous day.

9.24 Sanction of Advance

All Head of Departments would make a judicious assessment regarding the requirement of funds by them to meet the different exigencies, which they may have to handle on account of the Natural Calamity situation. The HoDs would inform the FA&CAO on telephone or in writing or through a messenger regarding their requirement of advances. The FA&CAO in turn would examine the advances sought by the Head of Departments and sanction the advances early without any delay. The FA&CAO would keep the Chairman and Dy. Chairman informed about the amount released by him and seeks approval.

9.25 Vehicle Pool

As soon as this Action Plan comes into force, the vehicle pool stands formed; the vehicle pool shall be controlled by Senior Engineer (Pipeline) and Senior Labour Officer. The following vehicles will be there in the Pool:

Sl No	Vehicle No.	Type of Vehicle	Name of Driver	Parking Place/Tel. No.
01	GJ-12W 1738	Ambulance	Mr. Soni/Abubakar/Dilip	Gopalpuri Hospital 220497
02	GJ-12W 1763	Ambulance	Mr. N D Parmar/Jiwa Hari/Uttam	Kandla Hospital 270005
03	GJ-12W 1730	Ambulance	POCD of Fire Brigade.	Old Kandla Fire Station 550421/271377/ 270176/270178
04	GJ-12W 1799	Ambulance	Cargo Jetty Area	270540 ATM Shipping.

9.26 Private Vehicles (Jai Samantha Travels)

Sl No	Vehicle No.	Type of Vehicle	Name of Driver	Parking Place/Tel. No.
01	GJ-12G 4881	Staff Bus	Mr. Bharat Gadhvi	Shri Mishra 9727304414
02	GJ-12W 4878	Staff Bus	Mr. Shambhu Chauhan	Shri Mishra 9727304414

Apart from the above, Senior Engineer (Pipeline) shall have vehicles from the Private Vehicle Contractors for emergency work. The list of private contractors is as shown below

9.26.1 List of Civil, Electrical & Mechanical Contractors

Sr. No	Name & Address of Contractor			
		Office	Resi	
1	Mr. Dilip Bhandbe, M/s Mukund Ltd.	223412		
2	M/s. Maheshwari Const. Co., SDX-N-5, Gandhidham-Kutch Mr. Rameshbhai	232134		
3	M/s. Apex Engineers, Bajaj Chambers, 12/B, Gandhidham – Kutch (Mr. Vishal)	222002 222223	___	9898226666
4	M/s. Gadhvi Constructions, Plot No.524, Sector – 5, Gandhidham – Kutch	235772	___	9426215258
5	M/s. Advance Builders & Contractors, B-23, Apnanagar, Gandhidham – Kutch.		232864 234242	9825255934
6	M/s. Mohan Construction Co., 415, 2/B, Adipur (Mr. Mohan)	____	264140	9825174351
7	M/s. Star Decorators, 17, Plot No.5, 12/A, National Highway, Gandhidham – Kutch (Mr. Vinod Bajaj)	221450	____	____
8	M/s. Kamal P. Chellani, DBZ-S-81-A, Gandhidham-Kutch (Mr. Kamal)	_____	_____	9825221542
9	M/s. K.K.Construction, E-71, Gujarat Housing Society, Devi Krupa, Sector –5, Gandhidham (Mr. Milanbhai)			230064
10	M/s. Mepabhai Madan, Plot No. 21/22, Sector-9, Opp. KPT Office, Gandhidham Mr. Rajubhai	222209 222210		233627
11	M/s. S. B. Singh, B-110, Sapna Nagar, Gandhidham – Kutch	239351	_____	_____
12	M/s. Dipesh Construction Co., 11, Apurva Chambers, Ganga Gate, Anjar – Kutch. (Mr. Parth) (Mr. Sukhdevbhai)	242997	243319	9824294260 9825179040

13	M/s. Raj Construction Co., Deepak Complex, Plot No.315, Ward 12/B, Gandhidham-Kutch Mr. Rajesh Makhijani	220911		
14	M/s. M. V. Rajani,444, 2/B, Matruchhaya,Rambaugh Road, Adipur – Kutch (Mr. Narayan)	260800 262920	____	9825225690
15	M/s. Bhimji Velji Sorathia, 21, Nilesh Park, Plot No.80, Sector – 8, Near New Court Building, Gandhidham – Kutch (Mr. Bhimji Velji)	231383	____	9825225948
16	M/s. Sollone & Parco Engg. Co., CCX-165, Adipur – Kutch (Mr. Ravi Solanki)	261298 263248		9825222919
17	M/s. Mahesh Construction, Plot No. 415, 2/B, Adipur- Kutch (Mr. Mahesh)	_____	264140	9825091599
18	M/s. Patel Construction Co. Zanda Chowk, Gandhidham (Mr. Tejabhai Kangad)	220421	_____	9825227199
19	M/s. M. G. Bhavnani, Plot No.102, Sector 1/A, Gandhidham – Kutch	_____	_____	9825191636
20	M/s. Patel Engineering Works, Gandhidham	231832		
21	M/s. H.M.G. Gandhidham	235710 234609		
22	M/s. Mukund Limited Mumbai	022-25347373		
23	M/s. Bajaj Electric Mumbai	022-23724192		
24	M/s. Mishra Brothers Gandhidham	221172		
25	M/s. Sonu Electricals 18, K.P.Shopping Centre, Near Jivan Bharati School, Karelibaug, Vadodara-390018 Shri Jayendrasingh.B. Thakker	0265-2464108	2647886	
26	M/s. Ravi Electronics, "Prashant", 20, New Jagnath Rajkot – 360 001 Mr. G.K.Patel	465256 460 253		

27	M/s Megha Technicals, CCX - 165, Adipur - Kutch (Mr. Ravi Solanki)	261298 263248	____	9375320232
28	M/s Maruti Construction, Gandhidham – Kutch	___	_____	9824893851
29	M/s Ramesh Meghji Sorathia, Anjar – Kutch	____	____	9825225948
30	M/s Mohit Construction, B-168, Shaktinagar, Gandhidham - Kutch	____	____	9825227072

Senior Engineer (Pipeline) should ensure the availability of the Drivers and the Vehicles and report to the Secretary. All Vehicles whether it is of KPT or hired should be parked in the location as decided by the Senior Engineer (PL) and Senior Labour Officer, from where it can be taken for immediate use as soon as the people move into action. The list of travel agencies is given below:

9.26.2 The list of Travel Agencies

Sr. No.	Name of Agency	Phone No.	
01	M/s. Rathod Tours and Travels, Gandhidham	222444	222959
02	M/s. Gayatri Tourist, plot No. 720/721, Valmikinagar, Bharatnagar, Gandhidham.		231715 230252
03	M/s. Panch Tirth Tours, BBZ-S-12, Gandhidham	232215 230760	9825234455
04	M/s. Maheshwari Travels, Plaza Centre, Shop No. 110, Ist floor, Plot No. 110, Sector No.8, Gandhidham	232211 234455	252120 253433
05	M/s. Titan Travels, Behind Shyam Electric Stores, Jhanda Chowk, Gandhidham	222832	236911
06	M/s. Rohit Enterprises, Plot No. 99, Sector No. 4, Near IOB, Gandhidham	228550 237538 237547	234140 9825225121
07	M/s. Jai Somnath Travels, Mr. Mishra		9727304414
08	M/s. Agrawal Tourists, Gandhidham	221311 220068	
09	M/s. Ashirwad Travels, Gandhidham. Shri Laxman Singh	225608 225609	9825225608
10	M/s. Krishna Travels, Gandhidham	220683 234838	
11	M/s. Shiv Tourists, Gandhidham	221454	

12	M/s. Thakker Travels, Gandhidham	225097	9825271072

9.27 Contact with Railway & GSRTC

Secretary, Dy. Secretary (G) & Dy. Secretary (P) should ensure for the smooth movement of workers/employees for which he may get in touch with the following officers of Western Railway/GSRTC and apprise them about the situation so that the movement of Staff is not suffered.

Transport	Contact Person	Telephone Nos.	
		Office	Residence
Western Railway	Area Manager	221340	236237
	Control Room	232578	
	Enquiry	131/220011	
GSRTC, Anjar	Depot Manager	241192	243746
GSRTC, Bhuj	Depot Manager	220002/220102	
GSRTC, G'dham	Depot Manager	220198	

9.28 Generator Sets

Generators of following capacities have been installed at Kandla, Gandhidham, and Gopalpuri to supply power to various installations in case of power failure:

1. **Cargo Jetty Area - 2 Nos of 1000 KVA EACH:**

These Generators can cater power inside Cargo Jetty Area, Seva Sadan-III, Nirman Building, and Old C.D.C. Building restricted up to 2000 KVA.

2. **Kandla Hospital -25 KVA**
3. **A O Building -200 KVA**
4. **Gopalpuri Hospital -45 KVA**
5. **Guest House - 25 KVA**
6. **Old Kandla Fire Brigade -5 KVA**

In addition to above, small portable generators have been provided in the following locations to cater power need in case of emergency: -

1. **Signal Station in Seva Sadan – III -5 KVA**
2. **Floating Craft Section - 1.5 KVA**
3. **ATM's Office inside Cargo Jetty -1.5 KVA**
4. **Control Room in A. O. Building -2 KVA**

In addition to above, if any additional Generator Sets are required at Kandla or Gopalpuri, the following officers shall be contacted who shall immediately hire/procure or provide in whatever manner the D.G. Sets giving preference to the operational area.

(i) Deputy Chief Mechanical Engineer
(ii) S E (Electrical)
(iii) Executive Engineer (Mechanical)
(iv) Asstt. Executive Engineer (Electrical) Shri AK Sharma

The above officers shall also be responsible for operation and maintenance of Generators provided at various locations and submits daily report to the Chief Mechanical Engineer about the working of Generators.

Additional requirement will be assessed by Dy CME/S.E (Electrical) and submitted to Chief Mechanical Engineer for approval. Necessary Fuel (POL) shall be procured and stored in advance by the concerned officials of Mechanical Engineering department.

9.29 Fire Dewatering Pumps

There are 10 Nos. of Dewatering Fire Pumps available with Fire-Cum-Safety-Officer at various points. The details of which are as under:-

Dewatering Pump	Old Kandla Fire Station	Tilak Fire Station (West Gate-I)	Azad Fire Station (West Gate -II)
Portable Fire Pump Capacity:270 LPM	04	01	01
Trailer Fire Pump Capacity:1800 LPM	-	01	01
Trailer Fire Pump Capacity:2250 LPM	02	-	-

The Portable Fire Pump single delivery having capacity of 270 litre per minute are useful for dewatering the congested places like ship holds, barges and other intricate areas.

All the above Fire Pumps will be operated by the Fire-Cum-Safety-Officer. The maintenance of major nature and breakdown will be attended by Executive Engineer (Mechanical).

Fire cum Safety Officer (O) 270176 (R) 238238 Mob: 98252-27041
Dy. Fire Officer (O) 270176/270178 (R) 226478
Station Officer (Mr. A S Christian)(O) 270176/270178
Station Officer (Mr. K. Varghese)(Mob.) 9426857040

9.30 Shipping Navigational Aid Section

Executive Engineer (Dry -dock) shall ensure that heave-up barge "Bhimsen" is shifted to Bunder area and secured properly; Mr. Monohar Dana, Assistant Engineer (Mechanical) shall attend the above work.

Steel Floating Dry Dock

Executive Engineer (Dry Dock) and Mr. Haridas Nair, AE(DD) shall ensure that the Steel Floating Dry Dock and the Electric Wharf Cranes at the maintenance jetty are properly secured as per procedure and compliance reported to Chief Mechanical Engineer and Dy. Chief Mechanical Engineer shall monitor the safety of the Steel Floating Dry Dock.

9.31 Periodical Reporting by all HODS

All Head of Departments shall have to send Action Taken Report to the Secretary / Control Rooms in writing by Fax or through telephone with regard to the action taken by them as per the Action Plan. If the report is not received from the Head of Departments, the Officer In-charge, Control Room shall obtain the information, compile it and submit the same to the Chairman / Dy. Chairman on 12 hourly basis i.e. twice a day.

9.31.1 Chief Engineer

The Chief Engineer shall ensure through Superintending Engineers that all Road Blockades are not cleared as also he should ensure that blockades caused in Port quarters due to the falling of trees, walls, sheds, etc. are got removed immediately. He will ensure that the colonies are got cleared and wherever logging of water is found, the water is pumped out and disinfected. A report shall be submitted to the Chairman / Dy. Chairman every day.

9.31.2 Chief Mechanical Engineer

Chief Mechanical Engineer, Dy. CME/S.E (E) shall ensure that all Generator Sets are properly functioning at A.O. Building, Seva Sadan-III, P&C Building, Hospitals, and Guest House. They will ensure quick restoration of Power supply arrangements by keeping close liaison with the officials of Pachim Gujarat Vija Co. Ltd. They will report to the Chairman / Dy. Chairman every day.

9.31.3 Action Plan – Land Fire Station

The Port Fire Brigade has its Head Quarter at Old Kandla Oil Jetty area with two Sub- Stations at Dry Cargo Jetty at New Kandla.

The contact Numbers are as under:

Main Station (Emergency Response Centre) - 270176, 270178, 271377

Cargo Jetty – West Gate No. 1 - 270439

Cargo Jetty – West Gate No. II - 295974

Fire cum Safety Officer - 270176 (O) / 238238 (R)/ 98252 27041(M)

Dy. FcSO - 270178(O) / 226478 (R)

9.31.4 Resources Available

Refer 4.12 to 4.14.4

In case of any fire, or other crisis an information is received through telephone - or VHF channel - Fire Station Control Room, the Duty telephone attendant raises the fire alarm bell and lights the vehicle indicating light (turn-out bell and Turn out light)

The Duty Station Officer proceeds to the scene of fire with fire Tenders and crew. Station Telephone Attendant should inform other officers like Fire-cum-Safety-Officer, Dy. Conservator and Port Control. Telephone Attendant should inform

hospital and if fire is in wharf should inform Traffic Manager. Fire cum Safety Officer after apprising the situation should inform Deputy Conservator directly or through the Telephone Attendant immediately.

9.31.5 Ensuring the Functioning of Telephones

The name and telephone No. of the Officer Telephone Department to be contacted in case of any problem:

1. General Manager, Bhuj (O) 231201/231648 (R)
2. District Engineer, Bhuj (O) 525410
3. SDO(P), Gandhidham (O) 232453/229666 (R)

Dy. Secretary (Personnel) shall ensure that the telephone of all the Head of Departments and other responsible officers of different Departments are functioning properly by ringing personally. In case any of the telephones does not function or give satisfactory service, he shall take up the matter with the higher authorities immediately.

9.32 Accidents in the Channel

9.32.1 Fire on Board Tanker / Anchor / OTB

The Ship Master - Pilot should raise & alarm and inform Kandla Tower on VHF Channel 8 or 16 about the intensity and location of fire.

Kandla Tower will inform the Dy. Conservator, Harbour Master and FCSO.

Master should immediately ensure that the loading/discharging operation is suspended and all the connected valves are closed.

Master of the vessel should immediately gear up his firefighting equipment and post his staff for extinguishing the fire. CO_2 should be injected in the affected compartments.

Dy. Conservator after contacting the ship will inform Chairman and Dy. Chairman about the situation.

Harbour Master, will arrange for availability of chemical dispersant and its equipments and keep them in readiness in case of any oil spillage.

Fire float, with personnel and equipments should immediately start for tanker. Harbour Master on board 35 Ton B. P. Tug also to reach the tanker.

Dy. Conservator to remain in constant touch with the Master/Pilot of the Tanker to assess the situation.

In case no power is available on deck, the floating hoses connected on board can be disconnected by means of mechanical puller. Hose can be heated up slightly and the weight can be taken off. The Special Clamps on the flange can be removed. This operation takes about 20 Meters for each hose.

If it found necessary to safeguard jetty and the tanker is required to be removed from the jetty, one tug should remain near to tow the tanker and when given orders

should pick up the fire spring and take the weight off the moorings. Master and the Pilot should take due precautions and safety measures and by using Fireman's suits to send the personnel to forward of the vessel for unmooring the tanker. Two lines to be passed on to the Tug for towing to a safe anchorage. In case, the magnitude of fire is more and beyond the control, other agencies such as Indian Coast Guard, ONGC to be called for assistance.

9.32.2 Grounding of a Tanker

Master or Pilot of the vessel should immediately contact Kandla Tower on VHF Channel 8 or 16 and give the detailed information and the seriousness of grounding. Kandla Tower Signal Station will in turn inform Traffic Manager, Dy. Conservator and Harbour Master, Kandla Port Trust. Dy. Conservator will inform Chairman/Dy. Chairman.

Harbour Master will immediately proceed to site and will immediately board the vessel and after assessing the situation will inform Dy. Conservator about the seriousness of the crisis.

Dy. Conservator in the meantime will remain at Kandla Tower and will be in constant touch with the vessel and if required give necessary guidance to Master/Pilot.

Dy. Conservator to direct Sr. Hydrographic Surveyor to proceed to grounded vessel and check the exact position of the ship and also the grounding around.

Tugs and Launches available at Kandla should remain in readiness and wait for the order of action from Dy. Conservator /Harbour Master.

Fire Float "AGNISHANTI" to be also kept in readiness. Fire-Cum-Safety-Officer along with staff and equipment salvage pumps etc to remain on board fire float.

Master of vessel to obtain soundings of all the tanks and to maintain a record of the same to ensure any leakage. He should also take hand lead surroundings around the ship and plot them on the chart.

Master should inform his Chief Engineer to change over to high sea suction for cooling water.

If found necessary, Dy. Conservator can decide and ask for a small tanker/salvage tug which can be brought alongside of the grounded ship and part of cargo can be discharged to this daughter ship. This will help to lighten the grounded ship.

Master should instruct his staff to prepare all her ropes including insurance wire for towing, pulling operation.

Tug MEHUL / MEKAN / KALINGA to immediately to proceed to grounded vessel and take towlines and start pulling the vessel under the instruction of Harbour Master. If required, Dy. Conservator can decide and send more than one Tug also to the grounded ship for assistance. In case the vessel cannot be re-floated within a day, a navigational warning should be sent to the Chief Hydrographer, Dehradun and the same will be transmitted through Mumbai Radio and Navtex.

9.32.3 Breaking / Ground of a Ship outside Kandla Port Limit

Kandla Port has not had any major incident of grounding/sinking or breaking of a ship in recent past. However, minor incidence of grounding could be tackled by Port's own personnel and equipments.

If there is any major breaking or grounding of a ship outside the limits of Kandla Port, the Port can activate its own crisis management plan to deal with the situation. On receiving message from the Master of the Vessel/ or from Principal-Officer, MMD or Coast Guard, Mumbai, Dy. Conservator/Harbour Master, KPT will immediately inform Chairman/Dy. Chairman, Kandla Port Trust.

Harbour Master will instruct Flotilla Superintendent/Tug Master, Fire-Cum-Safety-Officer to keep the tugs, launches in readiness. Crafts with chemical dispersant spraying system at Kandla and Vadinar should rig the booms etc, Store enough stock of chemical dispersant and stay in readiness. In case, there is any major oil spillage port to activate its oil spill crisis management plan.
Port Signal Station to be made Control Room and to remain in constant touch with the Ship. Master should immediately send messages and inform nearest Port or Coast Guard about the latest situation of the Ship.

Port command team headed by Dy. Conservator will mobilize the resources available with Port to help the Ship.

Indian Coast Guard, to utilize the services of Helicopter and indicate the location and magnitude of the oil spill. They should keep the nearest port informed about the oil spill/sleek.

If the oil sleek is dangerous/approaching the limits of Kandla Port Trust, the Harbour Master along with one Senior Pilot and Safety Inspector (antipollution Scheme) to proceed on chemical dispersant Spraying craft and to reach oil sleek and under his guidance all available port crafts can spray chemical dispersant. They can go up & down and try to stop/minimize the oil sleek danger to port, Harbour Master to keep Dy. Conservator informed about the situation.

Indian Coast Guard, IOC, ONGC and other agencies who have the system to recover the floating oil should he directed with oil recovery vessel to the area.

If it is necessary, Dy. Conservator can requisition a privately owned small tanker or tank barge, which can recover the oil, store it fro-eventual disposal ashore. If the oil sleek is very large and beyond the control of the Port, the Chairman should inform the Ministry and seek their guidance for mobilizing equipments from outside Parties.

9.33 Contingency plans in grave situation

Immediately on the occurrence of a crisis, the local Internal Action Plan under the Disaster Management Act, 2005 would be put into effect by the local/District and the state authorities. If the situation has wider ramifications and warrants response at the State/National level, the Chairman/ Deputy Chairman will contact the Nodal Ministry of the State / Central Government and seek the required help. The concerned authorities would activate its control room, call for a meeting of the Crisis

Management Group and put into operation its contingency Plan.

9.33.1 First Information

As and when a critical crisis situation develops, the first information would be sent by the Chairman/Deputy Chairman to the State/Central Nodal Ministry through Wireless/Cellular Mobile Phone/Fax/e-mail or any other quickest possible means.

Security measures at Vital Installations are inspected by I.B. periodically. The Deputy Conservator and Traffic Manager shall implement the recommendations of I.B. with the help of CISF, made from time to time for beefing up/strengthening the security at important vital installations.

9.33.2 Authorities responsible for sending of First Information

Crisis	Authorities responsible for reporting	Remarks
Natural Disasters	District Magistrate or District Collector Indian Meteorological Department State/Central Water Commission	Information relating to forecasting/warning of the natural calamity will be sent by the IMD, State/Central Water Commission to the Relief Commissioner as laid down in the contingency Action Plan of the State/Central Ministry.
Chemical/Biological Disasters	Chairman / Deputy Chairman	The Chief of the Public Sector/Undertakings would be equally responsible to send the first information through his channel to the Nodal Ministry.
Major Disaster having off-site implications	Chairman/Deputy Chairman	
Break-down in Power Generation/Supply	Chief Mechanical Engineer and Executive Engineer (Electrical) through Gujarat Electricity Board Authority.	
An Oil Installation	Chief or In-charge of the Oil Installation through his channel to the Nodal Ministry.	

Hijack of an Indian Merchant ship or Indian Crew in a Foreign ship	Chairman/Deputy Chairman	Commandant of CISF, Traffic Manager, Deputy Conservator would inform to Chairman/Deputy Chairman immediately.

9.33.3 List of Members / Alternate Members of the National Crises Management Committee (NCMC)

Mr. Madhukar Gupta Home Secretary Ministry of Home Affairs Telephone (O) 23092989 / 23093031 (R) 24621234 RAX (O) 2235 (R) 2928 FAX 23093003 Mobile No. 9818745550	Mr. U. N. Panjiar Secretary (Border Management) Ministry of Home Affairs Telephone (O) 23092440 / 23092717 (R) 26876970 RAX (O) 3654 (R) 3781 FAX 23092717
Mr. Shekhar Dutt Defense Secretary Telephone (O) 23012380 (R) 23014489 RAX (O) 2225 (R) 3188 FAX 23010044 Mobile No. 9810222250	Mr. Akhil Kumar Jain Special Secretary, MoD Telephone (O) 23017678 (R) 23386511 RAX (O) 2030 (R) 2906 FAX 23019658 Mobile No. 9811755335
Mr. N. C. Padhi Secretary (Security) Cabinet Secretariat Telephone (O) 23094382 (R) 26255169 RAX (O) 2351 (R) 2743 FAX 23094227 Mobile No. 9810105618	Mr. Vijai Sharma Additional Secretary Cabinet Secretariat Telephone (O) 23012697 (R) 26883988 RAX (O) 2285 (R) 2968 FAX 23012095 Mobile No. 9891711122

Mr. L. K. Ponappa Deputy NSA National Security Council Secretariat Telephone (O) 23345287 (R) 23070811 RAX (O) 2263 (R) 3236 FAX 23742811	Mr. Rahul Dua Director (Security) Cabinet Secretariat Telephone (O) 23093648 (R) 25671048 Mobile No. 9818574333
Mr. P. C. Haldar Director I.B. Telephone (O) 23093330 / 23094897 / 23092892 (R) 23012252 / 23012161 RAX (O) 2259 (R) 2437 FAX 23092410	Mr. S. D. Pradhan Chairman, JIC National Security Council Secretariat Telephone (O) 23349314 (R) 23070505 RAX (O) 2848 (R) 2799 FAX 23349314 Mobile No. 9810008798
Mr. Ashok Chaturvedi Secretary (R) Cabinet Secretariat Telephone (O) 23796470 / 23796647 (R) 23017524 RAX (O) 2566 (R) 3416 FAX 23796462 Mobile No. 9811314982	Mr. Rajiv Mathur Special Director, IB Telephone (O) 23093492 (tele-fax) (R) 24673573 RAX (O) 2734 (R) 2933
Mr. Amber Sen Special Secretary Cabinet Secretariat Telephone (O) 23796453 (R) 24601030 RAX (O) 2562 (R) 3496	

10 PRESS MANAGEMENT

A Cell shall be created and headed by TP&PRO. The following staff member shall remain in the Press Cell.

(1) Dy. Secretary. (P) (2) PRA (3) Sr. Clerk (BDC) (4) Photographer

The Press Room shall come into operation immediately in the chamber of BDC. The Press Cell shall issue Daily Bulletin at 2:00pm and 07:00pm every day. The photographer should collect photos and develop every day, which will depict the situation as well as the work done by the Officers. P.R.A will accompany the photographer and bring the photos to the Cell every evening. He shall also bring daily Paper cuttings of reports. All Media people, Press, Journalists, etc. shall be attended to by the Dy. Secretary (P).

BDC Section will hire videographers and keep them standby for videography. They will accompany Chairman and Dy. Chairman also. One videographer will be placed at Kandla and another at Gandhidham. Similarly, BDC section will also ensure to keep one additional photographer at Kandla for taking photographs and these people should be hired as soon as Signal No. 5 is hoisted.

Secretary will be the overall In-charge of Liaison work with the Central / State Government officials / IMD, Ahmadabad / Pune Laboratory / Delhi Laboratory in which he can take the help of Dy. Secretary (P), Assistant Secretary (P) and report the matter to Chairman / Dy. Chairman immediately. They shall remain present in all the meetings relating to the Action Plan and report the proceedings of the Meeting to the Chairman/Dy. Chairman. They shall also communicate the action to be taken to the concerned Head of Departments. List of IMD Telephone is given below:

10.1 Important Telephone Numbers of Indian Meteorological Department

Designation	Address	Office	Resi.	Fax
Director General	Mausam Bhavan, Lodi Road, New Delhi.	011-24611842	011-24633692	011-24611792
D.D.G.M. (C.W)	-do -	011-24611068		011-24619167
D.D.G.M. (WF)	Met Office, Simla Office, Pune	020-25535886	020-25884104	020-24623210 25893330 25535201
D.D.G.M.	RC Colaba, Mumbai	022-22150517	22150417	
Director (ACWC)	-do-	022-22150405	022-22150452	

Director (I/c)	Met Center Ahmadabad	079-22865012 22865165		079-22865449 22865012 22861413
Met I/C	MET Centre, Ahmadabad	22861413		
Duty Officer		22865012		
Meteorologist	Ahmadabad	22861413		

Websites - www.imd.emet.in. www.imdmumbai.gov.in

10.2 List of Journalists

Sl. No.	New Service/Org.	Address	Tel. Nos.	Fax/e-mail
01	Kutch Mitra, Gandhidham	Mr. Adwait Anjaria, Umiya Mahal, OSLO, Gandhidham	222930	222930
02	Pandya News Agency, Gandhidham	Mr. Jagdish Pandya, Main Bazaar, Gandhidham	220212 238112 238212	221412
03	Chanchal, Bhuj	Mr. Jayendra Upadhyay, Nr. Bhaveshvar Mahadev Temple, Lal Teri Bhuj.	912-252942/3/44 252944(R)	912-252945
04	Kutch Uday, Gandhidham	Mr. Gangaram Bhanushali, Plot No. 287, Sector 1/A, Near Gayatri Mandir, Gandhidham	235851 223146	231267 239887 kutchuday@wilnetonline.Net
05	Gujarat Samachar	Mr. Suryakant MEhta, P.B. No. 619, Millpala, Rajkot	95281-2226954 2227303	95281-224934
06	Indian Express, Rajkot	Gymkhana Complex, 1st Floor, Nr. Gaisford Cinema, Rajkot	95281-2481156/58	95281-2240553
	Ahmadabad	4th Floor, Sanidhya Building, Ashram Road, Ahmadabad	079-6575756 079-6575796	079-6575826
07	UNI, Ahmadabad	Mr. K. J. Alexander, Senior Reporter, Sakar-2, B/11, Ellis Bridge, Ashram Road, Ahmadabad	079-6576931	079-6579658 uniandreporter@rediff.com
08	Sandesh, Rajkot	Mr. Ramesh Godasrra, Satish,	95281-2446627	95281-2477909

		Bhavan, Sadar, Rajkot	95281-2448306 95281-2447641	
09	Sandesh, Ahmadabad	Mr. Falgun Patel, Sandesh Bhavan, Vastrapur, Ahmadabad	079-6762952 079-6765480/3	079-6762952 sandesh@an1. vsnl.net.in
10	Exim Newsletter	Shri P.G. Nair, Plot No. 332, Ward 12/C, Gandhidham	234194 224971	224379
11	Daily Shipping Times, Gandhidham	Shri Haresh Manji, Sector-1/A, Popular Plaza Building, Above Kutch Kala Shop, Gandhidham	222665	222933 dstnews@bom3. vsnl.net. in
12	The Time of India, Rajkot	Mr. Sudhir Vyas, Sterling Apartments, Jawahar Road, Rajkot	95281-2226965 2227490	95281-2227238
13	The Times of India, Ahmadabad	Mr. Kind Shuknang, Fadia Chambers, 139, 1st floor, Ashram Road, Ahmadabad	079-6582151/55 079-6583137	079-6587741 ahmedit@hotma il.com
14	Information Deptt., Bhuj	Dy. Director, Multipurpose Building, Bhuj	224859 224576	250954
15	Hindustan Times, Ahmadabad	50, 5th Floor, Srikrishna Centre, Mithakali, Ahmadabad	079-6560049 079-6560061	079-6560037
16	Reuters, Ahmadabad	Mr. Thomas Kutty, 540, Satkar Complex, C. G. Road, Ahmadabad	079-6469162 9825095002	079-646161 thomasktty.abr ahama@reuters. com
17	Press Trust of India, Ahmadabad.	Mr. Anand Kumar MR. Khan	079-6431128	079-6430471

11 DEPARTMENT WISE ACTION PLAN

11.1 General Administration Department

The overall in charge for setting up control room at Gandhidham will be the Secretary. He shall ensure setting up the control room at AO Building within two hours of warning and the matter reported to the Chairman/Dy. Chairman. Two telephones should be kept in the control room, one for receiving and the other for outward calls. Tel. No. 238055 will be used for incoming calls and 239055 for outgoing calls.

Labour Officer (Mr. Pradhan), and the Head Masters of BVM School shall reach and open the schools/community hall etc, and keep them ready for accommodating the shifted people.

The OSD (Estate), Land Section and Mr. J. K. Chauhan, Asstt. Estate Manager should ring up major salt leaseholders and advising them to evacuate their labourers and report the action to the Chairman within two hours. Action taken should be confirmed in writing thereafter, Mr.Sureshkumar.M, Dy. Secretary (E) will guide them and will do the overall supervision of this job.

Librarian shall ring up all the private/public sector companies of the area and inform them about their situation and tell them to evacuate their people and take necessary steps. **List of private/public sector companies is as shown in Point No: 9.17.3.2**

Senior Labour Officer, Labour Officer along with Executive Engineer (R) and Headmasters of BVM School shall ensure that temporary evacuation centers are established in the school/community center of Gandhidham-Kandla area.

11.1.1 List of Schools in Gandhidham – Kandla Complex

Sr. No.	Name of School	Contact Person	Telephone No.
1	Dr. C. G. High School	Principal	220271
2	SVP Gujarat Vidhyalaya	Principal	220242
3	M.P. Patel Kanya Vidhyalaya	Principal	220705
4	Adarsh Maha Vidhyalaya	Principal	234172
5	Adarsh Kanya Vidhyalaya	Principal	220175
6	Bhartiya Vidhya Mandir, Kandla Bhartiya Vidhya Mandir, Gopalpuri	Head Master Head Master	271049 233684
7	Central School, (IFFCO)	Principal	221288
8	Central School (Railway)	Principal	220657
9	Modern School	Principal	220284
10	Mount Carmel School	Principal	234262
11	Aum Vidhyalaya, IFFCO	Principal	221104
12	Saint Xavier's School, Adipur	Principal	260265
13	Maitri Maha Vidhyala, Adipur	Principal	260445
14	Maitri Kanya Vidhyalaya, Adipur	Principal	260612

15	Model Excelsior High School, Adipur	Principal	260707
16	Gujarat Vidhyalaya, Adipur	Principal	261312
17	Nagarpalika High School, Anjar	Principal	242510
18	Adarsh Nivasi School, Gandhidham	Principal	223246
19	P.N.Amersey School	Principal	223646
20	Shree Gurunanak English School	Principal	238421
21	Swaminarayan Gurukul	Principal	228098
22	Kairali English School	Principal	221050
23	Sarvodaya Pradhamic Shala Near Oslo Cinema, Gandhidham	Mr. Kangodia	227958
24	Ganeshnagar Pr.Shala, G'nagar	Mr. Kangodia	
25	Jagjivan Pra. Shala, Sapnanagar, Gandhidham	Mr. Kangodia	
26	Cargo Pra. Shala, Sapnanagar, Gandhidham	Mr. Kangodia	
27	Old & New Sunderpuri Schools	Mr. Srimali, HM	224867
28	G'dham Pr. Shala, Near Shivaji Park, Gandhidham	Mrs. Arunaben.	229255
29	Adipur Prathmic Shala, Adipur	Mr.C.M.Rami	264525 264181
30	Kandla Pr. Shala, Shirva Camp & Thermal Colony & United Salt Works	Mrs. Shantaben	253198

Dy. Secretary (P) shall ensure that the telephone of all the Head of Departments and other responsible officers of different Department are functioning properly by ringing personally. In case of any of the telephone does not function or gives satisfactory service; he shall take up the matter with the Higher Authority of Telephone Department.

The staff attendance on days when the Action Plan is in operation shall be collected from PA to HoDs and complied by Asstt. Secretary and reported to Chairman/Dy. Chairman every day with separate list of absentees. Secretary will do the overall supervision of the work and report compliance to the Chairman/Dy. Chairman within two hours of the warning received.

Secretary will be the overall in charge for liaison work with central/state government officials/IMD, Ahmadabad/Pune Laboratory/ Delhi Laboratory in which he can take the help of Dy. Secretary (P) and Dy. Hydraulic Engineer and report the matter to the Chairman/Dy. Chairman immediately. They shall remain present in all the meetings relating to the Action Plan and report the proceedings of the meetings to the Chairman/Dy. Chairman. They shall also communicate the action to be taken to the concerned Head of Departments. List of IMD telephone numbers is shown below:

11.1.2 List of Important Telephone Nos of Indian Meteorological Department

Designation	Address	Office	Resi.	Fax

Director General	Mausam Bhavan, Lodi Road, New Delhi.	011-24611842	011-24633692	011-24611792
D.D.G.M. (C.W)	-do -	011-24611068		011-24619167
D.D.G.M. (WF)	Met Office, Simla Office, Pune	020-25535886	020-25884104	020-24623210 25893330 25535201
D.D.G.M.	RC Colaba, Mumbai	022-2215051	22150417	
Director (ACWC)	-do-	022-22150405	022-22150452	
Director (I/c)	Met Center Ahmadabad	079-22865012 22865165		079-22865449 22865012 22861413
Met I/C	MET Centre, Ahmadabad	22861413		
Duty Officer		22865012		
Meteorologist	Ahmadabad	22861413		

Websites – www.imd.emet.in, www.imdmumbai.gov.in

All Head of Department shall have to send Action taken report to the Secretary/Control rooms in writing by fax or on telephone with regard to the action required of them as per the Action Plan. If the report is not received from any of the HoDs, the Officer In charge, Control Room shall obtain the information, compile it and submit the same to the Chairman/Dy. Chairman on 12 hourly bases i.e. twice a day.

11.2 Contacts of Officials of GAD

Sr. No.	Designation	Present incumbent	Contact Telephone Numbers		
			Office	Res	Mobile
01	Secretary	Capt. B. Tewari	233172 220167	231939	9825227035
02	Deputy Secretary(G)	V.Murlidharan	221375	236990	9825505969
03	Sr. Deputy Secretary (P)	Md.Feroz Hussain	231854	234730	9825227480
04	Asst. Secretary	Joy Mathew	221679	234691	
05	Asst. Secretary	D.V.Parmar	220051		9426789667
06.	Asst. Secretary	L.M. Chavda	220010	252994	9427266905
07.	Sr. Labour Officer	Y.K. Singh	223828	228584	9825227079
08.	Labour Officer	A.B. Pradhan	223828	238643	

09.	TR &PRO	Sanjay Bhaty	238055	222055	9825227039
10.	Labour Officer	Abbas Patel	223828	221641	
11.	Librarian	A.B. Dave	221233	234433	

11.3 Duty Roster for Staff of General Administrative Department

Sl. No.	Name	Tel Office	Tel Resi	Mobile
01	Mr. Pulli S. Rao, Steno	220416		
02	Mr. Umesh Lalwani, Assistant	220010	261803	9426737761
03	Mr. Purshotam B., Assistant	220010	263833	
04	Mr. N.K. Raba, Senior Clerk	220010	228623	9426737760
05	Mr. Jacob Thomas, Sr. Clerk	220010		
06	Mr. Kalpeshsingh Rao, Senior Clerk	220010		9427407370
07	Mr. Kamalesh S Bajaj, Senior Clerk	220010		9825241998
08	Mr. Haresh Gulrajani, Junior Clerk	220010	225813	
09	Mr. R.V.Jadeja, LWA	270872		

11.4 Central Industrial Security Force (CIF)

The Sr. Commandant shall remain in contact with in charge of control room at Kandla (Capt. T. Srinivas) regarding the position of the cyclone / calamity.

The Sr. Commandant shall ensure that Public Address System is fitted on Jeeps provided to CISF. He will make arrangements for announcements, with the coordination of police through Public Address System mounted on at least 03 vehicles. The CISF personnel will procure truck with the help of TM. The list of fleet owners and major lift operators are given below:

11.4.1 List of Major Heavy Lift Operators at KPT

Name of Party	Name of Contact Person	Phone Number
Swastik Heavy Lifters	Mr. Jigneshbhai Mr. Aslambhai	9825758151 9825228421
Kutch Carrier Transport Co	Mr. C. R. Thackar	9825225591
Agarwal Handling Agency	Mr. Rakesh Thackar	9426928728
Active Cargo Movers	Mr. Narendra	9825220411
Raghuvirsingh & Sons	Mr. Harcharan	9879104853
Thacker Brothers	Mr. Kamleshbhai	9825296107
Kiran Roadlines	Mr. Pankaj Gadvi	9879104552
Regal Shipping	Mr. Ashok Dudi	9825326328

Rathore Freight Carriers		220759/ 220380

11.4.1.1 Additional list of firms for pay loaders / cranes

M/s Mahalaxmi Transport Co., Plot No. 35, Sector No. 8, Behind Hotel Fun & Food, Gandhidham	Mr. H K Rathod	(O)222387 (R)233500
M/s Kandla Earth Mover, DBZ-S-151, Gandhidham	Mr. Sanjay Goyal	(O)221759 (R)222338 (M) 9825020550
Mr. Lalji Bhavanji Sathwara, Laljibhai Sathwara, Plot No. 27, Shop No.5, Sector-9/A, Gandhidham		(O)234118 (R)232566 (M) 9825225957

11.4.1.2 Equipments available with ABGKCTL

Sr. No	Type of Equipment / Quantity	ID. No
01	Reach Stacker - - 4 Nos	GJ 12 AN 514 GJ 12 AN 516 GJ 12 AN 517 GJ 12 AN 518
02	Hydra Crane - 1 No	GJ 12 AN 515
03	AMW Truck - 18 Nos	PM 01 TOPM 18
04	RTG Cranes - 04 Nos	

11.4.2 List of Fleet Owners at KPT

Sl. No.	Name of Company	Contact Person	Tel. Office	Tel. Resi.	Mobile
01	M/s A V Joshi & Company	Mr. Ramesh Singhvi Mr. Thacker MR. Harshandhu	231386 232605 233147	234176 221451 234325	98251 91325 98252 26105 98252 26013
02	M/s Rishi Shipping	Mr. B. K. Manshukhani Mr. Manoj Manshukhani	220843 229830 238943	234889 235587	98252 25170
03	M/s Maheshwari Handling Agency	Mr. C. P. Maheshwari Mr. Chandan Maheshwari	223228 230393	222339	98252 27111
04	M/s ABC	Mr. Latif Mr. Mithu Mr. Kasam	220483 221390 270190	234163 231477 251684	98252 26707
05	M/s Ganesh Transport	Mr. Hira Rabari Mr. Visa Rabari	223638 223915	260425	
06	M/s Kewar Carrier		220483 227553	234163	

07	M/s Krishna Transport Service	Mr. K. M. Thakker Mr. Pankaj Thacker	223814 224938	220998 234988	98250 19699 98252 25228
08	M/s Gautam Freight Ltd	Mr. Ramesh Singhvi	220163 230345	230328 234176	98251 91325

11.5 Contact Nos of CISF Officials

S. No	Designation	Present incumbent	Contact Telephone Numbers		
			Office	Res	Mobile
01	Commandant	K.K. Dutta	271037	229140	9825227282
02	Dy. Commandant	R.P. Kaushik	271036	220192	9825227045
03	Asst. Commandant	M. Kannaian	270440	271041	8000954482
04	Control Room		271040		
05	North Gate		270440		
06.	West Gate – I		271039		
07.	West Gate II		270876		

11.6 Finance Department

As soon as the Calamity/Cyclone warning Signal No. 5 is hoisted the Dy. Director (EDP) should monitor it through Internet and give two hourly printouts to Dy. Conservator, Secretary, Chief Engineer, FA&CAO, Dy. Chairman and Chairman. And Dy. Director (EDP) will monitor the website in the A O Building, Gandhidham.

Mr. Ajay Gupta, DD (EDP) along with Dy. Hydraulic Engineer will monitor the weather report through website at Kandla and Mr. Ramesh Sorathia and Mr. Kishore Chavda, JSA (Met) will assist them and send the daily bulletin to Harbour Master, Traffic Manager, Chief Mechanical Engineer, Executive Engineer (Harbour) and Senior Commandant, CISF.

All Head of Departments would make a judicious assessment regarding the requirement of funds by them to meet with the different exigencies, which they may have to handle on account of the Cyclone/Calamity situation. The Head of Departments would inform the FA&CAO on telephone or in writing or through a Messenger regarding the requirement of advances. The FA&CAO in turn would examine the advances sought by the Head of Departments and sanction the advances early without any further delay. The FA&CAO would keep the Chairman and Dy. Chairman informed about the amount released by him and seeks approval.

11.7 Medical Department

Two Casualty Emergency Wards, one at Gopalpuri and other at Kandla Hospital shall start functioning as soon as warning of Cyclone is received. Chief Medical Officer will ensure that no Doctor is given leave during the emergency period. These

casualty emergency wards will function round the clock with posting of Doctors and Staff round the clock. Chief Medical Officer will ensure the functioning of casualty emergency wards at Gopalpuri and Kandla. A Register shall be maintained at both the places where in the record of patients attended would be maintained. Adequate number of chlorine pills should be distributed after Cyclone to avoid epidemic from spreading. Chief Medical Officer shall submit a report every evening to Chairman/Dy. Chairman.

11.8 During Disaster

1. Maximum alertness of staff members for their safety.
2. Ambulances/vehicles with Drivers to be kept standby awaiting further orders.
3. Liaison with: - Control Room, Disaster Site/Spot, P.A.s to all HoDs, New Kandla Hospital.

(Action: P.A. to CMO)

11.9 Post Disaster Phase

11.9.1 Tackling of Patients

1. Use of ambulance will be purely on priority basis. The A.C. Ambulance can be used as an Emergency Mobile Van for carrying medicines along with a doctor and other essential Para-medical staff, to the site of crisis.

(Action: Dr. Sunil Suryavanshi)

2. Line of treatment to be decided by attending Doctors, such as Indoor/Outdoor/Under observation etc.

(Action: All Doctors)

3. Cases will be attended depending upon the gravity of injury/condition of case, i.e. very serious, stable.

(Action: All Doctors)

4. To ensure supply of adequate medicines and any other items.

(Action: AMO Stores / S P S K)

5. Dead bodies to be shifted to Govt. Hospital, Rambaug promptly for identification, disposal, and issue of death certificate etc.

(Action: Mamlatdar/PSI/Medical Supdt. Rambaug Hospital/PA to CMO)

6. If needed be, liaison with local Medical Practitioners, Local Hospitals, etc.

(Action: P. A. to CMO.)

7. If need be, to arrange for outside ambulance, in consultation with FA&CAO to whom details have been submitted earlier.

(Action: P. A. to CMO.)

8. Transfer of serious patients to Govt. Hospital, Bhuj/ Rajkot/ Jamnagar be made but such transfer to be restricted.

(Action: All Doctors on approval by CMO)

9. To mobilize additional nursing /Para-medical staff to cope with additional workload.

(Action: Dr. AK. Tilwani, Physician)

10. Re-deployment of Manpower from Gopalpuri Port Hospital to Kandla Hospital and vice versa.

(Action: C.M.O.)

11.10 Prevention of Epidemics

1. Chlorination of drinking water at source.

(Action: Sr. Engr. (P/L) & Estate office In-charge)

2. Mass Survey of residents of Port Colonies at Kandla and adjoining areas.

(Action: Dr. Malik & Volunteers)

3. To get chlorine tablets from DHO-Bhuj and arrange for distribution thereof.

(Action: Dr. S. B. Suryawanshi and Volunteers)

4. To educate residents/public to promote hygienic condition in and around their dwelling place, use boiled water

(Action: Dr. {Mrs.} Manju A. Tilwani, Dy C.M.O. and Volunteers)

5. To shift cases afflicted by contagious or infectious diseases to Govt. Hospital and notify such cases to the notice of State Authorities.

(Action: Dr. A. K Tilwani, Dy C.M.O.)

6. To ensure hygienic condition/cleanliness in both hospitals and colony in coordination with concerned staff of respective Estate Office.

(Action: Dr. Suryavanshi & Dr.Malik with in charges of respective Estate Officers)

7. In Rehabilitation Centre, Medical care will be looked after by Dr. Mahesh P Bapat & Dr. A. J. Chellani besides supply of Chlorine Tablets.

8. To provide on the spot medical-aid at New/Old Kandla Port colonies.

(Action: SMO In charge (Dr. A. J. Chellani)

9. Antidotes of all the poisonous gases to be kept ready.

(Action: Dr. Tiwani, S.M.O. (P)/Safety Officers/Dr. A. J. Chellani)

10. Any further actions depending upon the conditions and restoration in the matter being decided by Administration.

11. Re-deployment on services as mentioned before.

12. In life threatening condition of Staff members - their evacuation.

11.11 Marine Department

As soon as warning of Cyclone Signal No. 5 or above is received, following measures shall be taken:

- Setting up of Control Room at Signal Station.
- Pilots and other Supervisory personnel in Flotilla Section should reach Kandla even if they are on leave, to tackle emergency, if any.

- Evacuation of Ships and securing all Port Crafts at Shortest possible time.
- No leave shall be granted to Pilots, Flotilla Superintendent, Fire-Cum-Safety-Officer, 2nd Officer, BS, AFS and similar other supervisory staff.
- Essential Staff (Fire Brigade) will not be given any kind of leave.
- The following personnel of Marine Department will not be granted any leave and they shall report for duty including holidays, during such time when Action Plan is put into operation.

  ⇒ All Operational Staff in Flotilla Section and Signal Station.

  ⇒ Ministerial Personnel at Point No: 11.11.1 apart from P. A.

11.11.1 Particulars of the Action Plan Committee Members

Sl No	Name	Designation.	Telephone Nos.			
			Office	Resi.	Fax	Mobile
1	Mr. P.D. Vaghela	Chairman	233001 234601	233002	235982	9825327760
2	Mr.M.A.Bhaskaracchar	Dy. Chairman	234121 236323	234113 236346	236323	9825227037
3		FA&CAO	220047	228819	233174	9825227914
4	Mr. R S Singh	Deputy FA&CAO	220543	239250		9825351107
5	Mr.N.B.V Ramana Rao	Sr. DD(EDP)	239623	234116		9825505620
6	Capt. B. Tewari	Secretary	233172 220146	231939	233172	9825227035
7	Mr. Muralidharan.V	Dy. Secy (G)	221375	236990		9825505969
8	Mr. Md. Feroz Hussain	Sr Dy. Secy (P)	231854	234730		9825227480
9	Mr. Joy Mathew	A. Secy (G)	221679	234691		
10	Mr. B.H. Gehani	XEN (T.D)	223912	235683		9825225963
11	Mr. Y K Singh	S.L.O.	223828	228584		9825227079
12	Mr. H C Vankatesh	Traffic Manager	270625 270246	235100	270475	9825227076
13	Mr. M. S. Balani	Sr. Dy TM	270270	263006		9825227047
14	Capt H. K. Sibal	Deputy Conservator	233585 220235	232806	233585	9825227043
15	Capt. T. Srinivas	Harbour Master	270201	234427		9825232982

16	Mr. M.R.Tilakan	Dy.Hydl. Engr	270277	227927		9825227201
17	Mr. I D Bhagchandani	Flotilla Supdt.	270280	220805		9825289204
18	Mr. A. J. Maheshwari	FCSO	270176 270178	238238	270176	9825227041
19	Mr. R. Murugadoss	Chief Engineer	233192		220050	9825226944
20	Shri S.K. Das	Addl CME	270426			9825235196
20	Mr. B G Somaiya	Supdt. Engineer (P)	233569			9825325390
21	Mr. M N Tewani	Exe Eng (R)	236165	222056		9825706255
22	Mr. C M Manwar	SE (PL)	220013	226153		9825225962
23	Mr. N M Parmar	S E (H)	270429	252624		9825227046
24	Mr. B. Rajendra Prasad	Exe Eng (D)	220038	232880		9725338260
25	Mr. N.M. Borwankar	CME	270632 270184	222866	270184	9825226944
26	Mr. A. Ganeshan	Dy.CME	270209	229345		9825227048
27	Mr. J K Verma	XEN (M)	270354	222771		9825227255
28	Dr. C. M. Joshi	CMO	225767 220072	234598		9825505795
31	Dr. Mahesh Bapat	A.M.O	220072	228167		
32	Mr. K.K. Dutta	Com. CISF	271037	229140		9825227282

- For dewatering, if required, Fire-Cum-Safety-Officer will make arrangements by operating the dewatering Fire Pumps available with him.

11.12 Ships

- All the Pilots of the Port should reach Kandla immediately in case of emergency.
- Dy. Conservator/Harbour Master/Pilots should be available at Kandla during emergency.
- Removal of vessels whenever the cyclone is located in close proximity to the danger line plotted between 65 degree E longitude 18.2 degree N latitude and 73 degree E longitude 18.2 degree N latitude. Map showing the above position is given at Annexure-XXX.

Under such a situation the ships shall be removed during 1st/next available tide. It will be the duty of Harbour Master and DC to ensure that the ships are removed during 1st/next available tide as soon as the storm reaches to close proximity to the danger line as defined above without seeking any further instruction from the

higher authorities. This action shall be taken automatically and suo-moto without any confusion and for which purpose Traffic Manager shall stop all loading and unloading operations immediately upon instructions from Dy. Conservator, so as to enable him to remove the vessels in time. The removal shall be done with the help of all the available Pilots plus all empanelled Pilots together at one go in the shortest possible time, so as to ensure that all the vessels cross the bar before the tide restriction sets in.

Dy. Conservator shall ensure that all ships are moved out of the Harbour at the earliest. All pilots shall immediately report at Kandla and stay there till the Action Plan is in operation. Dy. Conservator/Harbour Master shall immediately plan removal of vessels to the OTB as soon as the Action Plan is put into operation irrespective of the Single number, which must be hoisted. If, it is impossible to remove them, all other steps should be taken to ensure safety of the vessels at the Port as also it would not cause any damage to the Port. Dy. Conservator shall also ensure adequate stock of fuel for all crafts.

11.13 Securing of all Crafts

Dy. Conservator /Harbour Master shall immediately arrange for securing all the Port Crafts at safer places, so that there is no loss to the Port and send a report to the Chairman/Dy. Chairman as early as possible after operation of this Action Plan. Flotilla Supdt. (Mr. I. D. Bhagchandani) shall be overall in charge of each craft for ensuring their safety.

For parking of crafts in emergency, three places are mainly identified, viz. Bunder Basin, Launch Jetty and Maintenance Jetty as per:

11.13.1 Placement of Port Crafts on Cyclone Warning

(A)	Shipping Tugs	Heera Mehul	Bunder
		Kalinga Jumbo	Maintenance Jetty (West side)
(B)	Pilot Launches & Survey Launches	M. L. Bharini, M. L.Niharika M. L Swati	Floating Crafts Jetty
		ML Karishma	Bunder Basin
		ML Sarveshak ML Nirishak	Inside Bunder Area North Side.
(C)	G.S. Launches & Mooring Launches	M. L. Mrinal	Inside Bunder Area North Side on Pilot Launches
		M.L. Vaishali M L Alli M L Thamrai F F Agnishanti	Inner Side of Floating Craft Jetty
		M. L. Vijay M. L. Priyadashani PL Prahari	Inside Bunder Area North on G. S. and Pilot Launches.

Maximum number of crafts such as mooring launches, GS launches and pilot launches will be placed in Bunder Basin.

In the inner side of Passenger Jetty, one pilot launch and one G S launch will be kept.

Three tugs will be kept in the inner side of maintenance jetty.

Priority will be given to the Port crafts for parking in the bunder basin and other areas. Rest of the places available in the Northern side of bunder basin area will be allowed to the self propelled barges and private crafts. Dumb barges will be allowed on the beach between maintenance jetty and oil jetty area.

Mr. Maharam Yadav, BS will render all possible assistance to FS, being the overall in charge of the crafts. The following flotilla staff will take care of the crafts.

11.13.2 Flotilla Staff

Sr No	Name	Residential Phone
01	Mr. Maharam Yadav Passenger Jetty	229795
02	Mr. T Sunil Kumar Craft Jetty	226121
03	Mr. R B Chauhan Maint. Jetty	271004
04	Mr. P K Pandey Maint. Jetty	234669
05	Mr. Sreekumar Bunder Basin	235498

11.14 Private Barges / Crafts

The parties who have been Harbour Crafts License by the DC have to keep their barges and crafts inside the port limits being earmarked for the purpose.

Necessary instructions shall be issued to all these people having valid license immediately. The work of informing these parties will be carried out by the Office Supdt. of Dy. Conservator's office and will personally ensure that the instructions are carried out and reported to Harbour Master within two hours of the Action Plan coming into operation. The representatives of the above parties shall reach Kandla at once, failing which the Dy. Conservator will cancel the license granted to them and take over the barges/crafts of the party who violates the instructions.

The position shall be appraised to Chairman / Dy. Chairman within two hours of the receipt of warning and at frequent intervals.

11.14.1 List of Duty Roster of Marine Department (Ministerial Staff)

Sr No	Name	Office Phone	Residence Phone
01	Mr. V. S. Chavate	221971	233396
02	Mr. AR Jadeja, Signal Supdt	270549	232551
03	Mr. JK. Chavda, D.A	270427	222848
04	Mr. P. Srinivasan, Sr. Steno	220235	233470
05	Mr. HD. Mengani, Assistant	221971	-------
06	Mr. AK Patel, Assistant	221971	-------

07	Mr. Nandlal Makwana, Sr. Clerk	270427	225597
08	Mr. Sanjay Saluja, Messenger	221971	235390
09	Mr. Hiralal Motwani, Marine Khalasi	221971	263755

11.14.2 List of Telephone Nos & Addresses of DC, HM & Pilots

Sr No	Name of Officer / Pilots	Address of Gandhidham Res	Tel Nos: Cell / Landline	W/off or Remarks
01	Capt H K Sibal, DC	A – 4, Gopalpuri	9825227043 232806	Sunday
02	Capt T Srinivas HM	B – 3, Gopalpuri	9825232982	Sunday
03	Capt S K Pathak Pilot	C – 32, Gopalpuri	9825803499 231310	Saturday
04	Capt D C Bhatt. Pilot	C – 38, Gopalpuri	9879603641 235653	Monday
05	Capt A K Sharma Pilot	C – 40, Gopalpuri	9879603642 238154	Sunday
06	Capt V Madan, Pilot	C – 31, Gopalpuri	9879603643 221478	Thursday
07	Capt Ashok Modi Contract Pilot	Plot 120, Sec. 3, Opp Syrian Church	9825172975 234950	
08	Capt Bharat Modi Pilot on call	Plot 111, Sec. 3, Opp Syrian Church	9825140889 238627	
09	Capt Prakash, Contract Pilot	C – 49, Gopalpuri	9099674149 236647	
10	Capt Genius Raj, Contract Pilot	C – 52, Gopalpuri	9726097129 232826	
11	Capt Vinod Ranjan, Contract Pilot	C – 53, Gopalpuri	9726097126	
12	Capt A Mishra, Contract Pilot	C – 60, Gopalpuri	9099694747 229914	
13	Capt M Kumar, Contract Pilot	C– 51, Gopalpuri	9726097127	
14	Capt Pradeep, Contract Pilot	Gopalpuri Guest House	9586150784	
15	Capt R P Singh, Contract Pilot	Gopalpuri Guest House	9586152050	
16	Capt D S Katoch, Contract Pilot	Gopalpuri Guest House	9727817020	

11.14.3 Contract / Empanelled Pilots

Sr No	Name	Mobile
01	Capt. A C Modi	9825172975
02	Capt. B C Modi	9825140889
03	Capt. Arvind Kumar Mishra	9099694747
04	Capt. Manmohan Kumar	9726097127

05	Capt. Genuis Raj	9726097129

11.14.4 Sections

1.Flotilla Section 270292
(Mr. I. D. Bhagchandani, F/S 270280220805 (M) 9825289204

2.Signal Station 270549/270194/Fax 270624

3.Fire Station 270176/270178/270439/550421/271244/271377

In case of Natural Calamity, first start with rescue operations, restoration activities on war footing on the advice of Chairman/Dy. Chairman, Dy. Conservator/ Harbour Master/Fire-Cum-Safety-Officer/Flotilla Supdt as the case may be.

11.15 Traffic Departments

After, the warning of Cyclone or any other Natural calamity is issued at the Port, Traffic Manager shall ensure that the loading/unloading operations at the Port are stopped immediately, hatches closed, ships derricks properly secured and all labourers evacuated from the Port Area. Public Address System shall be installed at the Cargo Jetty Area, which shall be under the charge of Traffic Manager. He shall use it for necessary arrangements relating to evacuation. Traffic Manager should also ensure that responsible persons make announcements in a proper way, so as not to create any misunderstanding/panic.

Notwithstanding above, Traffic Manager shall stop all loading and unloading operations immediately upon instructions from Dy. Conservator, so as to enable the latter to remove the vessels in time.

The responsibility of evacuating the Port Shore Workers and Private Shore Labourers rest with Traffic Manager. He along with Mr. Suresh Babu, Dy. Traffic Manager, Mr. Gulrajani, Safety Officer and Dy. Commandant, CISF should ensure that the Port is completely evacuated and there is no fresh entry in the Custom bounded area. Mr. Suresh Babu, Dy. Traffic Manager should get in touch with the Main Contractors in the regard.

Traffic Manager shall render necessary help to procure requisite number of Trucks for Public Announcement and evacuation.

Traffic Manager shall inform all the Stevedores List given below:

11.15.1 List of Stevedores

Sr. No.	Name	Address	Fax No.	Telephone Nos.	
				Office	Resi.
1	M/s. Cargo Movers	"Cargo House" BBZS-32A, Gandhidham	231687	220453 231365	261280

2	M/s. DBC & Sons (P) Ltd.	Seva Sadan-II, Room No. 303 / 304, New Kandla	270631	270503 270263 270348	-
3	M/s. A.V.Joshi & Co.	Plot No. 18, Sector-8, Maitry Bhavan, Nr. Post Office, Gandhidham – Kutch	233924	231070 232227 231588	234909
4	M/s. Agarwal Handling Agencies	DBZ-N-47, Gandhidham – Kutch	232749	220282 233187	232749
5	M/s. ACT Shipping P. Ltd	Seva Sadan-II, Room No. 206/207, New Kandla	232175	270111 270112 270015 229967	261308 231416
6	M/s. Cargo Carriers	214/215, Rishab Corner, Plot 93, Sector- 8, GIM	230030	220816 231649 230030	231694
7	M/s. Cargo Clearing Agency (Gujarat)	Plot No. 271, Ward 12-B, Gandhidham	233034	221721 220655	231452
8	M/s. Chotalal Premji Stevedores Pvt. Ltd	C-8, Shaktinagar, GIM	231509	270009	-
9	M/s. Hiralal Maganlal & Co.	C-11, GIDC Area, Gandhidham – Kutch	223914	223914 231832	223878 232430
10	M/s. New Dholera Shipping Company	Goyal Commerce Centre Building - 1, Plot No.259, Ward 12B, Gandhidham - Kutch	-	222637 232267	237284
11	M/s. J.M. Baxi & Co.	Seva Sadan – II, Room No. 301 / 306, New Kandla	270646	270630 270550 270448	260427
12	M/s. Pestonjee Bhicajee (Kutch)	Seva Sadan-II, 203, New Kandla	270650 270556	270257 270367	262914

13	M/s. OTA Kandla Pvt. Ltd.	BBZ-N-324, Gandhidham	223241	220145 270560	223241
14	M/s. Purshotam das Jeramdas & Co.	5, Vaswani Chamber, 16, Sector-8, GIM	222850	238242 222598	220598
15	M/s. R. Tulsidas & Co.	Ahit Building , Plot No.323, Gandhidham – Kutch	232308	222717 221943	-
16	M/s. Robinsons	101 / 102, Maritime House, Plot No.45, Sector – 9A, Gandhidham – Kutch	234394	221578 223836	231767
17	Rishi Shipping	Plot 50, Sector 1/A GIM	238943	229830 229831	
18	M/s. Vinsons	BBZ-S-25, Gandhidham – Kutch	231948	220466	222395 239460
19.	Sical Logistics Ltd	403, 4th Floor, Madhuban Compex, OSLO, GIM	234416	234646 234194	
20	Parekh Marine Agency	C-8, Shaktinagar GIM	231509	229297 221158	
21	Krishna Shipping and Allied Services	Transport Nagar, NH GIM	233135	230501 223814 229085	
22	Kevar Carrier Handling & Transport	Shop 24, Tolani Chamber, Sector –8,GIM	228298	228298	
23	Trinity Shipping & Allied Industries	Trinity House, Plot 46 Sec 1/A, GIM	232060	230911 230910	

24	Velji P & Sons(P) Ltd	2nd Floor, Deepak Compex, 315, 12/B GIM	236168	231545 231546 225466	
25	Asean Marine Services	Ashit Bldg, Plot 33 Sector 1/A, GIM	232308	222717 221943 222145	
26	Rishikiran Roadlines	Kiran House, Plot 8 Sector 8, GIM	231422	231894 234108	
27	Universal Shipping Services	Hotel Sea Bird, Plot 173, Sector 1/A,GIM	235251	230663 226050 226037	
28	R.T.Bhojwani &Sons	DBZ –S- 146, GIM	232423	222211 221831	
29	Logistic Enterprises (P) Ltd	C-8, Shaktinagar, GIM	231509	235341 230587	
30	Seaways Shipping (P) Ltd	2nd Floor, Plot 351 Ward 12/B, GIM		226183 237147	
31	Seacrest Shipping Services Pvt. Ltd	216, 2nd Floor Om Corner, Plot 336 Ward 12/B, GIM	227028	233325	
32	Shree Maruti Shipping Services	18/21, Swaminarayan Bldg, Sector 9, GIM	234107 250690	233245 237247 250690	
33	Liladhar Pasoo Forwarders P.Ltd	Plot 4, Sector –1 KASEZ, GIM	252383 253506	252286 252297 252612	
34	Shree Radhey Shipping Company	14-16/C, GF Green Park, GIM	232967	222919 228919 238883	
35	Pearl Shipping	220, Rishab Corner, Plot 93, Sector 8 GIM	235570	225283 225284	
36	Patel Shipping Agency	Patel Avenue, Floor 2,Plot 170, Sector 1/A, GIM	231143	224024	

37	Ashirvad Shipping	18-21, Swaminarayan Bldg, Sector- 9, GIM	250690	233245 237247 222822	
38.	M/s. Swaminarayan Vijay Trade Carriar	1st Floor, H-6, Op. Tejas Society, Ghatlodia, Ahmadabad	079-231983	231981, 231982	

11.16 Mechanical Engineering Department

- Marine Engineer/Engineer In charge should be available in emergency cell and remain in constant touch with Chief Mechanical Engineer/Signal Station and Assistant Engineers posted on Shipping Tugs.
- All Assistant Engineers (D/T &F/C) should be available on operational tugs irrespective of their duties. They should keep main engines and associated equipment in readiness all the times.
- Assistant Engineers posted in tugs Jumbo, Kalinga, Heera and Mehul should contact Superintending Engineer (Mech)/ Engineer In-charge for all technical & personal problems.
- Mr. Karnial Singh, Assistant Engineer (F/C) will be responsible for timely supply of food packets and drinking water to officers and staff of tugs.
- Mr. P.S. Pathan, Executive Engineer (Electrical) will be responsible for Securing Cranes at Cargo Jetty. He may, if need be inform about requirement of advance and to draw accordingly. He will be responsible to run 2 X 1000 KVA Generator Sets at Cargo Jetty Area in case of Power failure and also maintain additional Generator sets required at Kandla/Gopalpuri and Attending work of maintenance of major nature and breakdown.
- Mr. B.J. Solanki, Asstt. Executive Engineer (Mech.) and Mr. J.T.Rughwani, JE (Mech) will be responsible for timely supply of Drinking Water/Food Packets to the staff of Mechanical Engineering Department during operation of the action plan.
- Mr. Rajesh Roat Assistant Engineer (Mech.) will be responsible to attend breakdown of Fire Fighting Pumps and DG Sets of 2 X 1000 KVA at Kandla.
- Steel Floating Dry Dock and one Electric Wharf Crane at maintenance jetty and one crane at bunder area are to be properly secured by Executive Engineer (Dry Dock) with help of his team mentioned below, as per prescribed procedure and concerned officers shall constantly monitor the safety of the Steel Floating Dry Dock and Electric Wharf Cranes in side Bunder Area. He shall ensure all the required wedges, wire ropes, shackles etc.. and other fixtures as required to be kept ready so that the same can be fixed without loss of time & to check the site for the requirement, from time to time.

Action: Mr. V.I. Vazirani, XEN (DD) and Mr. Haridas Nair, Asstt. Engineer (FC) will lead the team of Mr. Shiva Mudaliyar, JE(Mech) and will be in contact with Executive Engineer (Mech) and Chief Mechanical Engineer/Deputy Chief Mechanical Engineer.

- All the V.H.F. and other Wireless Sets, and other required equipments of VHF Unit, including the sets kept at S.F.D.D. should be kept in perfectly working condition and the batteries are fully charged and to be kept in ready position and staff will remain in touch with control room till the emergency is called off to attend all communication equipments. It shall be responsibility of the Control Room Staff to ensure that timely information is passed on and timely and proper monitoring is done.

  Action: Mr. Haridas A. Nair, Assistant Engineer (F/C) and R./R. Technician will render all possible assistance to Ex. Engineer(DD) during the course of calamity period.

- All the vehicles belonging to the Mechanical Engineering Department to be kept in perfectly working condition and sufficient stock of fuel and lubricant to be kept in ready position.

  Action: Mr. Dana Manohar, Assistant Engineer (Mech.) with the help of Mr. N. H. Veghad, Junior Engineer (Mech.)

- During the course of calamity all the vehicles lying inside the premises of Auto Workshop should be kept in the parking ways meant for parking the individual vehicles and inside the shed. No vehicle is to be parked under any tree or under any such structure where there is possibility of falling such structure or tree over the vehicles. All the concerned drivers to be informed accordingly well advance to avoid such possible damage to vehicles and to remain present at duty place in consultation, Vehicle –in-charge of Pipeline Division.

  Action: Mr. Dana Manohar Assistant Engineer (Mech) with the help of Mr. N H Veghad, Junior Engineer (Mech).

- Record of attendance of the employees during these periods to be kept ready and to be fed to the Control Room or any official responsible for such duties.

  Action: Mr.B.G.Solanki, Assistant Executive Engineer (Mech), Mr. Rajesh Roat, Assistant Engineer (Mech) with the help of Head Clerk (Mechanical Division) and Mr. Vasu Tilwani, Divisional Accountant for all sections.

- Mr. Haridas Nair, Assistant Engineer (F/C) to remain in Control Room at New Kandla to attend the communications with help of R/R Technician.

- Mr. B.J. Solanki, Assistant Executive Engineer (Mech) and Mr. R. Padmanabham, Assistant Engineer (Mech) are to be associated with Executive Engineer (M) to constantly monitor the safety of the Port Crafts.

- The heave up water barge "BHIMSEN" is shifted to Bunder Area and secured

properly in Naval Aid Salvage Section and Floating Craft. Absent/Present report of the above staff will be reported to the concerned section immediately on starting of each shift and maintenance of major and breakdown etc…
Action: Mr. Manohar Dana, Assistant Engineer (Mech)

- All the telephones and intercom telephones and their allied communication systems and equipments should be kept in perfect working condition to ensure that timely information is passed on and timely and proper monitoring done till the emergency is called off. He will ensure quick restoration of telephones by keeping close liaison with the concerned personnel. He will report to the Executive Engineer (Electrical) every day and to carry out all work assigned by the Executive Engineer (E) in case of emergency.

  Action: Mr. D.K. Hazra, Assistant Engineer (Instru).

- Mr. A. Ganeshan, SE (E) and Mr. P.S. Pathan, Executive Engineer (E) shall be responsible for liaison with the PGVCL for receiving power in case of power failure. In the event of disturbance in the distribution network necessary arrangements shall be made by them as per the requirement depending upon the situation.

- If any additional Generator Sets are required at Kandla or Gopalpuri, the following officers shall be contacted who shall immediately hire/procure or provide in whatever manner the DG Sets giving preference to the operational area.

  1. Mr. A. Ganeshan Superintending Engineer(E)
  2. Mr. P.S. Pathan Executive Engineer (Electrical)
  3. Mr. J K Verma Executive Engineer (Mechanical)
  4. Mr. A.K. Sharma AXEN(E)

  The above officers shall also be responsible for operation and maintenance of Generators provided at various locations and submits daily report to the Chief Mechanical Engineer about the working of Generators.

  Additional requirements, if any, will be assessed by Dy. CME and the same shall be submitted to Chief Mechanical Engineer for hiring, well in advance so that XEN (E) can take necessary action for hiring, installation etc…

- After the warning of Cyclone or any other Natural Calamity is issued at the Port, Chief Mechanical Engineer shall ensure immediately that the cranes are secured and properly locked as per procedure and report submitted to the Chairman/Deputy Chairman after the operation of the Action Plan.

  The following officers shall constantly monitor the safety of the cranes;

  1. Mr. P.S. Pathan Executive Engineer (Electrical)
  2. Mr. J K Verma Executive Engineer (Mechanical)

The responsibility of evacuating all Mechanical/Electrical and Civil workers rests with Chief Mechanical Engineer with the assistance of respective Executive Engineers.

The maintenance of major nature and de-watering fire pumps operated by Fire-Cum-Safety-Officer will be attended by Mr. J K Verma, Executive Engineer (Mech).

Mr. V.I. Vazirani, Executive Engineer (Dry Dock) and Mr. Haridas Nair, AE(DD) shall ensure that the Steel Floating Dry Dock and Electric Wharf Cranes at the maintenance jetty are properly secured as per the procedure and compliance reported to the Chief Mechanical Engineer immediately. Mr. L.N. Punjwani, SE (Mech) shall monitor the safety of Steel Floating Dry Dock.

The following staffs have to report for duty even if it is a public holiday to actively participate in the Action Plan and they shall be responsible for record keeping of attendance, preparation, and submission of reports etc.

1.Mr. M.Y.Chacko P A to CME

2. Office Superintendent

3.Mrs. Sunita Bajaj Superintendent Accounts

4.Mr. Anil Panikar Stenographer

5.Mr. Pradeep Pandey Junior Clerk

11.16.1 List of Duty Roster of Mechanical Engineering Department

Name of Officer	Designation	Office	Resi.	Mobile
Mr.Niteen Borwankar	CME	270632	222866	9825226944
Mr. S.K. Das	Addl CME	270426	242036	9825235196
Mr. M.Y. Chacko	PA to CME	270184	238813	9913582859
Mr. A. Ganeshan	SE(Electrical)	270209	229345	9825227048
Mr. L.N. Punjwani	S E (M)	270354	265781	9875310678
Mr. J K Verma	Dy Material Manager	270354	222771	9825227255
Mr. P S Pathan	XEN(E)	270469	229038	9427205563
Mr. V.I Vazirani	XEN(DD)	270285		9375357125
Mr. B J Solanki	AXEN(M)	270285	240010	9825340169
Mr. Dana Manohar	Asstt. Engr (M)	234199	295536	9427719184
Mr. Haridas Nair	Asstt. Engr (FC)	270165	235458	9426730306
Mr. D. K. Hazara	AXEN (E)	270209	227185	9427436025
Mr. S.M. Gor	AE(E)	270322	226460	9879630888

	Office Supdt	270245		
Mrs. Sunita Bajaj	Div. Accountant	270245		9925547755
Mr. Anthony Varghese	Div. Accountant	270342		
Mr. Anil Panikar	Steno	270184	236833	9427437804
Mr. Pradeep Pandey	Junior Clerk	270245		9426277390
Mr. A.K. Sharma	AE(E)	270469		9913200232
Mr. B.S. Sharma	AE(E)	270458	240966	
Mr. Rajesh Roat	AE(M)	270370	225182	9825692785
Mr. R. Padmanabhan	JE(M)	270127	225162	9428032272
Mr. Mohan Dhanji	Head Clerk	270342		9428897954
Mr. Vinod Sondhra	Head Clerk	270498		9979323157
Mr. Yuvraj	Div. Accountant	270498		9428316341
Mr. Vasu Tilwani	Div. Accountant	270484		9429426734

11.17 Civil Department

Based on the practical experience and seriousness of the two Natural Calamities - the devastating Cyclone in 9th June 1998 and the Earthquake on 26th January 2001, the following Action Plan for Civil Engineering Department, is proposed to be implemented.

As soon as the message on anticipated Cyclone/Natural Calamity is received from concerned authorities, the same will be intimated to all the concerned under the Civil Engineering Department and will be instructed to be alert. All the staff members/officers should note that they will come into action on their own as soon as the Warning is issued without waiting for any further instructions. Failure on the part of any employee/officer to carry out the earmarked Action Plan shall attract severe consequences.

Immediately after receiving the information on the Natural Calamity, nobody will be granted any kind of leave and the persons who are already on leave will be called back after canceling the leave.

Absent/Present report of the staff and the officers will be reported to the concerned Section immediately on starting of each shift for this purpose, Sectional Heads of all Divisions will be responsible to report the matter to P. A. to Chief Engineer for compilation of the information and onward transmission to General Administration Department.

The Engineering Department will assist in shifting of the persons to safe places in the event of such action is required.

Water Supply arrangements will be made to various colonies/sites of work/camps where the workers are shifted, etc. The Senior Engineer (Pipeline) will be the in charge for supply of water to various destinations.

Sufficient number of vehicles will be arranged for transportation workers/staff/officers. This arrangement will also be made by the Senior Engineer (Pipeline).

The Engineering Department will ensure that all Road blockades are got cleared as also blockades caused in Port Quarters due to failing of trees, walls, shed, etc. are got removed immediately. Further, it will be ensured that the colonies are got cleared and whatever logging of water is found is pumped out and disinfected. A report will also be submitted to Chairman/Dy. Chairman.

11.17.1 The following officers are to be contacted in the event of any such problems

Area	Designation	Office	Resi.	Mobile
New Kandla Gopalpuri	XEN(R) XEN (TD)	236165 223912	222056 235683	9913949700 9427205610
Old Kandla	Senior Engineer (Pipe Line)	220013	232880	9825225962
Cargo Jetty	Executive Engineer (Harbour)	270429	252624	9825227046

11.17.2 List of Duty Roster of Civil Engineering Department

Name of Officer	Designation	Office	Resi.	Mobile
Mr. R Murugadoss	Chief Engr	233192	228777	9825227243
Mr. B.G. Somaiya	Supdt. Engr.(P)	233569	--	9825325390
Mr. M K Khushalani	Supdt. Engr.(C)	270787	260964	9825227038
Mr. D. D. Somaiya	Supdt. Engineer (Const)	270419	252856	9825227203
Mr. M H Makati	PA To CE (T)	220016	237513	--
Mr. Ravi Maheshwari	P.A. To CE	220050	222550	9426737553
Mr. N M Parmar	Supdt Engineer (Harbour)	270429	252624	9825227046
Mr. M. N. Tewani	Exe. Engr (R)	236165	222056	9913949700
Mr. B Rajendra Prasad	Exe. Engineer (Design)	220038	232880	9725338260
Mr. B.H. Gehani	Ex.Engr (TD)	223912	235683	9427205610
Mr. Suresh Kumar	Dy.Secretary(E)	221758	236086	9825227044
Mr. J.K. Chauhan	Asst.Estate Manager	221598	237512	

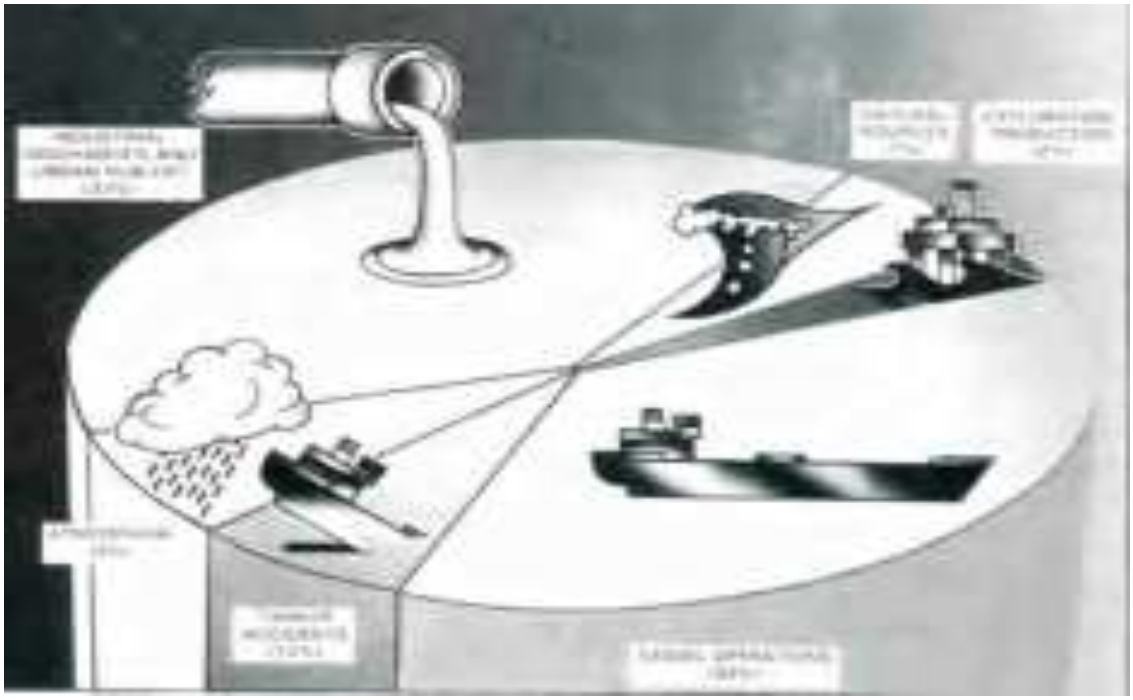
Periodical Meetings will be conducted with the Executive Engineer's/ DSOs/Staff Member to assess the progress made during the day and to instruct further course of action in the matter.

12 RESPONSE TO MARINE OIL SPILLS

12.1 Sources of Petroleum Hydrocarbons

The best estimate for the total input of petroleum to marine environment from all sources is some 3.2 million metric tons per year. By far the biggest contribution comes from terrestrial sources, mainly in the form of municipal and industrial wastes. Accidental spills from ships, together with offshore exploration and production activities, account for about 0.47 million metric tons which is a relatively small amount considering the worlds current production of three million metric tons, half of which is transported by sea.

Major Inputs of Petroleum to the Marine Environment. (Figure)



12.1.1 Accident Spills from Tankers

Accidental spills from tankers contribute an estimated 4, 00,000 tones annually. Analysis of tanker spills occurring throughout the world shows that the majority (some 75%) occur in port during routine ship operations such as loading, discharging and bunkering. Most of these spills are, however, relatively small: over 92% are less than 7 tones given in the table below and probably, in total, contribute less than 20,000 tons annually. In comparison, accidents such as collisions and groundings give rise to less than 10% of all spills from tankers, but a quarter of these are larger than 700 tones given in the table below. In fact, a few large accidents give rise to the majority of the oil spilt and hence there is considerable annual variation in this figure below:

Comparison of Incidence of World Oil Spills from Tankers, 1974 – 1985, resulting from Routine Operations & Major Accidents

	< 7 Tones)	7 – 700 (Tones)	> 700 (Tones)	Total
Loading / Discharging	2236 (90%)	227 (9%)	11 (1%)	2474 (100%)
Bunkering	442 (95%)	22 (5%)	-------	464 (100%)
Collision	39 (17%)	134 (59%)	54 (24%)	227 (100%)
Grounding	69 (25%)	134 (49%)	70 (26%)	273 (100%)
Total	2786 (81%)	517 (15%)	135 (4%)	3438 (100%)

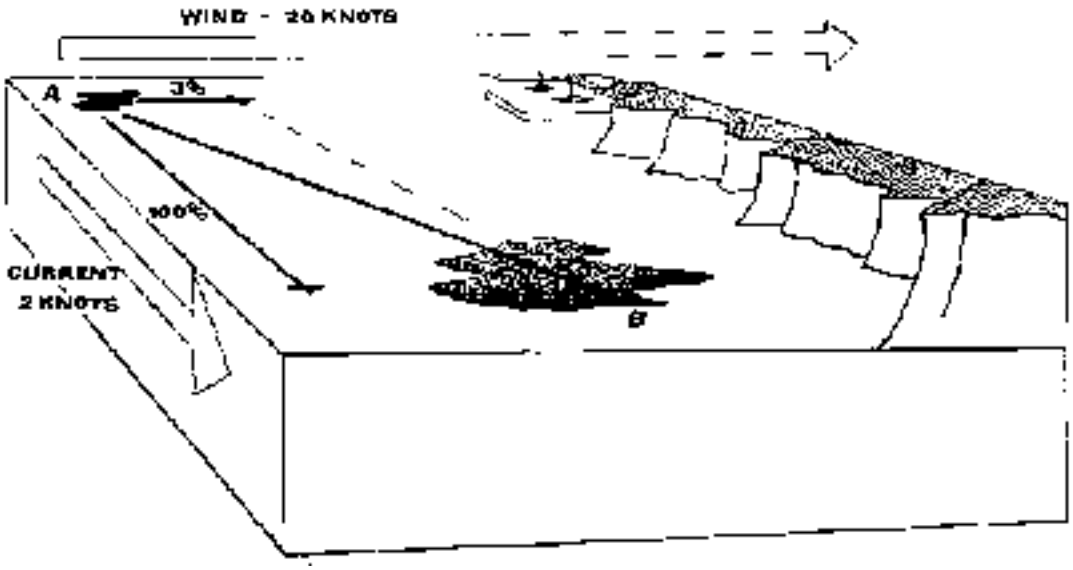
12.2 Forecasting Slick Movement

It is equally important to be able to forecast the probable movement of a slick as well as the likely changes in the properties of oil after it has been spilled. This allows sensitive resources in the path of the slick to be identified and, if appropriate, response measures to be put into effect. The task of forecasting the position of the oil can only be accomplished if data on winds and currents are available since both contribute to the movement of floating oil.

12.2.1 Effect of wind, Tidal currents

It has been found empirically that floating oil will move downwind at about 3% of the wind speed. In the presence of surface water currents, an additional movement of the oil equivalent to the current strength will be superimposed on any wind-driven motion. Close to land, the strength and direction of any tidal currents must be taken into account but further out to sea their contribution is usually less significant because they are cyclic and so tend to cancel out over time. Thus, with knowledge of the prevailing winds and currents, it is possible to predict the rate and direction of movement of floating oil from a known position, as shown in Figure given below, overleaf.

The influence of 3% of the wind speed combined with 100% of the current speed results in the movement of oil from A to B



12.2.1.1 Computer Models

This simple calculation can be easily done by hand but becomes very time-consuming if tidal currents have to be taken into account since it must be recalculated at regular intervals as currents change. Computers can be used to speed up such calculations by storing information on water movement and coastal outline for a specific geographic area. Wind data and the spill location are then the only additional information required at the time of a spill. The reliability of such models depends upon the accuracy of water movement and wind data. Often they are combined with mathematical models simulating weathering processes to provide a forecast of the overall fate of a spill.

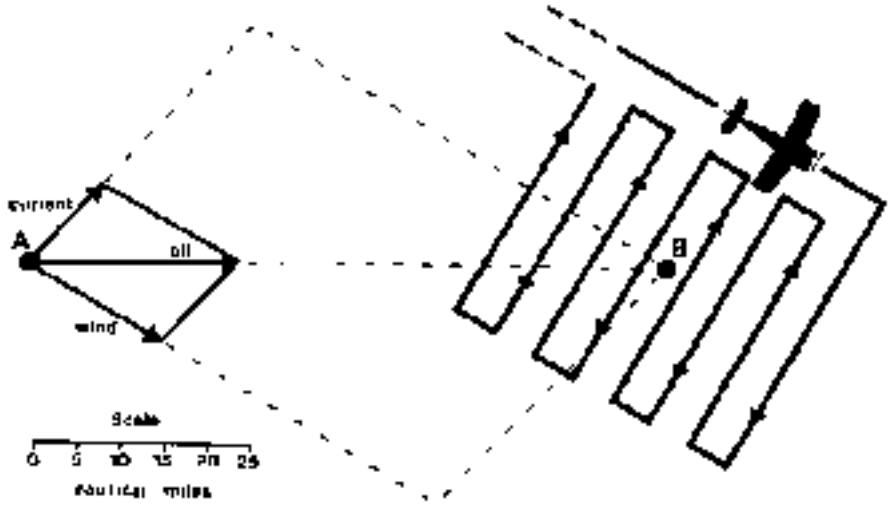
12.3 Aerial Surveillance at Sea

However reliable an oil spill model may be predictions of the fate and movement of oil slicks at sea should be verified through regular surveillance of the oil. This should be conducted from the air since observation from a vessel is highly inefficient.

12.3.1 Search Pattern

12.3.1.1 Ladder Search

A 'ladder search' is frequently the most economical method of surveying a large sea area. Since floating oil has a tendency to become aligned in long narrow windrows parallel to the direction of the wind, a ladder search across the wind will increase the chances of oil detection.



Movement of oil from A to position B three days later, predicted by combining 100% of the current speed and 3% of the wind speed as shown. The arrows from A represent current, wind and oil movement for one day. A cross-wind ladder search pattern is shown over position B.

12.4 Effect of Sunlight, Search Altitude

Haze and dazzle off the sea often affects visibility and the position of the sun may dictate the best direction to fly a search pattern. Sun glasses can give some relief from eye strain caused by strong light. Polarizing lenses can assist the detection of oil at sea under certain light conditions due to the differences in light reflected from oil and water. The search altitude is generally determined by the visibility. In clear weather 500 meters (1600 feet) frequently proves to be optimum for maximizing the scanning area without losing detail.

12.4.1 Navigation

However, it is necessary to drop to half this height or lower in order to confirm any sightings of floating oil or to examine its appearance. Over the open sea, away from any obvious reference points, it is easy to become disoriented. Ideally an observer will be able to consult the aircraft instrumentation for speed, direction and position, but it is worth ensuring beforehand that the instruments can be read without difficulty. In the absence of such aids, an observer with a suitable chart can keep track of course changes and positions by communicating with the pilot using the aircraft intercom.

12.5 Visual Quantification of Floating Oil

It is important that the port personnel estimate the amount of release for planning mitigating measures and allocating resources effectively. An accurate assessment of the quantity of floating oil is virtually impossible due to the difficulty of gauging its thickness. At best, the correct order of magnitude can be estimated by considering certain factors. Oil spreads rapidly and most liquid oils will soon reach an average thickness of about 0.1 mm, characterized by a black or dark brown appearance. Similarly, the color of sheen roughly indicates its thickness.

12.5.1 Appearance versus thickness, Cold water effects

A reliable estimate of water content in a 'mousse' is not possible without laboratory analysis but accepting that figures of 50% to 80% are typical, approximate calculations of oil quantities can be made, given that most typical floating 'mousses' are 1 mm or more thick. However, it should be emphasized that the thickness of 'mousse' and other viscous oils is particularly difficult to gauge because of their limited spreading. Indeed in cold waters some oils with high pour points will solidify into unpredictable shapes and the appearance of the floating portions will belie the total volume of oil present.

12.5.1.1 A Guide to the Relation between Appearance, Thickness and Volume of Floating Oil

Oil Type	Appearance	Approximate Thickness (mm)	Approximate Volume (m^3/km^2)
Oil sheen	Silvery	0.0001	0.1

Oil sheen	Irridescent	0.0003	0.3
Crude and fuel oil	Black/dark brown	0.1	100
Water-in-oil emulsions ('mousse')	Brown/orange	>1	>1000

12.5.2 Surface area, Percentage cover

In order to estimate the amount of floating oil it is necessary not only to gauge thickness, but also to determine the percentage area of the sea surface covered by oil, water-in-oil emulsion and sheen. Again, accurate estimates are complicated by the patchy incidence of floating oil. To avoid distorted views, it is necessary to look vertically down on the oil when assessing its distribution. By estimating the percentage coverage of each form of oil, the area covered relative to the total sea area affected can be calculated from timed overflights at constant speed or from position fixing equipment.

12.6 Spill Control Management

12.6.1 Contingency Planning

12.6.1.1 Tankers

Plans covering areas where a wide range of oil types are handled or where tankers pass in transit, cannot anticipate the impact of a spill. It is therefore important that the type of oil spilled is established at the earliest opportunity so that its fate can be predicted and the appropriate clean-up techniques employed.

12.6.2 Fixed Installations

For oil terminals where a limited number of oil types are involved, an appreciation of the likely fate of potential spills is valuable when drawing up contingency plans. Information on the prevailing winds and currents throughout the year will indicate the resources where oil spill impact is most likely. Data on the types of oil handled can enable predictions to be made regarding the lifetime of slicks and the quantity and nature of the residue, which may require a clean-up response. It will also assist in the selection of appropriate clean-up equipment to be held in readiness for spills.

12.6.3 Priorities for protection, Sensitivity maps

Because of the difficult decisions that will be required during an oil spill in order to mitigate damage and to resolve conflicts of interest, much can be done at the contingency planning stage to identify sensitive areas and to determine priorities for protection. The mapping of sensitive areas can be a useful starting point. Detailed consideration should be given to the likely impact that a spill would have on each habitat or activity, taking into account any seasonal variability. Attention should then be given to identifying areas to be protected and their order of priority. This will never be easy since the value of each resource to the community will depend upon the weight given to environmental, recreational, economic and political considerations. This may require a wide range of data to be gathered and evaluated.

If properly conducted, such studies of the resources at risk in an area can also form a basis for quantifying any damage caused by a spill at risk in an area can also form a basis for quantifying any damage caused by a spill.

12.6.4 Response decisions

Having determined priorities for protection, attention can be given to designating appropriate clean-up measures. It is necessary to make a realistic assessment of the feasibility of employing various techniques since a recommendation to avoid the more ecologically damaging response options may result in the adoption of ineffective techniques and greater damage to other habitats or activities.

12.6.5 Containment

The containment of floating oil for subsequent recovery or its diversion away from sensitive areas calls for the use of some form of barrier. Many different types of oil barriers have been developed. These include commercially available floating booms, netting systems, sorbent booms, improvised booms and barriers, bubble barriers and chemical barriers. Selection of the most appropriate barrier will depend upon the particular conditions as well as availability. Since commercially available booms are the most common form of barrier used in oil spill control they are described in greatest detail in this section.

12.7 Commercially Available Booms

Design features

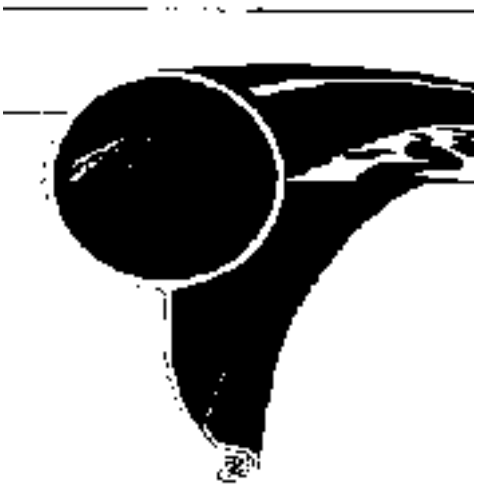
Designs vary considerably but all normally incorporate the following features:

1. Freeboard to prevent or reduce splash over;
2. Sub-surface portion (skirt) to prevent or reduce escape of oil under the boom;
3. Floatation by air or some buoyant material;
4. Longitudinal tension component (chain, wire or boom fabric itself) to withstand effects of winds, waves and currents.

Boom designs fall into two broad categories:

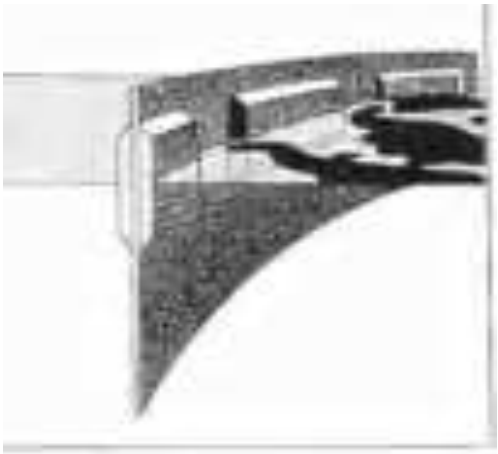
12.7.1 Curtain Booms

Curtain Booms provide a continuous sub-surface skirt or flexible screen supported by a solid or air floatation chamber usually of circular cross-section. Air floatation booms take up only a small storage area when deflated, whereas solid floatation booms, although more resistant to damage, are bulky in storage. Curtain booms generally have good wave-following capabilities, moderate escape velocities and are reasonably easy to clean.



12.7.2 Fence Booms

Fence Booms with a flatter cross-section are held vertically in the water by integral or external buoyancy. Solid floatation is most frequently used for fence booms but if external floats are used, turbulence may be generated leading to escape of oil at low water velocities. Such designs are bulky in storage and difficult to clean. In general, fence booms are more suitable for calmer waters where current velocities are low.



12.7.2.1 Common features

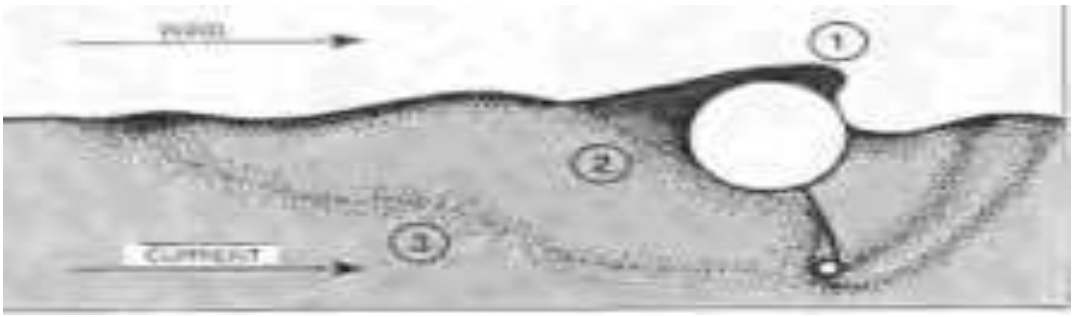
Many curtain and fence booms have similar features including bracing struts and/or integral ballast to keep them upright in the water, connectors for joining sections together as well as towing and anchoring points.

12.7.3 Performance/Limitations

12.7.3.1 Currents, Wind, Waves, Turbulence

The most important characteristic of a boom is its oil containment or deflection capability, determined by its behavior in relation to water movement. It should be flexible to conform to waves yet be sufficiently rigid to retain as much oil as possible. No boom can contain oil against water velocities much above 1 knot (0.5 meters per second) acting at right angles to it. The way in which oil escapes, and its relation

with water velocity is as much a function of oil type as boom design. Low viscosity oils escape at lower velocities than more viscous materials. With the latter, the oil tends to accumulate at the boom face and to flow vertically down and under the skirt whereas low viscosity oils are carried under the boom as droplets sheared from the underside of the oil layer. Besides river and tidal currents, wind and waves can generate water velocities in excess of the escape velocity as well as causing splash over of contained oil. Oil escape can also result from turbulence along a boom and therefore a uniform profile without projections is desirable.



Escape of oil from a boom:

1. Splash over by wave action
2. Flow down the face of the boom
3. Droplets sheared from the underside of the contained slick

12.7.3.2 Boom size

The size and length of boom sections are also important considerations. The optimum size of a boom is largely related to the sea state in which it is to be used. As a general rule, the minimum freeboard to prevent oil splash over should be selected. The depth of skirt should be of similar dimensions to the freeboard. While short section lengths can make booms easier to handle and can protect the integrity of the boom as a whole should one section fail, these advantages must be weighed against the difficulty and time taken to connect sections effectively. Connections interrupt the boom profile and, wherever possible, should not coincide with the point of heaviest oil concentrations. The design of connectors should allow easy fastening and unfastening during deployment and whilst the boom is in the water.

12.7.3.3 Strength, Ease of deployment

Other important characteristics are strength, ease and speed of deployment, reliability, weight and cost. A boom must be sufficiently robust for its intended purpose and it must tolerate inexpert handling, since trained personnel are not always available. Structural strength and durability are required particularly to withstand the forces of water and wind on a boom when it is either towed or moored. Ease and speed of deployment combined with reliability are clearly very important in a rapidly changing situation and may strongly influence the choice made.

12.8 Netting Systems

12.8.1 Advantages

The use of nets to recover solid tar balls is an obvious application and the extension of their use to contain viscous oils theoretically presents a number of advantages over the use of conventional booms. In particular, the open structure should offer less resistance to water movement so that light but strong sections could be manufactured which might realistically be long enough to enclose oil scattered over a wide area of sea. As a result of the lower resistance of nets to movement through the water, it should also be possible to operate in faster currents or to sweep or trawl the sea surface at higher speeds than can be achieved with conventional booms.

12.8.2 Designs

Two basic designs of net have so far been developed which draw on experience from the fishing industry a long double net based on the purse seine method of fishing which can be used to corral or collect floating oil or which can be moored to protect sensitive areas; and a trawl net with a detachable 'cod-end' which can be towed along the sea surface.

12.8.3 Experience

Although neither design has yet been fully evaluated during an actual oil spill, large scale field trials show some promise, especially in the case of the purse seine type when used to corral and retain floating oil. However, once oil has been adsorbed onto the net the mesh becomes blocked and the oil retention capabilities are similar to conventional booms.

Netting system of the purse seine type for oil containment and recovery using two vessels to corral floating oil.

Oil trawl for collecting floating solid oil into a detachable cod-end.

12.9 Sorbent Booms

12.9.1 Construction, Uses

Sorbent booms usually consist of a tube of netting or some other fabric filled with a synthetic or natural sorbent material. Booms constructed of sorbent material have little inherent strength and, in some application, may require additional support. Some also need extra floatation to prevent them sinking when they become saturated with oil and water. They are normally only used in areas of low current velocity to collect thin films of oil, since their recovery efficiency decreases rapidly once the outer layers of the sorbent material become saturated with oil. The handling and disposal of oil-soaked sorbent booms can also cause considerable problems. The use of sorbents is further discussed in the section on Recovery.

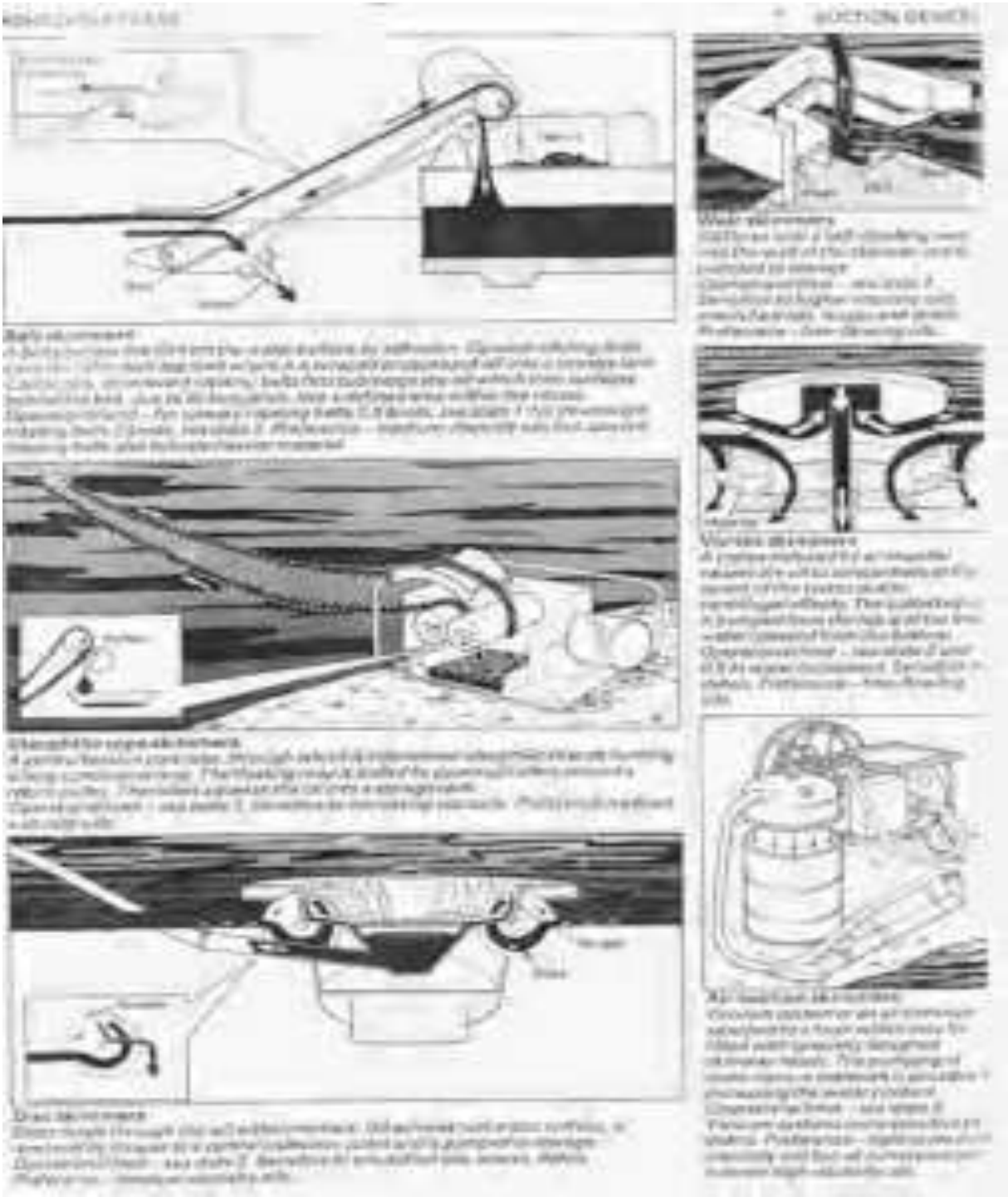
Fixed oil barrier constructed with straw bales and wire netting nailed to wooden

stakes.

12.9.1.1 Recovery

The rapid recovery of contained oil is vital to prevent its escape and the contamination of other areas. Recovery can be achieved using skimmers, pumps, sorbents, manual techniques and non-specialized mechanical equipment, such as vacuum trucks.

12.10 Skimmers



12.10.1 Design features

All skimmers incorporate an oil recovery element, some form of floatation or support arrangement and a pump to transfer collected material to storage. More complicated designs may be self-propelled and may have several recovery elements, integral storage tanks or oil/water separation facilities.

12.10.2 Suction skimmers

Two basic approaches can be recognized: SUCTION and ADHESION. The simplest concept is a suction device whereby oil is collected by a pump or air suction system from the water surface directly or via a weir. These designs tend to collect large volumes of water together with the oil. This can be an advantage when recovering viscous oils since the presence of excess water helps to maintain the flow of oils which would otherwise tend to block hoses and pipe work. Large storage is required to receive and separate the water which frequently represents more than 90% of the collected material. For oil spill control purposes, simple gravity separation in settling tanks is adequate.

12.10.3 Adhesion skimmers, Oil types

In contrast, skimmers which incorporate oleophilic materials into belts, drums, discs or synthetic ropes often achieve a higher ratio of recovered oil in relation to water. In general, they work best with medium viscosity oils between 100 and 2000 centistokes although skimmers with toothed discs or chain link belts have been designed specifically for the recovery of heavy oils. These high viscosity oils, such as heavy bunker oil, are extremely sticky and can prove difficult to remove from the adhesion surfaces, whereas, in contrast, viscous water-in-oil emulsions can be almost non-adhesive. Although low viscosity oils like diesel and kerosene can be collected, they do not accumulate on the oleophilic surfaces of skimmers in sufficiently thick layers for high recovery rates to be obtained.

12.10.4 Waves /swell, Currents

Skimmers are designed so that the oil recovery element is positioned at the oil/water interface. This is usually achieved by a self-levelling arrangement and although swell alone does not generally affect performance, none is effective in steep waves.

Small units are easily swamped and pitched around, whilst larger skimmers have greater inertia and cannot follow the wave profiles. The performance of skimmers is also adversely affected by currents in much the same way as for booms. This limitation is partly overcome in some self-propelled skimmers where a sorbent mop array or belt is rotated so that its velocity relative to the floating oil effectively reduced when the vessel is underway.

12.10.5 Self-propelled skimmers

Other designs of self-propelled skimmers can be effective in the calmer waters of ports and harbours. Because they are comparatively expensive they often combine some secondary function such as debris or waste oil collection. Such vessels are often an integral part of response arrangements for oil terminals and refineries where the pollution risk is more predictable.

12.10.6 Power source

Skimmers require power for the recovery element or for transferring the collected oil to a storage tank. Many systems are designed with an integral power pack. Diesel power can be used directly or to drive electric, hydraulic or pneumatic systems. All except petrol engines can be built to conform with safety regulations imposed in refineries, tank farms and other restricted areas where there may be a risk of fire and explosion. When used in potentially dangerous atmospheres, regular tests should be carried out with explosion meters to ensure safe operating conditions, since spark sources can never be completely eliminated.

13 ROLE OF INDUSTIRAL TERMINALS ON KPT LAND

13.1 Roles & Responsibility

Sr. No.	Tank Farm Owners	Persons to be contacted in case of emergency		
		Name and Position	Telephone No.	Mobile No.
1	Kesar Enterprises Ltd., Near Oil Jetty, Old Kandla (Kutch)-370210	Mr. R.K. Gupta Gen. Manager	270435 (O) 295676 (R)	9375349181
2	Kessar Enterprises Ltd, Terminal II, Plot No. 5 &6 Old Kandla	Mr. R.K. Gupta G.M	270435 (O) 270177 (O)	9375349181
3	Chemical & Resins Pvt.Ltd Terminal –I, Near Oil Jetty, Old Kandla, Kutch Terminal – II, Near West Gate, New Kandla – Kutch	Lt. Col. Pramod Kumar (Retd), GM,	270505(O) 236831(R) 270916 (O)	9825225676
4	Indo-Nippon Co. Ltd., Plot No.2, K.K.Road, Old Kandla,	Mr. R.N. Pathak Asst. Terminal Manager	270795(O) 235818(R) 270295(O)	9879571295
5	J. R. Enterprise, Plot No.3, Old Kandla,	Mr. Devendra Dadhich, Terminal In-charge	653528 (O) 257152 ®	9898238380
6	Friends Oil & Chemical Terminals Pvt. Ltd., Near Booster Pump Station, Old Kandla, Kutch	Mr.S.Ramakrishnan Terminal Manager	270987 (O) 257249 ®	9879572107
7	Indian Oil Corporation Ltd., Main Terminal, GIM	Mr. AK. Khanna Sr. Term. Manager Mr. KS Rao, Sr.TM	233274 (O) 229002 (R) 270394 (O)	9427216637 9426416108

	Foreshore Terminal, Kandla KBPL LPG Import Plant	Mr. PS Negi Plant Manager	270628 (O) 270477 (O) 233359 ® 270978 (O) 236944 ®	9426725342
8	United Storage & Tank Ltd Near IOC Foreshore Terminals, New Kandla Gas Terminal, Plot No. 4 Old Kandla	Mr. Manoj Gor Terminal Manager Mr. G. Chudasama	270609 (O) 653525 (O) 651238 ® 653529 (O)	989850029 9904366855
9	IFFCO Kandla Unit, Kandla, Kutch	Mr. L. Murugappan, G.M.(NPK-I) Mr. Brahmbatt Manager (F & S)	270711 270352(O) 270381 (O)	982506922 9099019861
10	BPCL, KK Road, GIM	Mr. RG. Dekate Sr. Manager Operations	234313 (O) 223235 (R)	9099929634
11	HPCL KK Road, GIM	Mr. Murthy Manager (Installation)	230936 (O) 220084 (O) 233078 Ext	
12	INEOS ABS (I) Ltd Plot No. 8 Old Kandla	Mr. Vineeth Nair Dy. Manager	270087 (O) 234409 (R)	9825237029
13	Liberty Investments Pvt. Ltd., Plot No. 1 & 2, Block 'H', New Kandla	Mr. Jitendra Vaidya Terminal Manager	270151 (O) 270464 (O) 270468 (R)	9825025645
14	Avean International Pvt. Ltd., Liquid Storage Tank Terminal, Plot No. B-1, New Kandla	Mr. Bharat Rathod Terminal Manager	270537 (O)	9375310260

15	Rishi Kiran Logistics Pvt Limited, Plot No. 7, Link Road Old Kandla	Mr. RH. Pandya GM (Terminal)	270223 (O) 270443 (O)	9879104556
16	N.P.P. Pvt. Ltd., Old Kandla	Mr. MD.Nagvekar	270347 (O) 257807 ®	9825227649
17	Friends Salt Works and Allied Industries, KK Road, Old Kandla	Mr. NJ.Zinduwadia Sr. Manager Mr. HA. Mehta,S.M	270814 (O) 262698 (R) 271260 (O)	9825506361 9825506360
18	IMC Ltd, Cargo Jetty New Kandla	Mr. Anil Brahmbhat	270369(O) 653524 (O) 296079 (R)	9898126243
19	Agencies & Cargo Care Ltd., Plot No.3, New Kandla.	Mr.Shivkumar Menon, Terminal Manager	270714 (O)	9825226765
20	Dipak Estate Agency Plot No. 5-6, Block – A New Kandla	Mr. Narendra Thacker	270375 (O)	9879611243
21	Parker Agrochem Exports Ltd, Plot No. 3 –4,Block-H New Kandla	Mr. Bharat Thacker	270486 (O) 270528 (O) 231876 (R)	9825238260
22	Tejmalbhai & Co New Kandla	Mr. Ankitbhai Chandan	271330 (O) 230090 (R)	9825225101
23	Parker Agrochem Product Pvt. Ltd, Plot 7-9/A,N.Kandla	Mr. Raja Babu Dy Manager	270528 (O) 231876 (R)	9979158543
24	Mother Dairy Fruit & Vegetable Pvt. Ltd, Near Oil Jetty, Old Kandla	Mr. Saju Therattu	270654 (O) 270655 (O) 230979(R)	9974022681

The individual terminal will have to ensure the following in the event of emergencies arising out of:

a) Natural disaster
b) Toxic release

c) Flammable vapour release
d) Road tanker / Rail tank truck transportation accident
e) Fire
f) Flooding

13.1.1 Natural Disasters

- Ensure that adequate staff are posted at the terminal to meet any eventuality
- Ensure all operations are shut down
- If possible, ensure disconnecting pipelines
- Provide 48 hours food supply as well as portable water supply at the terminal

13.1.2 Toxic Release

- Ensure that the staff is evacuated in the direction opposite or as far as possible at 90 degree to the direction of the wind
- The staff located at the site to ensure safe operation, should be provided with gas masks
- Do's and Don'ts should be posted outside the control room to ensure minimum loss to life

13.1.3 Flammable Vapour Release

- It should be ensured that all possible help is rendered to the affected site / terminal
- The fire and safety officer at Kandla Port fire station should be informed
- Information pertaining to fire should be relayed to Main Emergency Control room at Gandhidham
- Information regarding fire incident should also be relayed to Kandla Free Trade Zone fire station
- Security personnel of the individual terminals should also be on standby to assist in fire fighting if the need be
- Mutual Aid Agreement should be signed between all the terminals as well as the KPT
- IOC LPG terminal should assist the affected terminal by way of sharing their experience in terms of plugging a chemical/gas leak
- The terminal Manager of the terminal next to the affected terminal should also inform the CISF

13.1.4 Road Tanker / Rail Tank truck transportation accident

- The dispatch terminal to whom the cargo belongs is responsible for attending to the mishap
- The dispatcher has to inform the exact location of the accident to the Main Emergency Control Centre as well as to the local emergency control room at Kandla
- CISF Commandant has to be informed by the dispatcher of the site of accident
- The Fire and Safety Officer stationed at Kandla Port should also be informed with specific name of the chemical

- In case the road tanker involved happens to be containing POL products then HPCL, BPCL and IOCL should be contacted immediately
- Accident involving rail tank truck i.e. LPG should be informed to the IOCL LPG Terminal Manager immediately
- In case of any leakage reported from LPG road tanker or rail tank truck the same should be arrested by the IOCL team

13.1.5 Fire

- Inform the Kandla Port Fire and Safety Officer
- Ensure that information pertaining to the Chemical involved in fire is passed to the Main Emergency Control Centre at Gandhidham as well as Kandla
- Information should be relayed to CISF regarding the fire
- In case it is a fire related to POL product then the oil majors i.e. HPCL, BPCL and IOCL should be contacted
- In the event of chemical fire it would be the collective responsibility of the Kandla Port Trust as well as the dispatcher to ensure that the spill is controlled and collected

13.1.6 Flooding

- Terminal should have trolley mounted pumps preferably of flame proof type to ensure dewatering of the site
- Gum boots should be supplied the staff at the terminal
- The electricity supply to the terminals should be shut off to avoid short circuit
- The trolley mounted pump should have DC supply in order to ensure continues operation
- It should be ensured that all the drains should be cemented and free of any debris which could hamper the flow of water

The following occupiers shall be a part of the emergency team for rendering expert advice. (This composition may be changed once in three years on rotation basis.)

13.2 Toxic Team

- IFFCO
- Chemical & Resins Ltd.
- United Storage & Tank Terminals Ltd.
- Bayer ABS

13.3 Fire Team

- Kesar Terminal I
- Indo Nippon
- Friends Oil & Chemicals Ltd. (FOCL)
- Friends Salt Works & Allied Industries Ltd. (FSWAI)

13.4 Transportation Team

- IOCL POL TERMINAL

- HPCL
- BPCL

13.5 Natural Disaster Team

- J. R. Enterprise
- J. K. Synthetics
- Synthetic Chemicals

Individual terminals shall be responsible for ensuring that safe shut down has been affected aftermath of a disaster in the neighborhood.

In case of dry docks KPT shall assume the charge of the emergency controller along with P&O to ensure that all the staff is evacuated from the area barring the security and the emergency team.

The emergency team would be drawn essentially from CISF and Marine Department i.e. at the behest of Harbour Master as well as P&O. In the event of an impending natural disaster like cyclone only CISF personnel to be stationed at the wharf. For the ships berth at the dock please refer to the cyclone disaster plan as annexed.

The emergency team should have the following:

a) Chemical data sheet
b) Protective clothing
c) Breathing Apparatus
d) Safety Harness
e) General tools and flash light
f) Leak plugging equipment like wood plugs
g) Analytical equipment like explosivemeter
h) Flood light with generator
i) First Aid kit
j) Portable diesel operated fire water pump

The responsibility of the various teams mentioned above would be to follow the following procedure:

a) Keep people away
b) Inform incident Controller i.e. at Main Control Room
c) Contain the chemicals
d) Avoid igniting the chemicals by ensuring muffler on the exhaust
e) Obtain chemical data sheet

The communication parameters which need to be relayed to the Emergency Control Centre

a) Place and time of the incident
b) Chemicals involved
c) Condition of the container
d) Injuries or deaths

e) Area surrounding (open country, town)
f) Weather conditions
g) Assistance available (police, fire services)
h) Means of maintaining contact

Logistic Team

The function of Logistic Team is to ensure necessary supplies are available to Response Team during the emergency. In addition to above mentioned, the function is also responsible for organising and maintaining the staging area where emergency material and equipment is to be temporarily stored and assembled before rapid deployment. The Logistic Coordinator will be reporting to the Emergency Chief Incident Controller and keep him updated on the availability of supplies and equipment or of any anticipated need.

Typical list of emergency equipment and material is given below:

- Fire extinguishers
- Fire fighting agents
- Fire hoses an nozzles
- Personal protection apparatus like fire suit (proximity suit)
- Chemical resistance protective clothing
- Self contained breathing apparatus
- Respirators
- Emergency lights
- Power generators
- Portable radios and cellular mobile phones
- Spill control agents for decontamination of toxic spills
- Plastic containers and lining material for diking and damming
- Earth moving machinery
- Fuel and gasoline for operation of vehicles and machinery

14 LINKS BETWEEN THE ARMY, COAST GUARD & AIR FORCE

Aftermath of any disaster the recovery and relief operations are conducted on a war footing.

The task involved usually demands rough and tough and dedicated personnel who are trained professionals to meet any challenge be it evacuating people marooned due to flood or making shelters or transporting relief to inaccessible areas. It is for this purpose that the army, air force and the coast guard would be required to assist the Kandla Port Administration.

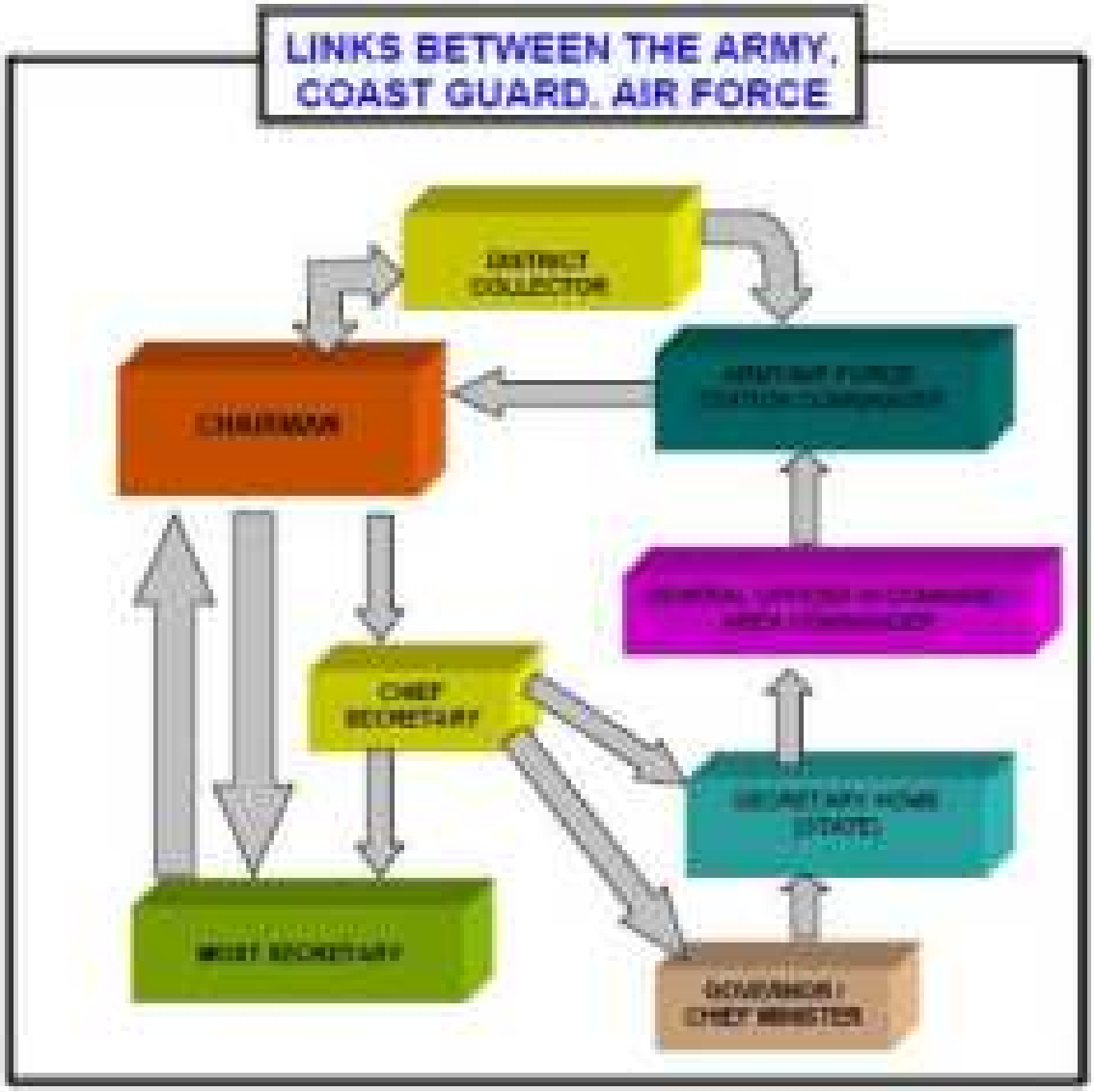
The Chairman / Deputy Chairman would be the coordinating officials for liaisoning with the Station Commander (army, navy as well as air force) after consulting the District Administration.

While seeking assistance from the army, air force or the coast guard the following documents should be kept ready for reference:

- Overall plot plan of the Kandla Port
- Clear demarcation of the affected area on the plot plan
- VHF link frequency for establishing contacts with the signal room as well as CISF commandant.
- List of all the important telephone numbers.
- In the event of Cyclone, keep the task force updated on the weather condition.
- Ensure that the emergency team is extending their full co-ordination to the task force.
- For ready reference the Secretary should nominate a person who should be made responsible to taking notes on what is happening and what sequence.
- The areas, which could be used as temporary shelters should be indicated to them.
- Open space which can be used as staging area should be indicated to them.
- All the medical staff should be kept on standby and they should be asked to act after consulting the Army or the Air force teams.
- In the event of air evacuation requirement it should be ensured that the people being evacuated are listed and the number of sorties required is noted.
- In the event of a cyclone and an resultant Ammonia Gas leak it should be noted that the Army and the Air force should be provided with gas mask (if the need be).
- Data pertaining to the number people in the affected areas (an approximate) should be made available to the Army / Air force.

The flow of information for co-ordination:

Chairman District CollectorChief SecretarySecretary - Ministry of Surface TransportGovernor / Chief Minister of the state ARMY/AIRFORCE.


LINKS BETWEEN THE ARMY, COAST GUARD, AIR FORCE
DISTRICT COLLECTOR
CHAIRMAN
CHIEF SECRETARY
SECRETARY HOME (STATE)
GOVERNOR / CHIEF MINISTER

15 PROCEDURE FOR CO-ORDINATION

The overall responsibility of the Emergency management lies with the Chairman, Kandla Port. He assumes the responsibility of Chief Site Controller on receipt of the information of an emergency or an impending emergency.

Some of the critical functions are:

- Activation of the emergency response organization
- An ongoing emergency assessment, including upgrading or downgrading of the emergency alarm level
- Notification of outside governmental agencies
- The decision to ask for outside help and resources
- The decision to evacuate the people
- Decisions involving the safety of off-site vulnerable points (e.g. recommendations to evacuate or take shelter, in the case of a toxic vapour release).
- Decisions to shut down/restart the Port.

The Chairman i.e. the Chief Site Controller shall be responsible for designating the Incident Controller, the Field Controller as well as the Liaison Officer as well as Public Relations Officer.

Functions like

- Communication
- Fire, Safety and Rescue
- Special hazard
- Utilities
- Engineering / technical function
- Medical function
- Logistic function
- Security function
- Administrative function

EMERGENCY NOTIFICATION SHEET	
1.	Plant / Location Name _____ Unit _____ Address of Plant / Site _____
2.	Date _____ Time of Call _____
3.	Caller's Name _____ Caller's Position _____ Caller's Telephone Number _____
4.	Time (or Anticipated Time) of Accident / Emission _____ Projected Duration of Accident / Emission _____

5.	Type of Accident / Emission _____
6.	Emergency Alert Level (EAL) : Check One ALERT [ ] SITE EMERGENCY [ ] GENERAL EMERGENCY [ ]
7.	In case of Toxic Release :
	Chemical Name of Substance Released_____ Amount and/or Rate of Release _____ Estimated Duration of Release _____ Type of Release (Gas, Liquid or Solid) _____ Toxicity / Flammability _____ Potential Impact on Offsite Area _____ Estimated Area Affected by the Release _____
8.	Weather Condition _____ Wind Speed _____
9.	Casualties / Damages _____
10.	Brief Description of the Accident _____ _____ _____
11.	Assistance Requested _____ _____ _____ _____
12.	Signature _____ Date _____ Time _____

15.1 Procedure for Co – ordination

CHAIRMAN / DY CHAIRMAN
DEPUTY CONSERVATOR
SECRETARY
MEDICAL DEPARTMENT
GENERAL MANAGER
CISF
DEPUTY SECRETARY (P)
EST MANAGER
CHIEF ENGINEER
PUBLIC RELATION OFFICER
HARBOR MASTER (FIRE & SAFETY)
PROJECT
FLOTILLA SUPDT.
TRAFFIC MANAGER
EXECUTIVE ENGINEER
ASSISTANT EXECUTIVE ENGINEER (PIPELINE)
ASST / TRAFFIC MANAGER
ASST / TRAFFIC MANAGER
SCIENTIFIC OFFICER
OFFICER
TUG OFFICER

16 ASSEMBLY POINTS & ESCAPE ROUTES

1. There are two main escape routes from the port side i.e. by land:

- Kharirohar road.
- Main NH 8 i.e. leading to Gandhidham.

2. The sea route would be the Kandla creek and other creeks i.e. Phang creek, Sara Creek or Rohar Crek or Nakti Creek connecting the same.
3. Air evacuation can be undertaken by Helicopter or from Kandla Aerodrome.
4. KPT to prepare list of all the personnel in their port colony and have it posted at the assembly area.
5. The assembly points in the Cargo Dock for the workers in the area between the North Gate and the plot number five would be the area in front of the Railway Station.
6. The assembly point for the port township could be between block E&D and at the intersection of Block 'B'.
7. The assembly point for each of the adjoining berth would be on the road i.e. used for moving between the warehouse A,B,C,D and the berthing area.
8. However for the workers working in the warehouses as mentioned above the assembly point would be the central road between the two streams of warehouses.
9. The workers working in the bins i.e. open storage the assembly point would be the area in front of the West Gate # 2.
10. For bins closer to the West Gate #2 fire brigade station the staging area for the fire station would be used as assembly point.
11. Computer should be installed in the rooms next to the assembly point connected to the time office for a list of people inside the port and the same should be made available at the railway station.
12. Railway station should have emergency evacuation counter all the personnel being evacuated from the area should be asked to check-in at the counter before they board the train.
13. The PA system at the assembly area should be used to announce "do not carry any luggage or belongings just carry as much is bare essential in clothing".
14. The point of departure from the Dry cargo area would be West Gate 1 & 2 as well as North Gate and in an extreme case one would have to use the jetty being used by the pilots for evacuation by sea.

17 RECOVERY FACILITY RENTRY & RESTORATION OF SERVICES

The recovery and re-entry phase will begin after the declaration of termination of emergency situation. This determination would be made by the Chief Incident Controller. The recovery plan would be flexible enough to adapt to existing conditions. All of the conditions that may be encountered in an emergency situation cannot be anticipated in advance. Detailed plans and procedures for recovery operations would be prepared at the time they are needed.

Re-entry operations would be performed by the Re-entry Team, which would be same as that of green team under the leadership of the Chief Incident Controller.

The team shall consist of personnel knowledgeable in procedures and facility layout. In the Re-entry planning process, the team will gather available information on the nature of the emergency and its present status by methods such as discussions with the operations personnel on-shift. Necessary protective clothing and equipment would be available for the team before re-entry is authorized.

Specific procedures for recovering from an emergency and re-entering the facility can hardly be provided, since they will have to be determined on a case by case basis, depending on the type of accident and the severity of the damage suffered. However, provision would be made for the following:

- Organising a re-entry team
- Inspecting the damaged area
- Declaring the emergency concluded and making the "all clear" known to the facility employees and the community
- Deciding which employees would report to work and notifying them
- Beginning an investigation into the causes of the emergency
- Assessing the damage to the facility
- Transferring necessary operations to alternative locations
- Decontaminating the damaged area
- Restoring services to the damaged area
- Clearing up the debris
- Salvaging material and equipment affected by the emergency
- Restoring the parts of the facility affected by the emergency
- Determining responsibilities and instituting possible insurance and damage claims

In case of an aftermath of a toxic release, it should be ensured that Chief Incident Controller and the party carrying out the recee to ascertain the termination of emergency, should be carrying self-contained breathing apparatus as well respiratory masks.

Please note in the event of a natural disaster the recovery team would involve the usage of ARMY or other paramilitary forces the same would be under the control of the station commander and the overall Controller shall be the District Collector.

18 MAINTAINING EMERGENCY RESPONSE CAPABILITES

In order to ensure a prompt and professional emergency response capability, port personnel are required to be knowledgeable of the possibility of various emergencies and emergency actions. General safety training should be provided to all employees to familiarize them with alarms, evacuation routes, safe assembly points, etc. In addition, personnel who are a part of the Emergency Response Organization are required to have additional training and should participate in periodic drills and exercises.

18.1 Training & Education

Regular training should be provided to all personnel who have a role in planning and operational response to an emergency. The main goal of training for emergencies is to enable the participants to understand their roles in the response organization, the tasks associated with each position and the procedures for maintaining effective communications with other response functions and individuals.

The training objectives are:

1. To familiarize personnel with the contents and manner of implementation of the Plan and its procedures.
2. To train personnel in the performance of the specific duties assigned to them in the plan and in the applicable implementing procedures.
3. To keep personnel informed of any changes in the plan and the implementing procedures.
4. To maintain a high degree of preparedness at all levels of the Emergency Response Organization.
5. Train new personnel who may have moved within the organization.
6. Test the validity, effectiveness, timing and content of the plan.
7. Update and modify the plan on the basis of experience acquired through exercises and drills.

Selected port personnel should receive instruction in the use of the fire fighting and emergency equipment available at the site. All personnel working at the site should receive instructions in fire prevention and in basic fire fighting techniques. Periodic refresher training should be provided and supplemented by fire drills.

Crews of tugs, which can be used for fire fighting, should receive instruction and

training in fighting petroleum fires in co-operation with land based fire-fighting services. In order to utilize fully the tugs firefighting equipment and capability during an emergency, it may be necessary to supplement the crew with trained shore personnel. Opportunities should be provided at frequent intervals for combined practices involving the tugs and shore fire fighting services.

Opportunities may arise whereby a combined fire practice or conference can be arranged between shore personnel and crew members of tanker at berth without imposing an operational delay on either the berth or the tanker. This should help make the tanker personnel familiar with the firefighting equipment ashore. Shore personnel should also have the opportunity of becoming familiar with the types and locations of firefighting equipment on and of being instructed in any design features on tankers which may require special attention in case of fire.

18.2 Drills & Exercises

Emergency drills and integrated exercises have the following objectives. These constitute another important component of emergency preparedness. They refer to the re-enactment, under the assumption of a mock scenario, of the implementation of response actions to be taken during an emergency.

1. To test the adequacy of the effectiveness, timing, and content of the plan and implementing procedures.
2. To ensure that the emergency organization personnel are familiar with their duties and responsibilities by demonstration.
3. Provide hands-on experience with the procedures to be implemented during emergency.
4. Maintain emergency preparedness.

The frequency of the drills should vary depending on the severity of the hazard. However, drills should be conducted once in a year. Scenarios may be developed in such a manner as to accomplish more than one event objective.

Drills and exercises will be conducted as realistically as is reasonably practicable.

Planning for drills and exercises should include:

- The basic objectives
- The dates, times and places
- The participating organizations
- The events to be simulated
- An approximate schedule of event
- Arrangements for qualified observers
- An appropriate critique of drills/exercises with participants

Evaluation of drills and exercises should be carried out which should include comments from the participants and observers. Discrepancies noted by the drill observers during the drill shall be pointed out during the drill. A written evaluation of the drill or exercise should be prepared by the individual responsible for conducting the drill or exercise. The evaluation should include assessments and recommendations on:

- Areas that require immediate correction.
- Areas where additional training is needed.
- Suggested modifications to the plan or procedures.
- Deficiencies in equipment, training, and facilities.

The evaluation of a drill or exercise shall be submitted to the Main Controller for review and acceptance who shall then determine the corrective actions to be taken and assign the responsibility to appropriate personnel.

The Chief Fire Officer should track all approved drill and exercise corrective actions as a means of assuring that corrections are made in a reasonable amount of time, and shall advise Main Controller of the status of implementation of corrective actions.

Records of drills, exercises, evaluations, and corrective actions should be duly maintained.

18.3 Review of the plan

The Plan and associated implementing procedures should be reviewed to ensure compliance with relevant regulations and applicable state and local emergency plans and written agreements with mutual aid companies also.

The plan should be reviewed under the direction of the Chairman who should encompass the plan, response procedures, equipment, training, drills and interfaces with local emergency management agencies. The need for changes is based upon the following aspects:

- Written evaluations of drills and exercises which identify deficiencies or more desirable methods, procedures, or organizations.
- Changes in key personnel involved in the organization.
- Changes in the facility organization structure.
- Changes in state regulations.
- Modifications to the facility which could affect emergency planning.
- Recommendations received from other organizations and state agencies.

18.4 Emergency Control Center

The Emergency Control Centre is located in the Board Room of Administrative Office Annexure Building at First Floor.

This room will have seating arrangements for all members of Disaster Management Group.

It will have the following:

1. Adequate number of telephones. One of these telephones shall be used for outgoing telephone calls only.
2. Internal telephones, telex, fax.
3. VHF transceiver having marine band capable of being operated by mains or battery.
4. Hot line linking deputy commissioner of the district.
5. Internal and external telephone directories.
6. Emergency manuals.
7. Emergency light.
8. Wind direction and speed indicator.
9. Plan of the port showing:
   - Berths/Areas where hazardous materials are handled
   - Sources of safety equipment's
   - Personal protective equipment such as aprons, gloves, gum boots, etc.
   - The fire fighting system
   - Stocks of other fire-extinguishing materials
   - Site entrance and roadways, updated at the time of the emergency to indicate roads which are to be used and which are not to be used.
   - Assembly points and routing
   - Medical centers.
   - Layout of pipelines in the Port area
   - Lorry parks and rail sidings
   - Port location in relation to the surrounding community (5 km map)

19 KANDLA PORT TRUST OFF SHORE OIL TERMINAL – VADINAR PORT

19.1 Vadinar Port Information

Vadinar Port is an important port in Kandla Port Trust Group of ports under the control of Kandla Port Trust, Kandla. The port is just 55 Kms from Jamnagar city.

Latitude: 22 Degree 26'25' North
Longitude: 69 Degree 40' 15' East

Charts – Gulf of Kutch Chart No: 203

19.1.1 Metrological Data

1. Temperature: Summer Maximum 38Degree C, Minimum 19Degree C
2. Temperature: Winter Maximum 36Degree C, Minimum 14Degree C
3. Annual rainfall: Average 241.2 mm
4. Average Wave Height: 30 Centimeter (Summer)
5. Average Wave Height: 25 Centimeter (Winter)
6. Maximum Wave Height: 45 Centimeter
7. Maximum Tide – 6.12 Meter
8. Minimum Tide – 0.02 Meter
9. Wind Speed – Average Wind Speed – 16 knots/hour
   - Summer – 25 knots / hour
   - Winter – 18 knots /hour
10. Anchorage: Anchorage areas are about 4.5 miles from shore.

19.1.2 Off Shore Oil Terminal (O O T) Vadinar

The Kandla Port Trust has commissioned the off shore oil terminal facilities in 1978 jointly with Indian Oil Corporation by providing Single Buoy Mooring (SBM) system having a capacity of 10MMTPA was first of its kind in India. The following are the salient features of the operations at OOT Vadinar.

- A draft of upto 30 meters at SBMs and Lighterage Point Operations (LPO)
- The Single Buoy Moorings can handle vessels having length of 335 meters.
- Handling VLCCs upto 3,00,000 DWT
- Providing crude oil intake for the refineries of M/s. IOCL at Koyali (Gujarat), Mathura (UttraPradesh), and Panipat (Haryana).
- Commissioned the first SBM on 27th August 1978.
- M/s. IOCL Commissioned the second SBM on 25th October 1997.
- Commissioned the third SBM (Essar) on 29th December 2006.
- Simultaneous handling of 3 vessels at three of SBMs
- Vast crude tankage facility of M/s. IOCL having capacity of 11, 44,000 KL.
- 2 High powered Tug of 50 Ton BP.
- Two Tugs of 35 ton BP &

- Two 50 Ton BP tugs for smooth operation is being acquired.

19.1.3 Export Jetty (Essar)

- One Ro - Ro / Lo - Lo Jetty for handling of project cargo / construction material / spare parts.
- Product Jetties (Private Berths at the Port)
- Essar Jetties are used for tankers Loading of POL product cargo by alongside.
- The Jetty No 1 – commissioned on 6th December 2006.
- The Jetty No 2 – commissioned on 29th December 2009.

19.2 Control Room –Vadinar Port

There is one control room at A.O. Building, Vadinar Jetty under the direct supervision of Pilot, stationed at Vadinar. In absence of Pilot, the other Pilot posted at Vadinar and XEN (M&E) shall be responsible for the direct supervision of the Control room at Vadinar, in association with Marine Engineers Grade - II. They shall rush to the Control room as soon as the Action plan is put into force. Two persons viz. one Assistant, Flotilla Supervisor and one Signalman shall report for duty to the In-Charge of Control Room immediately, as soon as the Control room comes into operation. The In-Charge should draw-up rosters of the said employees shift-wise and assign duties to them. The In-Charge shall ensure the presence of the staff as to whom various duties have been assigned. They should attend the meetings as and when called. In case of absence of the staff, the matter should be informed to the C.O.M. (OOT), who shall take disciplinary action against the erring employees.

The Control room has the following assets

Telephone	Fax	VHF Signal
(02833) 256749/256555/256296	(02833) 256540	Marine Channel 12,16,8,10
Mobile Phone Nos. 9825212359 / 9825212360 / 9825148556	(02833) 256296	
Xerox Machine/ STD telephone	(02833) 256540	

Inmarsat Mini M. Terminal and / or V.Sat Terminal Antenna are required to be set up and installed at Vadinar.

19.2.1 Manning at Vadinar Control Room Jetty

Any one of the Contract Pilots is available at Vadinar

Sr No	Name of the Official	Designation	Telephone
1	Shri S.M. Vaishnani	XEN(M&E)	256556(O) / 9825148556
2	Shri S. Prabagaran	M.E. Grade-II	256525 (R) / 9426711173
3	Shri H. M. Sathwara	Office Supdt	256574 / 9925303373
4	Shri Chainkukar	A.F.S	256269 (O) / 256517 (R)
5	Shri Virendra Yadav	A.F.S	256269 (O) / 256817 (R)

6	Shri S.P. Bariya	Signalman	256296/256555(O) 256750 (R)
7	Shri P.C. Kothari	Signalman	256296/256555 (O) 256745 (R)
8	Shri Rahul Ninjar	Signalman	256296/256555 (O) 256180 (R)
9	Shri Krishna Prajapati	Signalman	256296/256555 (O) 256994 (R)

19.2.2 Obtain Information from following Sources

1. State Meteorological Control Room, Ahmadabad
2. Meteorological Control Room. Delhi
3. District Civil Defense Control Room, Jamnagar
4. Air Force Station, Jamnagar
5. Naval Base, Porbandar / Vadinar
6. All India Radio, Rajkot
7. Doordarshan, Ahmadabad
8. Control Room, KPT, Kandla / Gandhidham
9. Meteorological Section, New Kandla,
10. Signal station, New Kandla.

The information so collected shall be maintained by making hourly log entry in a register.

19.2.3 Control Room Assets

1. Xerox machine
2. STD telephone
3. Fax machine
4. Inmarsat Mini M. Terminal / and or V. Sat Terminal antenna, are required to be set up at Vadinar jetty

The In-Charge of Control room should ensure setting up of the Control room at Vadinar jetty immediately on receiving warning and matter be reported to C.O.M. who in turn apprise the Dy. Chairman and Chairman, KPT.

The control room shall remain in touch with various authorities / agencies like State Govt. / Distt. Authorities / and local authorities. Besides, Naval Authority Okha-Porbundar should also be contacted on VHF/UHF frequency, round the clock. In the prevailing set up of CISF Security control staff at Vadinar, Officer-in-charge of C.I.S.F. Unit of KPT Vadinar along with his entire CISF Security Personnel will remain in contact with In-charge of Control Room for posting of CISF Security Personnel at various locations as per the requirements and they will carry out the duties and responsibilities as required & assigned under this Action Plan.

In case the Marine Signal No.8 is issued, the Vadinar jetty area will be evacuated including the Control Room, which shall be shifted to Room No.5 of Port Guest house at Vadinar colony. In this regard, XEN (E&M) shall pre-plan installation of VHF Antenna and drawing extension line of there available Telephone Nos. (02833)-256533 / 256714 at Port Guest House at Colony and ensure laying of cable

with suitable connectors with the Wireless Sets duly tested and thereafter to be set up there at Guest House.

19.3 Functions of Control Room –Vadinar Port

Control room shall remain in touch with State level / District level Meteorological Department / Masters of ships at Vadinar, Navy / Coast Guard at Porbandar / Vadinar and also with the Control Room of KPT at Kandla/Gandhidham.

Telephone numbers of concerned contact persons are as under:

STD code: Jamnagar (0288), Vadinar (02833)

Sr. No	Name of Organization / Contact person	Office	Residence
01	Chairman, Mutual Aid District Collector, Jamnagar	2555869	2554059
02	Joint Chair Person, Mutual Aid Commissioner, JMC, Jamnagar	Fax No.2554454 2552321	2552372
03	Distt. Supdt. of Police, Jamnagar	2554203	2555868
04	Police Control Room, Jamnagar	2550200	
05	Police Control Room, Sikka	2344249	
06	The Dy. Chief Controller, Civil Defense, Jamnagar	2540371 2674758	2671828
07	Control Room, Collector Office Jamnagar	2553404	
08	Port Officer, GMB, Jamnagar.	2712815 Mobile:9426239289	2554942
09	Commandant, Home Guard, Jamnagar	2553862	
10	Mamlatdar, Khambhalia	234788	234736
11	Dy. Collector, Khambhalia	234577	
12	Police Station, Khambhalia	234735	
13	Fire Officer, Fire Station, Jamnagar	2662690 Mobile:9879531101	2550340
14	DEAN, Irwin Group Hospital, Jamnagar (Now Guru Gobind Singh Hospital)	2553515	2553676
15	Indian Air Force, Jamnagar Extension: 222/257 Wing Commander	2720003 to 009 2720004-2720005	
16	Duty Officer, INS, Valsura, Jamnagar	2550263-222 extn.	
17	CISF, Coast Guard, Vadinar	02833-256559	02833-256558

18	DGM, IOC, Vadinar	02833-256527	02833-256567
19	Chief Operation Manager, IOC, Vadinar	02833-256984	02833-256559
20	Dy. Manager (operation), IOC, Vadinar	02833-256545	02833-256530
21	Fire Brigade, IOC, Vadinar	02833-256542	02833-256559
22	Main Board of M/s Essar Oil Limited, Vadinar	02833-241444	
23	Security Control Room, Essar, Vadinar.	02833-241917	02833-241191
24	Vice President, (P&Admn) ESSAR Vadinar Refinery.	02833-241107 02833-241167	02833-2550976 02833-2662856
25	M/s. Reliance Petro. Ltd., Moti Khavdi	0288-6610101	

Information from the above officers will be collected and transmitted to the C.O.M. (OOT) on hourly basis between 0800 to 2000 hours & 2000 hours to 0800 hours respectively. The said information shall be passed on to Dy. Chairman / Chairman on three hourly basis.

The Vadinar control room shall maintain logbook of messages received from and to Control Room at Gandhidham continuously and report to the COM (OOT) every hour. The information shall be passed on to Dy. Chairman / Chairman depending upon the importance. It shall be the responsibility of the Control Room staff to ensure that the information is passed on timely and proper monitoring is done.

The following are the Website addresses through which the required information regarding the position of the Cyclone can be ascertained.

http://www.imd.gov.in/
http://www.supertyphoon.com/indian.html
http://www.npmoc.navy.mil/products
http://www.solar.ifa.hawai.edu/tropical/tropical.html
http://www.wunderground.com/tropical

19.4 Stopping of Port Operations

In case of emergency situation, local port authorities like COM (OOT) will decide about the stoppage of the port operations which will be stopped after consulting DGM, IOC / Essar, and ordered by Dy. Chairman / Chairman. In case COM (OOT) is not available in the emergency situation, senior most Executive Engineer is authorized to take such decisions in consultation with Gandhidham officials. Under such situation COM (OOT) in co-ordination with officials of Indian Oil Corporation

Ltd. and M/s. Essar, shall get the operation at all three SBMs stopped and also get the hoses dis-connected from the tanker berthed at SBMs and un-berth tanker from Product jetty of Essar. Pilot of KPT on board the tankers will immediately take action to castoff the tanker from SBMs/Product berths and tankers will be directed to go to suitable safer place in that situation. All the ships waiting at own anchorage or working at anchorage will be asked by Vadinar control to go off in open sea at least 5 Nautical miles away from SBM. The tankers carrying out transshipment operation at LPO (Lighterage point), will be asked to stop the operation immediately and be on their own power to be away from other ships in the vicinity.

19.5 Securing of Ships / Crafts / Tugs etc

Pilot / M.E. Grade-II / both the AFS, should be available at Vadinar in case of Action Plan is in operation and situation like emergency. Immediate action for stopping the shipping operation should be taken by informing concerned agencies like IOC, ESSAR, and Shipping Agencies and also to KPT Tug / Craft working for the shipping operations at SBMs / LPO point and Product berth of Essar at Vadinar.

Both the AFS and AXEN (Mech.) should ensure that all the big crafts are moved out of Pathfinder Creek and all Port crafts & small crafts of private parties are placed at inner and outer side of the Vadinar Berthing Jetty or any other suitable location pre-decided and notified. If it is impossible to remove them, then all other steps should be taken to ensure safety of vessel / crafts at the Vadinar port, as also it would not cause any damage to the port. For the purpose of securing of ships / all crafts, pilots assisted by Marine Engineers Grade-II and XEN (E&M) will jointly assess the situation and get the crafts/tugs secured accordingly. The Pull Back tugs shall be secured safely at the Berthing Jetty and Crafts/dumb barge of outside agencies will be placed at safer places in this area. Both AFSs, will ensure while directing all the flotilla staff to take care of the safety of Floatilla. They will look after Pull back tugs and all other Masters will look after the Port flotilla with the help of team of Lascars, Serangs, Quarter Masters and Engine staff. The private Tugs & dump barges engaged by M/s. Essar and M/s. IOC and placed at approach jetty or RO-RO LO-LO jetty shall be ensured to secure at a place decided well in advance by XEN (E&M) and AFS after consulting authority of M/s. Essar and M/s. IOC. A compliance report of securing all crafts at safe places should be furnished to Control Room immediately on issuance of Cyclone Signal No.5.

Both the AFS should ensure the sufficient stock of mooring ropes and heaving lines, etc. to meet operational requirements during the emergent situation and sufficient number of life buoy, life jackets, etc. kept in easily accessible places in each crafts and at various other places on shore too.

19.6 Communication

XEN(E&M) and XEN (Civil-II) shall ensure on hourly basis by ringing personally that the telephones of signal station, AO Building, Estate Office, Hospital, Electric and Water supply are functioning, failing which they shall take up the matter with

concerned BSNL authorities. In case of any difficulty in communication system, COM (OOT) should be contacted.

The satellite phone or V-Sat communication network should be established and put into operation at the earliest, by the following Signalmen:

1. Shri S.P. Bariya.
2. Shri P.C. Kothari.
3. Shri Rahul Ninjar.
4. Shri Krishna Prajapati.

They will ensure the charging of walkie-talkie, Mobile telephones, as well as satellite phone available at the Signal Station, Vadinar.

The staff at Jamnagar Liaison office shall remain present on 12 hourly shift basis round the clock; to carry out the liaison work during the Action Plan is in operation and any other work as may be assigned during the period of Calamity. S/Shri V.M. Mehta, Assistant shall communicate with the Gandhidham/Kandla officials in case Vadinar communication is cut off from that of Gandhidham/Kandla

19.7 Traffic Movement & Security

XEN(C-II) and In-charge of CISF (KPT) Vadinar unit shall ensure that all incoming traffic to the Port jetty of Vadinar is stopped except those which are coming for rescue operations and essential services. They shall ensure posting of adequate security personnel, at various security points in co-ordination with the local police authority. XEN (Civil-II) and S.I. (W&W) should ensure safety of essential service premises like water overhead tanks / Main Store / Electric Station at colony. In addition, the in-charge of CISF Unit (KPT) Vadinar in co-ordination with XEN (Civil-II) shall ensure the posting of Security personnel with arms at all strategic locations, such as Control Station room at Jetty & Port Colony, Water supply tower, etc.

19.8 Medical Aid at Vadinar Port Health Center

Medical Officer (O.O.T.) being Officer in-charge at Health Center, Vadinar & other complete Health Center staff will remain in state of readiness to deal with any casualty by setting up a Casualty Emergency Room at the Health center, Port Colony, Vadinar. The Casualty Emergency Room shall start functioning as soon as Action Plan is put in operation and warning of the calamity is received. No staff of the Health center will be given leave during the period and Casualty Emergency room will function round the clock with posting of Doctor and staff round the clock. Medical Officer shall remain present and, apart from attending the patients, will allocate various duties to the available medical & Para-medical staff, such as maintaining records of patients attended and preparing a report thereof. Adequate number of chlorine pills should be distributed after the calamity is over, to avoid epidemic from spreading. M.O. (OOT), being Officer in-charge shall pre-plan for assessment & urgent requirements of all kind of the medicines to meet with the

situation which may arise in case of any Natural Calamity. He should arrange to obtain the advance approval for immediate procuring of such medicines and the same should be procured & stocked readily available in advance.

19.9 Action to be taken by Pilots

In case of receiving cyclonic weather warning i.e. **on declaration Weather Warning signal No.5 at Port**, Pilot on the Board at SBM should un-moor the tankers and direct the Master of vessel to move the vessels to safer places i.e. away from the SBM. While returning to the Jetty by the Port craft, the Pilot should ensure that all the Port crafts are secured properly and safely at both inner and outer sides of the jetty. He should also ensure that ropes are doubled up and the tugs are manned at all times and engines are kept in readiness to move out in case of emergency.

Meanwhile, till the time the Pilot returns to the Jetty, the AFS on duty will not waste time and initiate action to secure the smaller crafts, which will further be inspected by the Pilots. Masters of all the smaller crafts should also be directed to ensure proper fendering arrangements are provided and if required extra fendering to the crafts may be provided. AFS shall ensure that the proper fendering arrangements are provided to all crafts before on set of inclement weather. Port crafts will get the priority over the private crafts to come alongside jetty. If any space is available, the private crafts can be allowed to come alongside the jetty.

After observing/monitoring weather conditions, intensity, speed and direction of propagation of Cyclone, necessary arrangement for abandoning the crafts may be made and on declaration of weather warning Signal No.8, the Vadinar jetty area will be evacuated including jetty Control Room, which shall be shifted to Room No.5 at Port Guest House at Vadinar Colony. In the month of April every year, Signalmen under guidance of XEN (M&E), shall inspect & ensure working of all the equipments meant for Control Room of Jetty as also readiness of all the electric connections / charging points at the above alternate location of Control Room at Colony.

19.10 Generator Set

Wherever Generator sets are required due to power failure at Port Jetty and colony, AXEN (Electrical), JE (Electrical) shall be contacted who shall immediately arrange to provide the DG set already procured & available with Electrical section, giving preference to the operational area. However COM (OOT) shall be free to hire additionally required DG sets for a suitable period, if the same is not found adequate available in store.

AXEN (E), JE (Elect.) shall prepare a roster of staff of Electrical section for putting the D.G. sets installed & commissioned at the following destinations in operation and attending faults, if any occurs, during the operation of Action Plan and ensure readiness for meeting with emergency situation in case of power failure. Diesel oil drums, connecting cables with lugs etc. and any other such materials are to be kept readily available/accessible for use.

1. Jetty
2. Colony
3. Guest House
4. Health Center
5. Water supply complex at colony

Provision of sufficient emergency spares and cables, terminals, portable lights (Handle torch, emergency lights), tools, tackles, etc. should be ensured well in advance in planned manner to combat the situation. All precautionary measures should be taken to protect the D.G. sets from detrimental effect of thunderstorm, heavy rain showers and such cyclonic conditions. Sufficient stock of waterproof spread sheets, tarpaulins, canvas, etc. to protect the electrical gear from water showers/moistures, etc. should be planned, procured and kept at easily accessible place for instant use.

Power supply staff should be well equipped with jigs and fixtures, such as portable tower ladders, insulated axe, gumboots, hand gloves, shockproof accessories. All the above urgent items should be got procured & kept readily available, well in advance in association with Assistant Executive Engineer (Mech), to cater for emergent situations. XEN (E&M) shall take advance action for procurement of one No. De-Watering Pump (Diesel Driven) and the same should be kept stand-by along with its suction & discharge hoses connected for use

19.11 Vehicle Pool

As soon as the Action plan comes into force, the vehicle pool shall be formed and vehicles as allocated as per (List of Vehicles available with Chief Operations Manager (OOT) Vadinar) shall remain stationed at the said places along with operating staff. The pool shall be controlled by Assistant Executive Engineer (M) / AXEN (E) to be assisted by Junior Engineer (Mech) / (Elect), and following staff will render their services for posting of drivers and allocating of vehicles as per (List of Vehicles available with Chief Operations Manager (OOT) Vadinar)

1	Shri Suresh Keshavlal, Maistry	They will ensure that fuel tanks of vehicles are filled up and sufficient fuel and other oils are kept in store for ready use
2	Shri N. K. Tindel, S.K.	

Apart from the above, XEN (E&M) / XEN (Civil-II), shall hire vehicles, if needed for emergency work, from the private vehicle contractors. The list of private vehicles contractors is shown as Annexure – VII. Assistant Executive Engineer (M) / AXEN (E) should ensure the availability of drivers and vehicles and submit compliance report to the COM (OOT). All hired vehicles should be stationed at the location as decided by XEN (E&M) / AXEN (M), from where it can be taken for immediate use at the required places.

19.12 Temporary Evacuation Centre

The temporary evacuation center shall be looked after by XEN (Civil-II) and Assistant Executive Engineer (Civil) who will be assisted by the Principal of St. Ann's School & his staff and the following KPT staff members assisted by the volunteer's employees as mentioned in the Annexure-III, for setting up temporary evacuation centers and rendering required services for the same. They shall ensure that temporary evacuation centers are established immediately, in the school and staff club of Vadinar Port colony. Port vehicles such as Trucks, Buses, Ambulances, etc. will be put into operation for immediate evacuation of people from Port Jetty as well as colony, as the need be.

1. Shri Anil Oomen, Sr. Clerk
2. Shri C. L. Thomas, Assistant
3. Shri Shivcharan Meena, Junior Clerk
4. Shri Anil Patel, Junior Engineer (Civil)
5. Shri Lakdhir Gadhvi, Junior Engineer (Civil)
6. Shri Talab H. Bhaya, Junior Engineer (Civil)
7. Shri Sajan Karavadra, Junior Engineer (Civil)

Assistant Engineer (Water Supply sub division, Vadinar) shall ensure for providing adequate quantity of water supply at all the temporary evacuation centers.

Medical Officer (O.O.T) with the help of internees and staff of Health Centre shall ensure to provide necessary medicines / medical assistance to affected persons and ensure about the hygienic conditions at the temporary evacuation centers.

XEN(Civil-II) being Officer-in-Charge of Temporary Evacuation Centre, with the assistance of following staff members and volunteers employees mentioned in the Annexure-III, shall take care of the requirements of food/water etc. and supply the same for the evacuees in the temporary evacuation centers.

1. Shri Manilal K. Bhoya, Senior Clerk.
2. Shri C.A. Bhoraniya, Electrician.
3. Shri Deepsinh Vala, Lascar.
4. Shri Shri Shivcharan Meena, Junior Clerk.
5. Shri Ranjitsinh Vala, Lascar.
6. Shri R. M. Jadeja, Chowkidar.
7. Shri Mayursinh P. Parmar, Chowkidar.
8. Shri Malde Sundavadra, Diesel Mechanic.
9. Shri Babulal V. Dhorajiya, Junior Clerk.

The Officer-in-charge of C.I.S.F. Unit of O.O.T. Vadinar and Shri Praveen Gadhvi, SI(W/W) should arrange to make announcements regarding cyclone warnings with the co-ordination of local police, by vehicles mounted with public address systems and also should arrange for requisitioning and providing trucks for shifting peoples, as soon as Internal Action Plan comes in action.

Spray of Dis-infecticides / BHC powder etc will be looked after by Assistant

Engineer (Civil) Building Sub. Division along with staff of Estate office i.e. Jr. Engineers and other staff.

19.13 Press & Media Management

There will be a Press cell headed by C.O.M. (OOT). The following officers/employees shall remain in the Press cell.

1	Shri S. M. Vaishnani	XEN (M&E), as Officer-in-Charge
2	Shri T.O. Koshy	PA to COM
	Shri P.C. Kothari	Signalman

The press cell shall come into operation in the chamber of COM (OOT). The press cell shall issue daily press note with the knowledge and approval of Chairman / Dy. Chairman. If needed, a photographer be engaged, who will take photograph / video shooting everyday, which will depict the situation as well as the relief work undertaken by the officers. All media people of press, journalist etc. shall be taken care of by XEN (Civil-II).

As regards to their transportation, lodging / boarding and other hospitality, he shall take required advance amount from Accounts Officer (O.O.T.) and submit the bills thereof subsequently. Accounts Officer (O.O.T.) along with Superintendent of Accounts / D.A. will be the custodian of cash drawn and kept in their custody for the disbursement for various emergency payments to the designated Officers and the record of such advances to such individual Officers.

XEN (Civil-II), Vadinar and Pilot posted at Vadinar, shall remain present in all KPT meetings relating to the Action Plan. XEN (Civil-II) and Pilot in-charge shall remain in touch with State Governments / District Authority and Mutual aid scheme members, on daily basis, for sorting out the difficulty / problems of cyclone/calamity relief work in consultation with COM (OOT).

19.14 Action to be taken by Accounts Officer (OOT)

As soon as the Cyclonic Weather warning Signal No. 5 is declared, Accounts Officer (OOT) shall arrange for the cash amount to be disbursed as advances to various officers. All Officers-in-charge, should make a judicious assessment regarding requirement of funds by them to meet with different exigencies which they may have to handle on account of the situation arises due to Cyclone / natural calamity. A.O. (OOT) in turn, would examine the advances sought by the officers and disburse the advances immediately without delay and intimate C.O.M (OOT) and F.A & C.A.O about amount released by him and obtain sanction thereof.

19.15 Advance Planning

19.15.1 For stocking required equipments / machinery / material & medicines

Assistant Engineer (Civil) in association with Store Keeper, should ensure the advance stocking of Diesel, Petrol, Kerosene, Lubricant Oil, Emergency lights as well as Torches & Cell, required tools & tackles, jigs and fixtures etc. in sufficient

quantity to meet with the emergency requirements of Vehicles, Generators as stipulated under action at Sr. No.8 & 10 above and all such other services. All the Officers-in-Charge, must list out the materials required well in advance, to facilitate procurement & stocking in, sufficient quantity of the same by Assistant Engineer (Civil).

19.15.2 For securing of ships / crafts / tugs etc

A safe place to secure ships/crafts/tugs etc. on issuance of Cyclone Signal No. 5, should be decided & notified well in advance (By April end) by XEN (E&M), in association with both Assistant Flotilla Supervisors. The sequences of operations for shifting of all crafts shall be planned in advance by all the Masters along with related Marine staff, under the guidance & instructions of above officials.

19.15.3 Post Calamity Operations

19.15.3.1.1 Marine Operations

Immediately after the Calamity subsides, Marine Engineers Grade-II along with both the Assistant Flotilla Supervisors & related Marine staff shall carry out the inspection of all the Floating Crafts and check if the crafts can be put into operation for checking the condition of SBMs and hoses. Accordingly, a report to that effect, shall be submitted by both Marine Engineers Grade-II, to the Control Room at Vadinar, who in turn, after taking approval of C.O.M., will transmit the same to the Dy. Chairman/Chairman at Gandhidham/Kandla. C.O.M. shall co-ordinate with officials of M/s. IOC/Essar Vadinar, for their all Okey reports or otherwise, as regard to SBMs/Product Berth, Pipelines and their clearance for resumption of shipping operation & project works at Vadinar.

19.15.3.1.2 Other than Marine Operations

Shri S.M. Vaishnani, XEN (Civil-II), after taking the stock of situations, arrange for all relief/restoration measures for the damages caused during the Calamity. An advance planning of work-force (Work team/Volunteers by name), list of materials required and the arrangement of effecting the relief/restoration, shall be checked out & notified to all the connected persons in this operations.

For coping up with the immediate restoration work in Post-calamity period, an advance approval of Chairman, KPT, shall be obtained by XEN (Civil-II) by processing the case file, for authorizing the Chief Operations Manager (OOT) to engage Daily rated labour of various discipline in Un-Skilled, Semi-Skilled and Skilled category, at the fixed daily wage for each category personnel.

Further, to hire equipments such as Vehicles/Mobile cranes / Dumpers / JCBs / Pay Loaders etc. for immediate relief/restoration work at the required places at Vadinar, XEN (Civil-II) shall also process case file in advance, for obtaining approval of Chairman, KPT, to hire such equipments, for immediate restoration work in Post-Calamity period at Vadinar.

19.16 Action Plan – Land Fire Station

In case of any fire, the Control Room shall immediately establish a communication with C.I.S.F., Fire Brigade of M/s. IOCL and M/s. Essar Oil Ltd., Vadinar and immediately summon CISF In-charge of OOT to directly reach the site of the fire along with his Security Personnel & co-ordinate with fire fighters, for cordoning the site of fire and take actions to provide rescue and containment of fire.

CISF In-charge of KPT (OOT) Dept., Vadinar should keep informing the Control Room and C.O.M (OOT) from time to time about the gravity of situation and extent of control over the situation.

19.16.1 List of all the officers in charge & designated officers & employees covered

Sr. No.	Name & Designation	Tele. No. at Office	Tele. No. at Residence
1.	Dr. G. S. Rao, C.O.M.	256749/256540 (Vadinar)	256522 (Vadinar)
2.	Shri K. R. Tank, XEN( )	256576 (Vadinar)	256728 (Vadinar)
3.	Shri S. M. Vaishnani, XEN(M/E) i/c	256556 (Vadinar)	Mob 9825148556
4.	Shri S. M. Vaishnani, XEN(Civil)	256576 (Vadinar)	2750161 (Jamnagar)
5.	Shri V.N. Panchal, AXEN(E)	256493 (Vadinar)	256697 (Vadinar)
6.	Shri S. Prabagaran, M.E. Gr.II	-------	256525 (Vadinar)
7.	A.O.(OOT)	256585 (Vadinar)	256570 (Vadinar) 9879403435
8.	Dr. Sunilkumar T., Medical Officer.	256313 (Vadinar)	256706 (Vadinar)
9.	Shri T. R. Tarpada, AXEN (Civil)	256613 (Vadinar)	Mob 9427277288
10.	Shri Mahendra Jadav, A.E.©	256728 (Vadinar)	256992 (Vadinar)
11.	Shri C. M. Saraniya, A.E.©	256613 (Vadinar)	-----
12.	Shri S. V. Sreenivas, A.XEN.(Mech)	256748 (Vadinar)	2915231 (Jamnagar)
13.	Shri T.O. Koshy, PA to COM	256439 (Vadinar)	2751667 (Jamnagar)
14.	Shri H. M. Sathwara, O.Supdt.	256574 (Vadinar)	256483 (Vadinar) 9925303373
15	Shri Jayant Rathod, Supdt. A/cs.	256287 (Vadinar)	9998465290
16.	Shri Narain K. Tandel, (Store Keeper)	256347 (Vadinar)	256507 (Vadinar)

17.	Shri Chainkumar, A.F.S.	256269 (Vadinar)	256517 (Vadinar)
18.	Shri Virendrasingh Yadav, AFS	256269 (Vadinar)	256817 (Vadinar)
19	Shri P. C. Kothari, Signalman	256555/256296 (Vadinar)	256745 (Vadinar)
20.	Shri S. P. Baria, Signalman	256555/256296 (Vadinar)	256750 (Vadinar)
21.	Shri K. Prajapati, Signalman	256555/256296 (Vadinar)	256994 (Vadinar)
22.	Shri Rahul Ninjar, Signalman	256555/256296 (Vadinar)	256180 (Vadinar)
23.	Shri Anil Patel, J.E.©	256576 (Vadinar)	256118 (Vadinar)
24.	Shri Biswas S., J.E. © Gr-1.	256728 (Vadinar)	------
25.	Shri Hitesh Lakhdhir, J.E.©	256551 (Vadinar)	256049 (Vadinar)
26.	KPT Guest House at colony.	256533 (Vadinar)	256714 (VIP Room)
27.	Shri Dilip M. Thakor, Shed Master	256573 (Vadinar)	256524 (Vadinar)
28.	Shri V.M. Mehta, Assistant,KPT Liaison office at Jamnagar	2678214 (Jamnagar) 2550384 (Jamnagar)	9426717172
29.	Shri D.N. Patel, Time Keeper	256269 (Vadinar)	256751 (Vadinar)
30.	Shri C.C. Rathwa, (Clerk-cum-Time keeper).	256269 (Vadinar)	256310 (Vadinar)
31.	Shri Suresh Keshavlal, Maistry	256532 (Vadinar)	256684 (Vadinar)

19.16.2 List of Press Reporters & News Services at Jamnagar

Sr.No	News Service	Name and address	Telephone nos.
01	District Information Officer, Jamnagar.	Shri K. A. Karamata, District Information Center, Jamnagar.	2556827 2672939
02	Times of India, PTI	Shri Darshan Thakar, Journalist society, Jamnagar	2555731 9824232632
03	Indian Express, Jansatta & Financial Express	Shri Bipin Sukhpariya Limda lane, Jamnagar	2553717
04	Phulchaab	Shri Dinesh Vora,	2550320

		Nr. Old Railway station, Jamnagar	
05	Sandesh	Smt. Bhavnaben Soni, Opp. Apsara Talkies, Jamnagar	2553106 9825280456
06	Jay Hind	Shri Bharatbhai Raval, Nr. Old Railway station, Jamnagar	2557447
07	Sanj Samachar	Shri Mukeshbhai Joiser, Near Old Rly. Station, Jamnagar	2554109 9824219999
08	Bhoomi	Shri Dolarbhai Raval, Limda lane, Jamnagar	2679080
09	Nobat	Shri Pradeep Madhwani, Pancheshwar tower road, Jamnagar	2555924 2670924 2553752 (Fax)
10	Gujarat Samachar	Shri Vipul Hindocha Opp. Madras hotel, Teen batti Jamnagar	2670634
11	Ajkal	Shri Praful Tankaria, City Point, Near Town Hall, Jamnagar	2665602 2665603
12	Lokvat	Shri Jay C. Chauhan, New Super Market, Jamnagar	3092114
13	Sahara Samay	Shri Darshan Thakar, Journalist Society, Jamnagar	2555731
14.	Divya Bhaskar	Shri Mukesh Joiser, Near Old Rly. station, Jamnagar	9824219999

19.16.3 List of School & Buildings available at Vadinar for Shelter purpose

1. St. Ann's School, Vadinar Port colony Telephone No. 256568 / 256514
2. Staff club, Vadinar Port Colony.

19.16.4 List of volunteers employees at Vadinar (Dist Jamnagar)

1. Shri Malde Sundavadra, Qr. No. C-24, Port colony Vadinar, Ph No.256325.
2. Shri H. M. Sathwara, Qr. No. C/21 Port colony Vadinar Ph. No. 256483
3. Shri C. A. Bhoraniya, Qr. No. B/49, Port colony Vadinar Ph. No. 256615.
4. Shri Vanrajsinh Jadeja, Qr. No B /54, Port colony Vadinar Ph. No.256116.
5. Shri B. D. Dattani, Qr. No. B / 93, Port colony Vadinar Ph. No. 256681.
6. Shri Dilipkumar Kubavat Qr. No. A /35, Port colony Vadinar Ph.No.256120.
7. Shri Mayursinh P.Parmar, Qr. No. A/90, Port colony Vadinar Ph. No.256009.

8. Shri Ramsinh M. Jadeja, Qr. No. B/69, Port colony Vadinar Ph. No 256007.
9. Shri Natubha J. Zala, Qr. No. A/115 Port colony Vadinar Ph. No. 256011.
10. Shri Navalsinh Jadeja, Qr. No. A/81 Port colony Vadinar Ph. No.256665.
11. Shri Deepsinh Vala, Qr. No. B/129, Port colony Vadinar Ph. No. 256316.
12. Shri Ranjitsinh Vala, Qr. No. A/252, Port colony Vadinar Ph. No. 256031.
13. Shri Manilal Bhoya, Qr. No. B-34 Port colony Vadinar Ph. No. 256041.
14. Shri Babulal Dhorajia, Qr. No. A-61, Port colony Vadinar Ph No. 256063.
15. Shri Babubhai R. Solanki, Qr.No. B-107, Port colony Vadinar Ph No. 256784 Mobile 9825045737
16. Shri Yunus F. Bhaya, Qr. No. B-50, Port colony Vadinar Phone. 256336 Mobile 9979292289
17. Shri B. B. Chauhan, Qr. No. B-89, Port colony Vadinar Ph. No. 256737.
18. Shri Karim V. Noghani, at Vadinar-Dhar colony, Vadinar. Ph. No. 256027.

19.16.5 List of Vehicles available with Chief Operations Manager (OOT) Vadinar

Sr.No.	Vehicle No.	To be stationed at along with Driver
1.	Swift Devine AP 5397.	Stand by at Vadinar Jetty.
2.	"Narmada" Bus GJ 10V 0827.	Stand by at Vadinar Jetty.
3.	Jeep Mahindra Bolero GJ 10F 6835.	Stand by at Vadinar Jetty.
4.	"Yamuna" Bus GJ 10W 9713.	Stand by at Vadinar Jetty.
5.	Jeep Marshal Deluxe GJ 10 F 5216	Stand by at Evacuation Center Colony
6.	Tata Truck GJ 10U 4670.	Stand by at Evacuation Center Colony
7.	Tata Truck GJ 10U 4671.	Stand by at Evacuation Center Colony
8.	"Pooja" Bus GJ 10T 9498.	Stand by at Evacuation Center Colony
9.	Ambulance GJ 10W 6918.	Stand by at Health Center Colony.
10.	Ambulance GJ 10W 6874.	Stand by at Health Center Colony.
11.	"Sabarmati" Bus. GJ 10V 0818.	Stand by at Colony Auto Garage.
12.	Utility Van GJ-10V-4851	Stand by at Colony Auto Garage.

Name of Driver (Motor) & their Residence Telephone No

Sr.No.	Name of Driver	Residential address	Telephone No.
1	Shri Satu Roy	B-43, Port Colony, Vadinar	256619
2	Shri Ruda Tikam	B-66, Port Colony, Vadinar	256794
3	Shri Jatubha Jadeja	B-100 Port Colony, Vadinar	256660
4	Shri Haroon D.	B-108 Port colony, Vadinar	256043
5	Shri Rambhai B.	B-75, Port Colony, Vadinar	256311

6	Shri Ronak A. Murima.	A-36, Port Colony, Vadinar	256039
7	Shri Abhaysang Jadeja	B-32, Port Colony, Vadinar	256796

19.16.6 Names of local contractors working at OOT Vadinar

1. Rajlaxmi Construction, P.O. Vadinar. Phone No. 02833-256789/256505 - Contact person: Shri C.R. Jadeja.
2. Shree Shakti Construction, P.O. Meghpar (Padana) Ph. No. 246314 / 246411 Contact Person: Shri Pradumansinh G. Zala.
3. M/s Jai Chamunda Enterprises, Vadinar 361010 Contact person: Ranmal Vira, Ph. No. 02833-256719
4. Shri Kama Mala, Vadinar 361010.
5. Shri M. B. Jadeja, Vadinar 361010.
6. Shri Ganesh Construction, Village-Kajurda, Tal. Khambhalia Contact person: Shri Kherajbhai
7. Shri Hira Punja Rathod, Vadinar 361010
8. M/s. Shiraji Construction, Vadinar.
9. Shree Ashapura & Co Vadinar 361010 Ph No. 02833-256711
10. M/s. Bariya & Co., Near KPT colony, Vadinar.

19.16.7 Important Telephone Nos of IMD

Name	Designation	Address	Office	Resi.	Fax
Dr. Ajit Tyagi	Director General	Mausam Bhavan, Lodi Road, New Delhi	O11-24611842 011-24611792	011-24633692	011-24611792
Dr. A.L. Koppar	D.D.G.M. (C.W.)	- Do -	011-246338664	011-26108712	011-24638664
	Director (NHAC)	- Do -	011-24631913		011-24625917
Dr. A.B. Mazumdar	DDGM (W/F)	IMD. Simla Office. Pune	020-25535886	020-25530132	020-25533201 25535886 Email : imdpune@pn3.vsnl.net.in
Shri Medha Khole	Director (WF)	IMD. Simla Office, Pune	020-25532875	020-25898029	Email : abmajumdar @hotmail.co

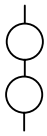
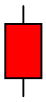
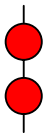
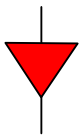
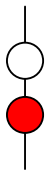
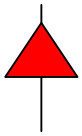
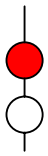
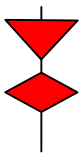
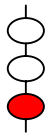
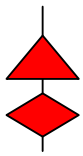
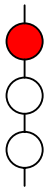
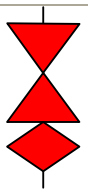
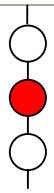
					m
Dr. R.V. Sharma	DDGM	RC Colaba Mumbai Email : ddgm@ imdmumbai .gov.in	O22-22150517 022-22151606	O22-22150417	O22-22160824
Dr. Sati Devi	Director (ACWC)	RC Colaba Mumbai	O22-22150405	O22-22150452	22-22160824
Dr. Kamaljeet Ray	Director, In-Charge	M.C. Ahmadabad	079-22865165 079-22867657	079-26857776	079-22865165 079-22865449
Mrs. M. Mohanty	Meteorologist, V.SAT, CD404100000423	MET Centre, Air Port Ahmadabad	079-22861413 079-22865012	079-226762456	079-22865449 Email : mcaahm@vsnl.net
Control Room IMD, New Delhi	In-charge of Control Room	IMD, New Delhi	011-24619943	--	011-24619167

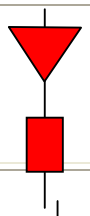
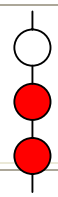
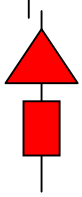
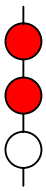
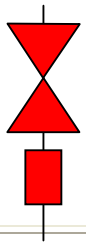
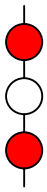
19.16.8 List of Vehicle Hire / Transport Travel Contractors at Jamnagar

Sr.No	Name and address of Transport / traveler	Telephone
1	Pavan Travels, Pancheshwar tower, Jamnagar	2552002
2	Patel Travels, Pancheshwar tower. Jamnagar	2552419 / 2660243
3	Ashwamegh Travels, Jamnagar	2670613
4	Sheenath Travels, Jamnagar	2663315 / 2662215
5	Royal Travels, Opp. Town Hall, Jamnagar	2553333 / 2553636
6	Pruthvi Travels, Sikka Patia, SIKKA (Jamnagar.)	244466
7	Shree Divya Travels, Jamnagar	2677601
8	Payal Travels, Jamnagar	2551514 / 2551415
9	Gujarat Travels, Jamnagar	2664315
10	Abhishek Travels, Jamnagar	2564380
11	Shiv Shakti Travels, Jamnagar	2566611
12	Sapan Travels, Jamnagar	2558558
13	Tulshi Travels, Jamnagar	2541054

14	Samay Travels, Jamnagar	2551925

19.16.9 Chart of Weather Warnings

Signal No.	Symbol Day	Symbol Night	Type of Warning	Description
I			Cautionary	There is a region of squally weather in which a storm may be forming.
II			Warning	A storm has formed.
III			Cautionary	Port is threatened by squally weather.
IV			Warning	The Port is threatened by storm, but it does not appear that the danger is as yet sufficiently great justifying extreme measures of precautions.
V			Danger	The Port will experience severe weather from a storm of slight or moderate intensity that is expected to cross the coast to the south of the port.
VI			Danger	The Port will experience severe weather from a storm of slight or moderate intensity that is expected to cross the coast to the north of the port.
VII			Danger	The Port will experience severe weather from a storm of slight or moderate intensity that is expected to cross over or near to the port.

VIII			Great danger	The Port will experience severe weather from a storm of great intensity that is expected to cross to the south of the port.
IX			Great danger	The Port will experience severe weather from a storm of great intensity that is expected to cross the coast to the north of the port.
X			Great danger	The Port will experience severe weather from a storm of great intensity that is expected to cross over or near to the port.
XI			Failure of communication	Failure of Communication with Meteorological head quarters has broken down and the local officer considers that there is danger of bad weather.

Red Light,

White Light

19.17 Vadinar Oil Terminal Limited (VOTL) of Essar

19.17.1 Facility Description

Vadinar Oil Terminal Limited (VOTL) is a wholly owned subsidiary of Essar Shipping & Logistics (ESLL) with a focus on investment in crude and product terminals. VOTL has set up a 32 Million tone terminal with crude reception and crude and product storage facility at Vadinar, Gujarat, India.

The VOTL facilities serve the following functions:

- Receiving crude oil from tankers at an SPM located in the Gulf of Kutch, with transfer of crude oil via pipeline to the VOTL crude storage facility, located within the fence – line of the EOL refinery;
- Receiving product from the refinery into a product tank farm, also located inside the Refinery fence-line for loading into tankers at the marine terminal jetty;
- Receiving seawater from the intake well that is pumped via pipeline to the

EOL refinery, and then discharging seawater via the seawater outfall located near the location of the SPM.

The crude oil tank and product tank farms, which are located inside the fence - line of the EOL refinery, while owned by VOTL, are actually operated and maintained by the Refinery, and were not covered by this HAZID or the ERA. (These tanks farms have been risk assessed separately).

The areas where the Marine Terminal and the SPM are located in the Gulf of Kutch are part of a designated and controlled marine park and represent a sensitive marine environment. The on-land pipelines pass through low lying areas which consist of some farming land and are adjacent to several villages.

The VOTL marine terminal facility consists of the following systems for supporting the aforementioned functions:

- A Single Point Mooring (SPM) and Subsea Line for loading crude:

  The SPM buoy is the gateway for crude oil input to the EOL refinery. The SPM is anchored to the seabed in the Gulf of Kutch, in around 35 m of water. Tankers are secured to the buoy via mooring hawsers. The tanker is held off the SPM by a pull-back tug. The offloaded crude oil is pumped by the crude tanker pumps through the floating hose(s), through the SPM, and then via flexible catenary hoses into the 48" rigid subsea pipeline, through a PLEM and then flows directly to the crude oil tank farm located within the EOL refinery. The SPM is located roughly 4Km from the Marine Terminal and 8Km from the crude oil pipeline landfall.

- Seawater Intake Unit and Outfall system:

  Seawater is pumped from the seawater intake facility (located at pathfinder Creek, adjacent to the jetty) and delivered to meet the water needs of the refinery. Seawater flows through two filter packages in the seawater intake well and is then pumped to a seawater storage reservoir located in the Refinery via a 48" GRP pipeline. Chlorine is added to the seawater downstream of the pumps at the intake facility for prevention of marine growth in the pipeline and the Refinery seawater reservoir.

  The seawater outfall dispose of waste brine (high salinity water) generated from different Refinery units through a diffuser located on the seabed close to the location of SPM. The seawater outfall flow is pumped from a seawater return reservoir at the Refinery through an on-land 48" GRP pipeline and then via an 8Km subsea pipeline.

- A jetty including three (3) Loading Arms:

  The jetty is located at the inlet to pathfinder Creek, and is situated between two coral reefs which are part of a declared "Marine National Park". The jetty is used for shipping of refined white and black products to vessels. The jetty is connected with the refinery through 3 x 32" diameter pipelines which bifurcate into 7 x 24" lines on the trestle and finally culminate into three (3)

loading arms. Each o the 7 x 24" lines are allocated to each of the seven (7) products handled at the jetty, namely: ATF (aviation turbine fuel), kerosene, MS 87 (motor spirit), MS 95 (motor spirit), naphtha, diesel and VGO / FO (vacuum gas oil and fuel oil). Tanker at the jetty is located via pipelines connected through three sets of loading arms with Quick Connector Disconnector Coupling.

- A pig station with three (3) Pig Receivers / Launchers and Terminal Area Slop Tank:

  Pigging is carried out for clearing any previous pipeline content, separation of cargoes, cleaning inside pipeline coating and assessing any leak- buckle or damage- deformation in the internal section of pipelines (intelligent pigging). Products for export are pumped from the refinery to the jetty through 3 x 32" diameter cross- country pipelines. There are two (2) pipelines for white products (naphtha, MS, ATF, Kerosene, and diesel), and other is for black products (VGO / FO). To enable the flexibility of these pipelines to carry different products, pigging is carried out between the Refinery and the Marine Terminal Pigging station, where each line has its own pig receiving and launching facilities (total of 3 pig receivers / Launchers).

  A slop tank is also provided for the pig stations to contain / collect liquid product drained from the pig station, and it is also used for transfer of products drained into the jetty Slop Tank (which are transferred by pump). Products drained into the slop tank are removed as required by an educator truck and taken back to the EOL Refinery where they are reprocessed.

- Pipelines between Terminal and Refinery (including crude oil and seawater lines) include the following:

  - 3x 32" diameter cross- country pipelines (two (2) pipelines for white products, and one for black products) between refinery and marine terminal (around 18 km in length)
  - Crude oil pipeline (48") between refinery and landfall (13 Km), and then a further 8Km of 48" subsea pipeline to the PLEM on the seabed below the SPM
  - Seawater intake (48") between marine terminal and refinery (17Km), and seawater outfall (48") between refinery and landfall (13 Km) plus 8Km of subsea line to the outfall diffuser.

    All pipelines are buried on land within an earthen berm. Steel lines are wrapped and cathodic protected (crude / product lines). The seawater lines are GRP. There are no flanges or connections on crude / product lines on –land (other than at marine terminal for product), and only air vents are provided along the seawater lines. The subsea crude oil pipeline is concrete encased, with the only flanges at the point of landfall and at the subsea PLEM.

- Buildings including the Main Terminal Control Building (MTCB) and two substations (main substation located near the seawater intake station, and jetty substation).

The response strategy for the VOTL plan has been developed taking into account the spill risks, and possible sources of spillage associated with Marine Terminal operations including those at the SPM and Jetty berths and facilities within the Port.

The geographical area of operations is bound by, but not limited to, one mile either side of the line joining following coordinates.

SPM	:	690 39' 35" E
		220 30 14"N
LFP	:	690 43' 26"E
		220 27' 59"N
Berth B (North End)	:	690 40' 10.26"E
		220 27' 15.25"N
Berth A (South End)	:	690 40' 11"E
		220 26' 54"N
Sea Water Intake	:	690 40' 32"E
		220 26' 11" N

19.17.2 Oil Spill Risks

19.17.2.1 Identification of activities and risks

Oil spills will be categorized in accordance with the internationally recognized three tier classification system

Tier One	100 - 700 T
Operational spillages which can be dealt with using the resources immediately available	
Tier Two	700 – 10000 T
Medium size spillages which exceed VOTL resources and which require District and/or Regional assistance	
Tier Three	10000 > T
Large spillages which exceed the full resources of the District/Region and which may require National assistance and/or the implementation of the NOS - DCP	

19.17.2.2 Types of Oil likely to be spilled

No.	Oil Type	Strategy Figure	Specific Gravity	Genre	Characteristics	Examples
1	Light Oil	5.1	< 0.84	White oils	Non-persistent, Volatile	Aviation fuel, Kerosene, Motor spirit, Naphtha, HSD
2	Crude	5.2	> 0.84	Black	Persistent,	Arabian Light,

	Oil			oils	Viscous, Emulsion. Fresh oil amenable to dispersants	Arabian Heavy, etc.
3	Heavy Oil	5.3	> 0.95	Black oils	Persistent, Viscous, Emulsion. Generally not amenable to dispersants	Fuel Oils, LSWR

Probable fate of spilled Oil

19.17.3 Preliminary Assessment

The ICG Coordinator will make a preliminary assessment of the incident by contacting the person reporting the spill, governmental officials, and the responsible party.

- Evaluating the magnitude and impact of the discharge or threat of discharge on the public health, welfare, and the environment;
- Determining in which jurisdiction the incident occurred;
- Determining or confirming the responsible party;
- Determining or confirming the source of the spill;
- Determining whether the spill has been stopped or is ongoing, and if ongoing, how quickly it can be controlled;
- Assessing the need for state assistance; and
- Assessing the feasibility of removal and determining the equipment needed to remove the oil.

19.17.4 Containment & Control

Clean-up actions must begin as soon as possible to minimize the effect on natural and economic resources. These actions may include locating the source of the discharge and preventing any further spillage, placement of containment boom to control the spread of oil and to protect sensitive areas, measuring and sampling, physical removal of the oil from water and land, the use of chemicals to herd or disperse the oil, and in situ burning.

19.17.5 Development of Oil Spill scenarios

VOTL is operating 02 Nos. Berths (A & B) for product evacuation & 01 No SPM for crude intake.

The VOTL is capable of accepting vessels ranging from 25000 to 100,000 DWT each at berth A & B and Vessels ranging from 87,000 to 325,000 DWT at SPM.

The Marine Terminal is located within an area which has been declared as a Marine National Park / Marine Sanctuary.

The mean tidal range is approximate 6 meters and current speed in excess of 2

knots may be experienced alongside jetty.

19.17.6 Port Operations

19.17.6.1 Pilotage

Pilotage is compulsory for all vessels. Pilotage and auxiliary support craft services are provided by Kandla Pot Trust (KTP).

19.17.6.2 Main Approach Channel

The least depth in the main approach channel to the tanker jetty is 13 meters; the maximum acceptable draft alongside jetty berths is 15 meters. A minimum under keel clearance of 6% of vessel's maximum sea going draft plus 0.60 meters is applied to all vessels under way.

While the risk of grounding is low, it cannot be wholly eliminated. The most likely cause is steering or propulsion system failure which could result in grounding on the channel margins with consequent damage to the bottom and/of the mid body plating. The potential spill quantities depend upon the size / type of tanker and the area of impact damage.

The vessels calling the product terminal, in bound and out bound will be escorted by minimum two tugs in fair weather condition. This considerably reduces the risk of the vessel running aground in the channel.

19.17.6.3 Approach to SPM Berth

Tankers bound for SPM will follow the deep water route. Berthing and un-berthing of the Tankers on the SPM will be done by KPT Pilots. Charted depth at SPM location is 34.5 meters. Grounding of Tankers in the SPM area is considered as very remote.

19.17.7 Oil Spill scenarios

19.17.7.1 Collision between Vessels Underway

The control which will be imposed on ship movements within terminal are designed to ensure that any risk or collision is minimized. For example, inward / outward bound ships will have sole occupancy of the approach channel to the jetty berth; additionally all departing vessels will remain under Pilotage up to the western limit of the terminal area. It is thus considered that the likelihood of collision between vessels underway within the terminal is remote. There is perhaps a greater risk of collision between vessels maneuvering to the SPM and the jetty anchorage position without Pilotage assistance.

19.17.7.2 Berthing incident (Jetty)

Oil spills can occur as a result of hull contact with the corners of breasting dolphins during ship berthing or un-berthing maneuvers. Such incidents are generally due to failure of a vessel's main propulsion or steering systems, loss of control onboard an attendant tug or pilot error or misjudgment. The potential spill quantities involved depend on the vessel type and the location and extent of the impact damage.

19.17.7.3 Tug impact

There are well documented incidents where cargo or bunker oil has been released as a result of hull impact damage by tugs. This can occur when tugs are approaching a vessel underway prior to berthing, or when coming alongside a moored vessel prior to un-berthing. The potential spill quantities again depend on the location and the extent of the impact.

Adequate fenders shall reduce the level of risk.

19.17.7.4 Cargo Transfer Operations (SPM Berth)

This section considers the potential sources of oil spills during the discharge of crude oil cargoes and is based on oil industry data and ITOPF statistics. It should be noted that the ITOPF statistics demonstrate that most oil spill incidents occur during routine cargo handling operations and that some 91% of these incidents resulted in spillages of less than 7 tones.

19.17.7.5 Connection of Floating Hose String

After the floating hoses have been lifted on board, blank flanges are unbolted from the ends of the hoses prior to connecting them to the ship's presentation flanges. Small spillages frequently occur during the removal of the blank flanges; these are caused by surging of the line contents as the floating hose sections follow the wave pattern. While in most cases such spillages are contained within the ship's manifold drip tray, there are recorded incidents where oil has escaped overboard via scuppers, which have not been effectively plugged. Spillages of this nature should not exceed 1 m3.

19.17.7.6 Snapping of 24" diameter Floating Hose

Spillage of crude oil due to snapping of a floating hose, during crude oil unloading operations @ 10000 m3/hr. estimated time taken for response is two minutes. Snapping of hose may occur due to accidental drifting of tanker, collision with SPM, the hose getting entangled due to movement of a tug boat very near to the SPM / Tanker, due to rough weather condition. Theoretically the quantity spilled would be 142 tons. Chances of a full bore snapping of the hose are classified as a rare phenomenon.

19.17.7.7 Sea and Overboard Discharge Valves

Oil can escape to the sea via sea or overboard discharge valves which are directly connected to the cargo pipeline system due to either incorrect line setting or defective valves. The likelihood of this occurring is considerably less on SBT vessels.

19.17.7.8 Slop Tank Overflow

Crude Oil Washing (COW) of cargo tanks will be undertaken during bulk cargo discharge; this operation entails the transfer of tank bottoms and washing oil back to back to the vessel's slop tank(s). The overflow of slop tanks as a result of instrumentation failure or operator error during this process is not uncommon. Checks on the system and operation, pre, during and post COW will considerably

lower the associated risk.

19.17.7.9 Vessel Breakout

Other than a sudden and catastrophic failure of the mooring hawser leading to rupture of the floating hose string, it can be reasonably assumed that cargo discharge will have been suspended in weather conditions which approach the established environmental limits. It would also be normal practice to station a crewmember on the forecastle head to maintain a mooring watch. Under most circumstances, therefore, early warning of a potential breakout situation can be anticipated.

In any event, an emergency stop button for the main cargo pumps will be located at the ship's manifold and the deck watch keeper would initiate an ESD immediately the hose string parts.

A vessel breakout and loss of integrity of the floating hose string could result in a spill quantity of some 142 m3. This quantity is based on the following assumptions:

- Bulk flow rate
- Reaction time
- ESD activation time
- Hose contents

In case of undue stresses experienced by the floating hose string, the breakaway couplings will get activated. These are designed to seal both ends on activation.

19.17.7.10 Hull Failure

The incidence of oil pollution due to hull failure is low and some 84% of the incidents attributed to this cause by ITOPF involved spill quantities of less than 7 tones; these spills were caused mainly by minor hull fractures and weld failures. The potential for more serious incidents with spill quantities in excess of 700 tones must, however, be acknowledged.

19.17.7.11 Fire and Explosion

Fires and explosions onboard ship represent a safety hazard with the risk of oil pollution as a secondary impact. All tankers engaged for trading to the SPM facility will be equipped with inert gas systems; gives the control which will be imposed and enforced by VOTL in respect of the oxygen content of cargo tanks, the risk of fire and / or explosion in the cargo spaces must be regarded as minimal.

Strict monitoring and control of the main cargo pump room atmosphere will minimize the fire and explosion risks associated with this space.
Fires resulting from uncontrolled smoking in the accommodation, organization hot work such as welding and engine room fires can spread rapidly if not dealt with swiftly and give rise to incidents of a very serious nature.

While the likelihood of fire or explosion occurring onboard vessels berthed at the SPMs is low, the risk is nevertheless acknowledged. Such an incident could give rise to a spillage of 700 tons or more.

19.17.7.12 Spillages of Fuel Oil

Fuel oil bunkers will not be supplied to tankers moored to the SPM. It may, therefore, be necessary for vessels to undertake the internal transfer of fuel oil for trim or other operational reasons. A bunker tank overflow during such operations could result in spillages of < 1 ton.

Cargo Transfer Operation (Jetty Berth)

19.17.7.13 Ballast Discharge

Only fully SBT (Segregated Ballast Tank) vessels shall be chartered for trading to the Marine terminal; those ships which load refined products will also discharge their segregated ballast water concurrent with the loading operation.

Under fair weather and operational conditions, tankers at SPM will not engage in de-ballasting activity.

On some older designs of SBT tankers, the ballast pipelines pass through the cargo tanks and vice versa, any loss of ballast line integrity can result in the entrainment of cargo oil in the ballast water discharge. Industry records indicate that the spill quantity from this cause on board product carriers should not exceed 25 tones.

19.17.7.14 Loading Arms

The operation of loading arms can lead to minor releases of oil. Common sources are vent valves, swivel joints and hydraulic lines. Loading lines are equipped with PERC (Powered Emergency Release Coupling) and with DDV (Double Disk Valve)

19.17.7.15 Cargo Tank Overflow

Cargo tank overflows can occur on board loading vessels; spills of this nature can be due to instrumentation failure or human error. The spill quantity is a function of the flow rate and also the number of tanks being loaded at the time of the incident. Some of the oil will be retained on deck but in a worst case scenario, some oil could go overboard.

19.17.7.16 Hull Failure - Fire and Explosion

The risks of hull failure - fire and explosion are also similar to those for SPM vessels with the attendant spill quantities being proportional to the tanker size.

19.17.7.17 Effluent Discharges

Treated effluent from the refinery is discharged into the sea area. The discharge consent levels are set and monitored by the State Pollution Control Board and VOTL regularly tests for effluent quality.

Instrumentation malfunction, failure of in-line samplers or operator error can result in the entrainment of oil in the final discharge to harbor waters. Most spillages of this nature are not substantial, and based on industry experience elsewhere, are unlikely to exceed 5m3 in volume.

19.17.7.18 Special Equipment which may be used

- Workboats
- Trucks / cars (four wheel drive)
- Radio transmitter / receivers
- Workshop / repair facilities
- Bulldozers, mechanical scarpers and similar earthmoving equipment
- Vacuum trucks
- Tank trailers
- Life vests
- Explosive meters

19.18 Fire Fighting Facilities at Vadinar Oil Terminal Limited (VOTL) of Essar

19.18.1 Fire water supply pumps at Sea Water Intake

Fire pumps are vertical turbine type as per IS 1710

Dedicated fire pumps are provided for:

1. Fire Tower monitor system
2. Fire Hydrant System (There is no interconnection between two header)

19.18.2 Fire water Pump for Tower Monitor – 4 Nos

a. Main Motor Driven Pump – 1 No (Discharge capacity 792m^3/hr at 15 kg/cm^2).
b. Engine driven – 1 No (Discharge capacity 822m3/hr (standby).
c. Jockey Pump (Discharge capacity 33m^3/hr at 10.5 kg/cm^2).

19.18.3 Fire water Pump for Hydrant System – 4 Nos

a. Main Motor Driven Pump – 1 No (Discharge capacity 792m^3/hr at 15 kg/cm^2).
b. Engine driven – 1 No (Discharge capacity 822m^3/hr (standby).
c. Jockey Pump (Discharge capacity 33m^3/hr at 10.5 kg/cm^2).

19.18.4 Fire Hydrant & Jumbo Curtain

Fire Hydrants is located at different section of premises to be protected depending upon nature of fire hazard, fire hydrants are double outlet type.

Each outlet capacity is 900 lpm at 7.5 kg/cm^2
The flow rate of hydrant is 1800 lpm at 7.5 kg/cm^2

19.18.5 Fire Hydrant Point – 31 Nos

a. Berth A - 4 Nos
b. Berth B – 4 Nos
c. Pig area / cross country / MTCB – 16 Nos
d. SWI – 03 Nos
e. Between Berth A & B – 4 Nos

19.18.6 Jumbo Curtain at Berth A

The Jumbo curtains nozzle shall have discharge capacity of 3000 lpm of sea water at 7.5 $kg/cm^{2.}$

Total – 6 Nos of Jumbo Water Curtain

The nozzle shall be able to produce 14 meters. Vertical plane & 20 meters horizontal radius dense water curtain through 160 degree angle – 04Nos at jetty to protect loading arms and – 2 Nos one each at the breasting dolphin to protect tower monitors from the radiant heat in case of fire on tankers.

19.18.7 Jumbo Curtain at Berth B

The Jumbo curtains nozzle shall have discharge capacity of 3000 lpm of sea water at 7.5 $kg/cm^{2.}$

Total – 02 Nos of Jumbo Water Curtain

The nozzle shall be able to produce 13.5 meters. Vertical plane & 22 meters horizontal radius dense water curtain through 180 degree angle – 02Nos at jetty to protect loading arms.

19.18.8 Water / Foam Tower Monitor at Berth A

The monitor shall be suitable for both sea water and foam, each monitor shall be capable of discharging 6000 lpm of sea water and 36000 lpm of expanded foam at 10 Kg.cm2 over a range of 100 meters in horizontal direction and 40 meters range in vertical direction. The monitor shall be capable of producing good quality of finished foam.

Horizontal range with water – 100 meters
Horizontal range with foam - 90 meters

The monitor shall be capable of 360 degree rotation in either direction in horizontal plane and 60 degree elevation 70 degree depressions in vertical plane. The monitors shall be achieved by remote control from control room.

Two nos of positive displacement pump have been provided. At a time one pump will be running and other will be acting as stand by. The Capacity of each pump 21.6 m^3/hr at $16kg/cm^2$

19.18.9 Foam Compound Induction

Foam compound induction system is in line with balanced pressure proportioning type to ensure proper mixing of foam concentrate and right proportion and supply the same to the monitor line depending upon the water flow rate necessary automatic valve, spool valve and duplex pressure gauge have been provided to ensure 0 to 6% of foam compound induction.

Induction rate is set at 3% foam compound induction.

19.18.10 Water / Foam Tower Monitor at Berth B

The monitor shall be suitable for both sea water and foam, each monitor shall be capable of discharging 6000 lpm of sea water and 36000 lpm of expanded foam at 7 Kg.cm2 over a

range of 75 meters in horizontal direction and 35 meters range in vertical direction. The monitor shall be capable of producing good quality of finished foam.

Horizontal range of monitor – 75 meters

The monitor shall be capable of 360 degree rotation in either direction in horizontal plane Elevation – (+) 85 and (-) 45. The monitors shall be achieved by remote control panel near pantry in open area.

19.18.11 Foam supply system at Berth B

Foam supply system shall be operated by manually, located near Foam Tank, Foam supply system located at approximately 50 meters away from Berth B central platform. Since the pipeline will always be under pressure for throwing water / foam through the monitor:

One No foam solution storage tank is provided at south side of berth B with capacity of 16KL.

Foam pumps – 2 Nos (01 No stand by)
Each pump discharge capacity is – 37m^3/hr

Two nos of positive displacement pump have been provided. At a time one pump will be running and other will be acting as stand by. The Capacity of each pump 37 m^3/hr at 16kg/cm^2

19.18.12 Foam Compound Induction

Foam compound induction system is in line with balanced pressure proportioning type to ensure proper mixing of foam concentrate and right proportion and supply the same to the monitor line depending upon the water flow rate necessary automatic valve, spool valve and duplex pressure gauge have been provided to ensure 0 to 6% of foam compound induction.

Induction rate is set at 3% foam compound induction.

19.18.13 Foam Trolley

Foam trolley is firefighting equipment ready to use initial level in case of fire, oil spillage in dyke.

Foam trolley capacity – 200 liters
Discharge capacity – 225 lpm

Total – 8Nos of foam trolley available in field.

- Berth A – 2 Nos
- Berth B – 2 Nos
- Pig Area – 3 Nos
- SWI - 1 No

19.18.14 Ground Fixed Water cum Foam Monitors

Fixed foam monitors are ready for instant use in case of emergency and are able to discharge dense foam from orifice type foam nozzle. The discharge capacity of monitor is 2850 lpm

Monitor having facility to discharge water for cooling purpose, all fixed foam monitors are having 200 liters foam drum ready to use by monitor pick up tube.

Total – 4 Nos

- Pig Area – 2 Nos
- Berth B – 2 Nos

19.18.15 Fire Extinguisher

Portable Fire Extinguishers are the first aid of fire fighting equipments. All fire extinguishers installed in the jetty premises are clearly visible and accessible.

At Berth A

- DCP 75 Kg –4 Nos
- DCP 50 Kg –2 Nos
- DCP 10 Kg –6 Nos

At Berth B

- DCP 75 Kg –4 Nos
- DCP 10 Kg –6 Nos
- CO2 6.5 Kg –2 Nos

Other jetty area locations are also equipped with fire extinguishers

19.18.16 Innergen Total Flooding System

Innergen Total Flooding System has been designed for protection of MTCB floor underneath cabling and DCS instrument panels. It is automatic fire extinguishing flooding system. The contents of gas are (52% nitrogen gas, 40% argon gas, 8% CO_2 gas)

The system is kept in both auto / manual mode operation. There are 12 Innergen gas cylinders which are pressurized to 200 bar at 20 Degree Centigrade for fire protection system.

Innergen Total Flooding system is divided in five different Zones.

Zone 01 & 02: is instrumentation room, Ground Floor MTCB (There are 6 Nos discharge nozzle of Innergen System)

Zone 3: is panel room right side (There is 1 No discharge nozzle of Innergen System)

Zone 4: is panel room left side (There is 1 No discharge nozzle of Innergen System)

Zone 5: is Battery Room Ground Floor MTCB (There is 1 No discharge nozzle of Innergen System)

The system has been put in manual mode.

19.18.17 Manual Call Point (MCP)

MCPs have been installed in premises in different accessible & visible locations like:

- Berth A
- Pig Station

- Around MTCB Building
- SIW & Berth
- All MCP are indentified with Zebra cross red and yellow

In case of Emergency Alarm to be raised MCP glass should be used.
Total 69 Nos of MCPs are in premises connected to DCS panel. On activation of any one MCP alarm will be blow on DCS

- Berth A – 13 Nos
- Berth B – 6 Nos
- Pig Area – 7 Nos
- MTCB – 6 Nos
- SWI / SS – 12 Nos
- Road / Tresle / KPT – 25 Nos

19.18.18 Smoke Detectors

Smoke detectors have been provided inside building (MTCB) cable cellar room, electrical panel room, instrument panel room.

Due to availability smoke particles detector will get activated. Fed Red Becon & hooter will start and on DCS alarm will be sounded repeatedly.

Total No of Smoke Detectors – 68 Nos

19.18.19 Fixed Gas Detectors

Fixed gas detectors have been installed in the jetty premises where most critical hazardous zone is identified.

Fixed hydrocarbon detector detects the hydrocarbon vapours available in the atmosphere and it gives pre explosion alarm. The alarm is set at 10% of LEL.

Total No of Gas detectors – 25 Nos

- Berth A – 6 Nos
- Berth B – 6 Nos
- Pig Area – 5 Nos
- SWI / (H2)/ MTCB – 8 Nos

19.18.20 Life Saving Appliances

1. Life Buoy Ring – Life buoy ring with 30 meters 8 Inch Nylon rope have been installed in entire jetty premises. Total No of Life Buoy – 29 Nos
2. Life Work West – Life work vest have been installed in emergency almirah at berth A and Berth B and also installed at central platform of berth and SWI. Total No of Life Work Vest – 18 Nos
3. Life Jacket – Life jacket is available with the terminal whenever persons go to the SPM / Sea shore side life jacket has to be worn. Total No of Life jacket – 12 Nos

19.18.21 Emergency Escape Breathing Device (EEBD)

Emergency Escape Breathing Device is used to escape from place where emergency arises

and it is difficult to reach a muster point / safe place, same shall be used in such emergency.

EEBD is ready to use for 15 minutes to see the person can be reached to safest place with normal breath.

Total Nos of EEBD – 5 Nos

- Berth A – 1 No
- Berth B – 1 No
- Pig Area – 1 No
- SWI – 1 No
- Store – 1 No

19.18.22 Breathing Apparatus Set (BA Set)

B A set is to be used in such emergency where it is difficult to breath during rescue operation. Fire Fighting, Toxic gas release, and Flammable gas in atmosphere.

B A set has been installed in jetty premises where it is most hazardous so it can be used immediately whenever necessary.

Total No of B A set – 6 Nos & 2 Nos Spare Air Cylinder

Emergency Almirah Berth A – 2 Nos

- SWI – 2 Nos
- MTCB – 1 No
- Store – 1 No

19.18.23 First Aid Box

First Aid Box is distinctively marked with a red cross on a white background. First aid box is kept in prominent place. Custodians of the first aid boxes are qualified first abiders only.

The names of the first aiders are displayed at the notice board of the control room.

The first aiders are available in each shift.

First aid box available at site – 8 Nos

First box location available in jetty premises and their locations are:

- MTCB – 1 No
- Berth A – 1 No
- Berth B – 2 Nos
- SWI – 1 No
- Security Gate – 1 No
- 70 – 1 – 1 No
- 76 – 2 – 1 No

19.18.24 Portable Safety Instrument

1. Area Monitor – Area monitor is available in control room. It is used for continuous monitoring of hydrocarbon vapors in atmosphere. The area monitor lowest alarm is

set at 5% of LEL on reaching this range area monitor will be sounding with high volume.

Area monitor is used in hot work area where the most critical hazardous area are identified such as Berth A / Berth B

2. Portable Multi Gas Detector – Multi gas detector is always available in control room and in the field with the fire men. Whenever any hot work permit is issued by SIC, Safety team checks the area and residual hazardous of concerned location and ensures that no hydrocarbon vapor is in the atmosphere. Stand by fire man continuously monitors and makes sure that the LEL always is 0%.
3. Chlorine Meter – The device is widely used for check the work environment before entering the chlorination room / area.
4. H_2S Meter – Very useful device for working crew for confined space work. I.e. Vessel, Tank & nearby hazardous area for continuous monitoring work environment.
5. Oxygen Resuscitator – It is a medical equipment and to give oxygen to casualty by trained person.

19.18.25 Chlorination System at SWI

Chlorine gas is most toxic and corrosive gas. In case of leak and in coming in contact with the skin irritation starts, inhalation is most dangerous if more than 15ppm it will be IDLH (Immediate Danger Life & Health)

Chlorine tonners have been laid down at chlorination system for chlorine injection in sea water line which is going to refinery.

3 Nos of fixed chlorine detectors have been provided at three different locations.
1 No Caustic Soda Tank capacity 8000 Liters with blower and hood

Hood provided on running cylinder, the detector laid would sense 0.5ppm in case of a leak. The blower starts automatically.

Chlorine containment kit & 2 Nos BA set is available in the SWI store.

19.18.26 Chlorine Kit

It is used for containment of chlorine gas in case chlorine leakage from the tonner valve assembly, plug or from body.

Work Permit System

Any routine work, testing of equipment, inspection, schedule maintenance, concern has to take work permit for particular job. SIC will make sure that before issuing work permit receiver must have completed TBRA & TBEA and also tool box talk.

- Hot work permit
- Cold work permit
- Electrical Isolation & restoration
- Confined space entry permit
- Vehicle entry check sheet

- Photography permit check sheet
- Isolation of fire fighting network
- Radiography check sheet.

19.19 Off Shore DMP of Indian Oil Corporation (Vadinar)

19.19.1 Introduction of Facility

Indian Oil Corporation (IOC) Ltd (Pipelines Division) owns and operates two offshore oil terminals in the Gulf of Kutch at Vadinar. The terminals are intended to handle the combined throughput requirement of its three refineries at Koyali, Mathura and Panipat. The oil terminal facilities comprise of two nos. Single Point Mooring (SPM) systems for moorings of tankers, off-shore /on-shore pipelines, the shore terminal comprising of 13 nos. of floating roof tanks with the total storage capacity of about one million tone and originating pumping station through which crude is pumped to the refineries at Koyali, Mathura and Panipat through the Salaya -Viramgam, Viramgam - Koyali, Viramgam-Chaksu, Chaksu-Mathura and Chaksu-Panipat pipeline system.

The offshore oil facilities are connected to the shore tanks by means of 1067 mm (42") dia. submarine pipeline of about 5.3 KM for SPM-I and 6.3 Km for SPM-II followed by twin 1067 mm (42") dia. onshore pipelines of 5.7 KM length each. Another 2.1 Km loop line of 1067 mm (42") dia. is also laid to interconnect the Pipe Line End Manifolds (PLEM) of both SPMs to facilitate shore based pigging operation of both offshore and onshore pipeline. A sketch showing the above is enclosed as Annexure-I. For operational flexibility, sub-sea isolation valves are provided at suitable locations. The tankers berthed at SPMs discharge the crude oil through two strings of floating hoses connected between the tanker manifold and SPMs, and two strings of submarine hoses connected between SPMs and the PLEM located at the end of the submarine pipeline at the seabed.

This off shore oil terminal in Gulf of Kutch near Vadinar together with its cross-country pipeline system to the refineries can be termed as a vital energy artery of the Western Region catering to the energy requirement of the entire Northwest region of the country.

19.19.2 Location of the SPM Terminal

The SPM facilities are situated within the territorial water of Kandla Port Trust (KPT). SPM-I is situated at Latitude 20o 30' 34" N and Longitude 69o 42' 04" E and SPM-II is situated at Latitude 220 30' 14.36" N and longitude 69o 40' 53.60" E.

The drafts available at SPMs are 34.9 meters and 32.5 meters for SPM-I & SPM-II respectively. The KPT provides the infra structure as well as Pilotage facility for operating this terminal. The entry channel of approximately 126 km (70 Nautical miles) in the Gulf of Kutch is identified for the navigation of vessels by KPT.

A zone of 3.6 Km (2 nautical miles) around each SPM has been declared as the "No Anchorage Zone" and no vessel is allowed to anchor in this area to prevent fouling of their anchors with our SPM anchor chains or sub-sea hoses and the pipeline.

Hardware Details of SPM System at Vadinar

Sr No	Parameters	SPM – 1	SPM – 1
1	Capacity of Tankers to be	3,00,000 DWT	3,15,000 DWT

	handled		
2	Mean Sea Level	34.9 MTR	32.5 MTR
3	Geographical Co – ordinates	LAT: 20° 30' 34 " N LONG: 69° 42' 04 " E	LAT: 22 ° 30' 14.36 " N LONG: 69° 40' 53.6 " E
4	Year of Commissioning	August - 1978	March - 1997
5	Off - Shore Line	5.3 KM	6.3 KM
	Loop Line Between SPM-I & SPM-II Is 2.1 Kms		
Hose Configuration			
(A) Floating Hose			
1	24" X 40' Half Float Hose	01 No in each String	01 No in each String
2	24" X 40' Decreasing Stiffness Hose	01 No in each String	01 No in each String
3	24" X 40' Standard Full Float Hose	21 Nos in STBD String & 22 Nos in Port String	20 Nos in STBD String & 21 Nos in Port String
4	Metallic Reducer	01 No in each String	01 No in each String
5	20" X 40' Full Float Hose	01 No in each String	01 No in each String
6	20"-16" X 40' Tapered Hose	01 No in each String	01 No in each String
7	16" X 35' Full Float Hose	02 Nos in each String	02 Nos in each String
8	16" X 30' Tanker Rail Hose	01 No in each String	01 No in each String
	Total Length in Meters in each string	Port STR: 331.83 STBD STR: 324.11	Port STR: 336.32 STBD STR: 324.13
(B) Submarine Hoses			
1	20" X 40' Double Carcass Submarine Hose	------	04 Nos in each String
2	20" X 37.5' Double Carcass Submarine Hose	04 Nos in each String	------
3	20" X 35' Double Carcass Submarine Hose	04 Nos in each String	04 Nos in each String
	Total Length in Meters in each String	OFF.SH : 44.20 ON. SH : 44.20	OFF.SH : 45.72 ON. SH : 45.72
	Type of Plem Valve Actuator	Rotary Vane	Spring Loaded

19.19.3 Tanker Operation

Tankers can be unloaded simultaneously from both the SPMs and any one SPM. The details of tanker operation are described below:

Pilots of KPT bring the tanker near SPM. There are two strings of floating hoses of 610 mm (24") dia for each SPM which are lifted by the crane of the tanker for connecting to tanker manifold. When the tankers are not there, these floating hoses are floating on sea and at the ends of the strings, butterfly valves are used to close/ blind the line and additionally blinds are fitted to avoid spillage of oil. Once the floating hose strings are connected to the tanker, the system is ready for discharge of cargo through SPM system.

Before commencement of discharge of the tankers, ullaging of the tanker is done and in the meanwhile shore tanks are also aligned and tank valves are operated for receipt of cargo

into shore tanks. The inlet and outlet valves of the shore tanks are motor operated and can be closed within five minutes in case of any emergency or after the discharge of the tanker is over. KPT provides the tug for pull back operation to avoid tankers overriding the SPM buoy, under buoy hoses etc. to prevent damage to the buoy and oil pollution.

Further during the operation of the tanker, there is a constant watch on the SPM system and the hoses for any leakage or burst and the operating parameters are kept well within the designed limits besides observing all safety aspects for the safety of the tanker, buoy and its accessories. The work of connecting and disconnecting hoses and repair of lines has been given on contract. During discharge operations technical personnel from following agencies are always available:

- Kandla Port Trust
- IOC Salaya Mathura Pipeline (SMPL), Vadinar.
- M/S Underwater Services, Mumbai
- Crude Oil Tanker

There are isolating valves provided for isolation of the floating strings and under buoy hose strings for use in any emergency arising out of failure of hose or burst of hose during operation to prevent oil loss, pollution and to sustain operation through the other string. Thus by meticulously following the international marine standards of operations and maintenance the entire tanker discharge operation is kept totally spill proof.

Further the entire off-shore facilities are subjected to stringent inspection checks as per Oil Companies International Marine Forum (OCIMF) guidelines and rigorous preventive and schedule maintenance for the upkeep of the facilities/ equipment is done in order to avoid any unforeseen instances of hose burst, leaks or any other eventualities which may result in either small or large scale oil spills in the ocean.

19.19.4 Definition of Oil Spill Management

Accidental and unwanted discharge of crude oil in the sea during the operation of SPM system including accidental spillage, if any, from the oil tankers may be termed as an oil spill resulting into pollution of marine environment.

The oil spill may be minor, intermediate or major in nature depending upon the source and duration of the oil spill.

19.19.5 Oil Spill Classification

Oil spill can be broadly categorized into three categories depending upon the volume and area of oil spill, which has taken place. These three categories of oil spill are generally classified as Tier one, two and three and each Tier will require response strategies to suit its magnitude and manifestations as mentioned below:

TIER ONE

This would be a spill of a magnitude the local resources could respond to, successfully without assistance from other agencies.

TIER TWO

This would be a spill of a magnitude that would outstrip the local resources and would

require assistance on a regional basis. This would either come from local/central Government or Local Industries Mutual Aid arrangement.

TIER THREE

This would be a spill of a magnitude that would surpass the capabilities of Tier one and Tier two. Additional resources would be required on a national and international level.

Clearly Tier one and Tier two levels of response equipment and manpower resources are governed by a number of criteria. These criteria are such as location, logistics for national and international assistance, nearby sensitivities and many others.

The following classification has been made as per OISD norms:

Tier Level	Volume
Tier –1	Up to 100 MT
Tier – 2	100 MT – 1000 MT
Tier – 3	More than 1000 MT

19.19.6 Risk Analysis & Causes of Spill

Accidental spill from tankers contribute an estimated 0.4 million tons annually globally. Analysis of tanker spills occurring throughout world shows that the majority occurs in port during routine ship operations such as loading, discharge and bunkering. The most of these spills are, however, relatively small. Over 92% are less than 7 tones and probably in total, contribute less than 20000 ton annually. In comparison, accidents, such as collisions and grounding give rise to less than 10% of oil spills from tankers, but a quarter of these are larger than 700 tons.

19.19.7 Spills Due to Collision

The statistical data shows that as a percentage of the total no. of incident, collision account for 5% of oil spill regardless of the quantity of oil released. The classification based on size of the spill shows more alarming statistics with 29% of all large spills (> 700 tons) being due to a collision. Almost 21% of the sizable spills involving the release of between 7 and 700 tons are due to collisions. Small spills of less than 50 barrel (7 tons) from a collision account for less than 2% of total.

19.19.8 Spills Due to Grounding

A similar analysis of statistical data shows that although as a percentage of the total incidence spills due to grounding are rather small, accounting for only 5.2 %. A different picture emerges when the quantities involved are scrutinized. Large spills of more than 700 tones caused by grounding account for 33% of all releases of that magnitude. Off the sizable spill between 7 - 700 tones about 18 % are a direct result of grounding. The small spills of up to 7 tones are fairly insignificant and are 2.7 % of the total spills in that category.

It is prudent to assume that in any collision or grounding, spill quantity may be more than 700 tones.

19.19.9 Most Likely Spills

The most likely maximum spill can result from a central compartment of a tanker being ruptured at the bottom of the hull releasing most of its contents. Quantities in the order of 7000 tones are therefore more probable due to the release of an assumed 90 % of the contents of a center tank of a typical 175,000 DWT single skin fully laden tanker ruptured due to grounding.

19.19.10 Collision with another Vessel

A collision with another vessel causing a tank to rupture will release only the contents of the tank above the water line. The ensuing spill caused by a gash in the tank resulting from a surface collision will release near about 1750 tones. Therefore the spill quantities in both the above scenarios pertaining to rupture due to collision and a bottom gash resulting from grounding are to be 1750 - 7000 tones when a single tank has been damaged.

19.19.11 Oil Spilled into Sea

Oil spilled into the sea undergoes a number of physical and chemical changes, some of which lead to its disappearances from the sea surface whilst others cause it to persist. The time taken depends primarily upon the physical and chemical characteristics of the oil, as well as the quantity involved, the prevailing climate and sea conditions and whether the oil remains at sea or is washed ashore.

In considering the fate of spilled oil at sea, a distinction is frequently made between non-persistent oil, which tend to disappear rapidly from the sea surface, and persistent oil, which in contrast, dissipates more slowly and usually requires a clean-up response. Most crude oils and refined residual oils have varying degree of persistent depending upon their physical properties and size of the spill. The main physical properties, which affect the behavior of oil spilled at sea, are specific gravity, distillation characteristics, viscosity and pour point.

19.19.12 Most Small Oil Spills

Most spills will in fact be small, involving less than two tones and will occur mostly when the hose system failed at the terminal. This can usually be dealt with swiftly and efficiently by the terminal operator. Major spills are fortunately considered rare with estimated probabilities between one in 100 years to One in 220 years. In the event of such a large spill at the Gulf of Kutch efforts can be made either to contain and collect the oil using booms and skimmers, or to disperse it using chemical dispersant which are spread either from marine craft using side booms or aircraft (similar to crop spraying).

If oil is washed ashore on a hard sand beach, for instance, it can be quickly and effectively cleared by manual labour with the aid of trucks and bulldozers.

In some cases, bio-degradation method may be applied using bacteria to digest the oil-which can halve the time that natural forces would take to achieve the same result. However, natural forces usually degrade any oil, which cannot be cleaned up, and such forces are exceptionally strong at the Gulf of Kutch and the effects of a pollution incident are rarely long term.

19.19.13 Impact of Second SPM at Vadinar

The second SPM was commissioned during March'97 at Vadinar location. Obviously this has an impact on the requirement for pollution preparedness.

It is felt that there will be an increase in the likelihood of a spill rather than the possible volume of oil spill. This position comes from the facts mentioned below:

Increase in vessel traffic.

Doubling of hoses, joints and other possible points of failure and Increases in connections and disconnection of hoses etc.

19.20 Responsibility during Emergency

The basic responsibility of combating oil spill disaster and marine pollution lies with the local port authority within its port jurisdiction and the defaulter companies/ organizations.

19.21 Chief Coordinator (Location Head, WRPL Vadinar)

a. On getting information of oil spill, he will report to KPT authority and other resource agencies.

b. He will co-ordinate all activities through Chief Operation Manager and Maintenance Manager (Marine).

c. He will ensure that appropriate response and techniques are in action to clean up pollutants.

d. He will ensure that all the resource agencies have been duly reported about incident.

e. He will apprise Head of WRPL about the incident and actions undertaken.

f. He will make arrangements for disposal of oil as per the directive of Regional Commander (West).

g. He will be responsible for the resumption of Operations at SPM terminal.

h. He will contact IOC (Shipping) and seek assistance required to meet the emergency.

19.22 Roles of IOC in Controlling Oil Spill Disaster

19.22.1 IOC Vadinar

a. To assist KPT off shore oil terminal, and Coast Guard Vadinar action group, in implementation of local action plan.

b. To assist KPT, Vadinar and Coast Guard Vadinar in obtaining additional available equipment and chemicals from identified resources if and when required.

c. To assist in chartering/hiring of tankers to undertake transportation/ transshipment operation if so required by KPT.

d. To arrange for storage of oil transshipped as above.

e. To make assessment of the value of the oil transshipped.

19.22.2 IOC Shipping New Delhi

a. To arrange for chartering tankers for Vadinar as required.

19.22.3 Indian Coast Guard – Central Coordinating Authority

a. To receive the report of significant spillage of oil at sea.

b. To keep the Ministry of Defense apprised of the development on receipt of information about oil spill.

c. To decide upon the nature and extent of actions required and to advise the Regional Headquarters/Local Action Groups/authorities concerned regarding the action to be taken by the latter in consultation with Apex Committee on Control of Marine Pollution/Task Force on oil spills.

d. To arrange for chartering of any tankers for oil transshipment operations, if required.

e. If the resources available with the Regional Headquarters / Port authorities/other agencies, Local Action Group/authorities are inadequate, to mobilize all available and necessary resources and direct the same towards the concerned Regional Headquarters/Local Action Groups/authorities.

Regional Coast Guard Commanders (RCC)

a. Receiving reports of oil pollution at sea.

b. Coordinating the activities of RCC when activated.

c. Keeping the Director General, Coast Guard apprised of developments.

d. Processing and coordinating claims of the affected parties and participating agencies with a view to compilation for processing by Director General Shipping.

e. Mobilizing Coast Guard resources to support On Scene Commander (OSC) action at spill area.

f. Maintaining the Regional Contingency Plan (RCP) and forward revised plans to members as may be required by RCC.

g. Receiving periodic reports from resource agencies on account of Pollution Equipment and material with a view to have an upto date inventory list in the Coast Guard western Region, Eastern Region and Andaman and Nicobar Region.

h. Providing the administrative infrastructure to the RCC for conduct of routine and operational tasks.

i. Providing additional sampling effort during spills when requested by OSC.

j. Maintaining a list of national and international agencies that may be called upon to assist for pollution response at the discretion of RCC.

k. Arranging for periodical exercise in pollution response.

l. Providing sensor data to RCC/OSC as required.

m. Pre-designating a Coast Guard OSC.

19.22.4 Responsibility of Port Authority

The port authorities will be responsible for response to accident / oil spill within Port Limits keeping the coast guard regional commander informed and request for any additional assistance through the Regional Communication/Operations Centers. The detailed responsibilities are as follows:

a. To arrange for the preparation of a local contingency plan in consultation with Regional Head Quarter/Central Coordinating Authority.

b. To identify a suitable sea going tug when required for operations

c. To identify surface crafts

- On which dispersant spraying equipment can be mounted and
- Which can be used for rigging the booms

d. To ensure that the purpose of part-XIII of Merchant Shipping Act, 1958, actions are taken by the various authorities under the overall legal receiver of the wrecks and dock concerned.

e. To ensure that at least following minimum equipment is kept available locally at all time:

Inflatable booms

Dispersant spraying equipments capable of being mounted on surface craft.

Suitable dispersant chemicals of the nature and quantity estimated as requirement of Local Action Group as part of the local contingency plan.

Oil skimmer equipment

a. Surface crafts on which above dispersant equipment can be mounted and which can be used for rigging booms etc.

b. To arrange for training of personnel expected to be engaged in above operation.

c. To arrange for periodic exercise under the guidance of the RCC to keep equipment and personnel on continuous readiness for oil spill response operation.

d. To consult the Coast Guard or Director General Shipping or any other authority, when further advice/assistance is required.

e. To keep the Coast Guard appraised of actions being taken.

19.22.5 Responsibility of Boarding Officer

a. Inform Chief Crisis Coordinator / Alternate Chief Crisis Coordinator, Maintenance Manager (Marine), IOC Control room, Marine Department about the oil spill incident.

b. Stop the cargo or slow down the cargo as may be the case and accordingly isolate the affected portion causing the oil spill.

c. Instruct the O&M contractor to fight the oil spill & locate the source of oil spill and co-ordinate with various agencies for oil spill containment.

d. To carry out the water flushing of the SPM system as per the requirement in co-

ordination with IOC control room.

19.22.6 Reporting & Alerting Procedure

After knowing major oil spill, Chief Coordinator, IOCL is to report the same immediately to KPT authority who in turn will inform Commander Coast Guard Region (West). Besides informing KPT, Chief Coordinator, IOCL should inform DC, Jamnagar, Forest Department Jamnagar and Gujarat Pollution Control Board Jamnagar, Gandhinagar regarding the incident.

19.22.7 Handling SPM Emergency

In case of any burst or leakage in floating / under buoy hoses or in any system of SPM, is noticed by the master or Deputy Officer or Our Boarding officer or any other person, the above incident should be immediately brought to the notice of Master/ Deputy Officer of the Ship. On getting the information, the discharging operation should be immediately stopped and the IOC control room at Vadinar should be informed through VHF channel 12 and 07 (US) about the stoppage of oil discharge. The master of the ship/ IOC Boarding officer with the help of crew members of ship and supporting contract vessel of IOC should try to assess where the spill is coming from and try to contain the spill by means of deploying booms available with the ship/contract vessels of IOC. Procedure to be adopted in case of leakage from following is as detailed below:

19.22.8 Floating Hose

- Stop discharge.
- Close the butterfly valve near tanker manifold and isolation valve near SPM.
- Contain the leak
- Further operation can be done only after replacement of burst/leaked hose or hoses

19.22.9 Under Bouy Hose

- Stop discharge.
- Close the PLEM valve of the leaking line.
- Contain the leak
- Further operation can be done only after replacement of burst/leaked hose or hoses.

19.22.10 Central Swivel Leak

If the leak is not controllable then

- Cast-off the vessel.
- Contain the leak.
- Arrest the leak.
- Re-berth the vessel.
- Restart operation.

19.22.11 Central Swivel Leak

The officer on board of the vessel can decide in consultation with pilot/master of the vessel whether the ship can continue at berth. If necessary, arrangement should be made to replace the damaged mooring rope.

19.22.12 Damage to Buoy

It is due to overriding of tanker. The officer on board of the vessel can decide in consultation with the pilot/master of the vessel whether the ship can continue at berth.

19.22.13 Pollution Control near SPM

a. The master of the vessel will be informed about the oil spillage by boarding officer. The master in turn will contact the port signal station, which is provided with VHF channels 16, 12, 10 and 07 (US) and give a detailed report of the incidence to KPT.

b. The signal station in turn will inform the Chief Operation Manager (COM) Offshore Oil Terminal (OOT) KPT.

c. Boarding officer will also inform IOC shore control room/ marine department through VHF and IOC control room in turn will inform the incident to CMNM / Chief Coordinator, IOCL, Vadinar.

d. Upon receipt of information from port signal station, COM, KPT will direct all the crafts presently posted at Vadinar to combat the oil spill within port limit.

e. The tug / launches of KPT should carry sufficient quantity of dispersant before leaving Vadinar jetty.

f. Since the flow of underwater current around Vadinar coast is very high, usage of oil skimmer to recover oil from any leakage from SPM and other floating hoses is not much effective, hence the pollution control near SPM done presently is limited to spray of dispersant.

19.22.14 Typical Case of Oil Spill Combating at Vadinar

In case of any accidental oil spill in and around SPM following action plan is to be brought to effect immediately in line with the disaster plan in association with KPT.

1. Reporting:

   a. On getting any information about oil spill noticed by the Master or the Duty Officer of the vessel, or Boarding Officer of IOC on board, working SPM Maintenance Contractor, Coast Guard patrol party, KPT pilot or any other person, the above incident should be brought to the notice of the Master / Duty Officer of the ship. On getting any such information, the discharging operation should immediately be suspended and the IOC tank farm which is also available on VHF channel 12 and 07 (US) should be immediately informed about the stoppage of discharge.

   b. On getting such information from Boarding Officers, the shift in charge in IOC shore control room shall inform the incident to Chief Coordinator, IOCL, Vadinar and the necessary line isolation from ship to shore tank farm should be ensured by closing necessary valves.

   c. The master or the Boarding Officer of the vessel should contact the Port Signal Station which is provided with VHF channel 16,12,10 and 07 (US) and give a detailed first hand information report of the incident.

   d. The Signal Station, in turn, should inform the COM, KPT. COM, KPT may in turn pass

on the information to their authorities and Coast Guard etc.

e. IOC officer on board should also pass on the information to location head Vadinar through IOC control room on VHF channel and check back with COM, KPT for confirmation of the message receipt through Port Signal Station.

f. Chief Coordinator, IOCL, Vadinar will immediately establish contact with ED WRPL Gauridad and pass on the first hand information report besides informing the incident to statutory bodies like Gujarat Pollution Control Board (GPCB) and Forest Department / National Marine Park authorities.

2. Alerting:

a. COM, KPT will direct the crafts posted at Vadinar to proceed to SPM and during the passage rig-up the dispersant spraying booms.

b. IOC, Vadinar should ask its maintenance contract vessel to be ready for deployment of spill combating facilities on board at short notice on demand from COM, KPT.

c. Small tug available with SPM maintenance contractor should also be put on alert for deployment, if so demanded by KPT for replenishment of oil dispersant and other support services.

3. Operational Requirements:

a. In view of the strong current experienced at Vadinar only dispersant may be sprayed by 3 tugs of KPT while the fourth craft would be busy in replenishing her stock of dispersant chemicals from the storage provided at Vadinar jetty.

b. The Master of harbour tugs / launches should ensure that sufficient quantity of dispersant chemical is carried out on board prior to leaving the jetty.

c. In view of the strong currents experienced at Vadinar and the location of the SPM, Commander TMS Hayes, Advisor on Marine Pollution, International Maritime Organization in his Mission Report has indicated that it will not be possible to contain the oil spill and use a skimmer to collect oil. He therefore has recommended that the KPT should equip at least three crafts with dispersant spraying units. Accordingly, the Port had provided only the dispersant spraying equipments for use at Vadinar.

4. Execution:

The craft should move downstream of the oil spill and then start streaming up against the current while carrying out spray of dispersant chemicals with a systematic run over the oil spill, till the total spill gets dispersed.

5. Support Services:

IOC shall assist KPT and Coast Guard in

a. Implementing the local action plan.

b. In obtaining additional equipments and chemicals from HQs of KPT and Coast Guard, if and when required.

c. Chartering of tankers to undertake transportation / transshipment operation if so required by KPT.

d. Arranging for the storage of oil transported at shore and

e. Making assessment of the value of the oil transshipped.

6. Claims:

In case the oil spill in and around SPM terminal is due to any problem of tanker or any negligence from tanker operation crew, following steps should be taken for claim, which will be done by DC / COM, KPT.

COM, KPT should inform the Master of the Vessel holding him responsible for the spillage/pollution and also steps taken by the Port to combat the oil spill and for cleaning operations and the charges thereof as per rules.

Record of all expenditures towards the use of port craft / tugs / dispersant chemicals / port vehicles and any other material should be maintained by the DC / COM, KPT for subsequent recovery from the Master/Agent of the ship, prior to her departure.

7. Final Report :

The detailed report of the oil spill in chronological order supported with available data/records will be prepared by KPT and sent to respective Organizations including IOC. However necessary reports for informing IOC official should be prepared by Chief Coordinator, IOCL, and Vadinar. He will also submit necessary reports to statutory bodies like Gujarat Pollution Control Board, Forest Department/National Marine Park authorities.

19.22.15 Relationship with Coast Guard & Port Trust

The Indian Coast Guard and Port Trust along with IOC would be among the main organization involved in the more practical aspects of oil spill response at Vadinar terminal.

It has been therefore, the endeavor of KPT / IOCL / ESSAR / Indian coast Guard to ensure that good working relationship, understanding of individuals, operating procedure are developed and understood before the high pressure environment of spill response prevents the building of such ties.

All relationship with the Indian Coast Guard has been undertaken with the knowledge that in the National Disaster Plan it states that ICG is the controlling body for all oil spill response activities.

19.23 Oil Spill Equipment Available with IOCL Vadinar

Sr.No	Item Description	Qty
01	Inter Tidal Boom	600 mm
02	Coastal Boom	600 mm
03	Disc Skimmer	1No
04	Mop Skimmer	1No
05	Dispersant Spray Sets	2 Sets
06	On Shore Cleaning System	1 No
07	Floating Tank 25m^3	2 Nos

08	Floating Tank 12.5m^3	4 Nos
09	Off Loading Pump	1 No

19.24 Oil Spill Consumables Available with IOCL Vadinar

Sr.No	Item Description	Qty
01	Oil Spill Dispersant	9800 Liter
02	Oil absorbent pillow (1.5'x1'x5")	72 Nos
03	Oil absorbent boom (length-10'x dia-7")	120 Nos
04	Oil absorbent sheet (1.5'x1.5')	760 Nos

19.25 Imp Telephone Nos of Govt Officials related to Oil Spill Combating

Sr No	Description	Telephone No		Fax Number
		Office	Residence	
1	District Collector Jamnagar (0288)	2555869	2554059 09427306210	
2	Collector Office Jamnagar (0288)	2557601 – 5	------	2555899
3	Superintendent of Police Jamnagar (0288)	2554203	2555868 09427305071	2556382
4	Municipal Fire Station Jamnagar (0288)	2550101	------	------
5	Regional Officer Gujarat Pollution Control Board Jamnagar (0288)	2752366	2540741	2753540
6	Conservator of Forest Jamnagar (0288)	2552077	2553327 09425049064	2679371
7	Police outpost Vadinar (02833)	256541	------	------
8	KPT Control Tower Vadinar (02833)	256555	------	------
9	Deputy Superintendent of Police, Khambalia (02833)	234262	234726	234262
10	Deputy Collector, Khambalia (02833)	234577	234714	234577
11	Commander Coast Guard, Porbandar (0286)	2241794 /2240958	2244234	2244056
12	Gujarat Pollution Control Board, Gandhinagar, (079)	23222756 /23222095	------	23232156
13	Chief Conservator of Forest Gandhinagar, (079)	23254123	------	23229917
14	Director Environment, Govt. of Gujarat. Gandhinagar, (079)	23251062	------	23252156
15	CG, Station Vadinar	256560 /256579	256534	256560

16	COM, KPT, Vadinar	256749	256522	256540
17	Head (Environment), RIL, (Mr. Kannan)	95288-3012152		952833-3012199
18	RPL, Port Operation Center			
19	Mundra (Port operation Center)	02838-288201 to 288207, 02838-220033		95288-288270

19.26 Important Telephone Nos of VOTL Marine Operations

Sr No	NAME	DESIG	TEL (OFF)	MOBILE NO.
1.	Capt Deepak Sachdeva	Chief Operations Officer	02833-241777	9925153618
2.	Capt. Alok Kumar	Port Captain		9909908611
3.	Commandt. Raghuvanam	Head- Port Facility Security	02833-241780	9909021183
4.	V. Gopalakrishnan	Admin Officer	02833-241779	9979891335
5.	Control room	Shift -in charge	02833-241775	9979868460
6.	Control room fax		02833-241779	

19.27 Emergency Telephone Nos of outside agencies including District Authorities

19.27.1 Fire Station

SL No	Dept. Name / Officer's Name	Office	Resident
1	Inspector CISF (02833)	256542	-
2	Municipal Jamnagar (0288)	2550340 2550101 2675091 101	2550340

19.27.2 SHO (Police)

SL No	Dept. Name / Officer's Name	Office	Resident
1	District Superintendant of Police	2554203	2555868
2	Deputy Superintendant of Police	2552940	2542970
3	Police Control Room	100 2550200	-

4	Police Inspector, City 'A' Division	2550243	2676667
5	Police Inspector, City 'B' Division	2550244	2550315
6	Police Inspector, Panchkoshi 'A' Division	2550359	-
7	Police Inspector, Panchkoshi 'B' Division	2676556	-
8	Dhrol	02897-222033	-
7	Dy. SP Khambhaliya Police Inspector Circle	234726	
8	Office, Khambhaliya	234744	

19.27.3 Collectorate

SL No	Dept. Name / Officer's Name	Office	Resident
1	Collector Shree & District Magistrate Shree	2555869	2554059
2	Additional Collector Shree	2550284	2672131
3	Resident Deputy Collector Shree	2553183	2556102
4	Sub divisional Magistrate Shree	2552130	2552807
5	Mamlatdar Shree (City)	2674575	2660950
6	Collector Control Room	2553404	-
7	Circuit House, Lal Bungalow	2550237-38	-
8	Deputy Collector, Khambhaliya	234577	

19.27.4 District Authority

SL No	Dept. Name / Officer's Name	Office	Resident
1	District Development Officer	2553901	2552402
2	Deputy District Development Officer	2550221	2755070
3	District Health Officer	2671097	2756252

19.27.5 Forest Department

SL No	Dept. Name / Officer's Name	Office	Resident
1	Conservator of Forest Marine National Park	2552077	2552327
2	Deputy Conservator of Forest Marine National Park	2552077	2679374
3	Deputy Conservator of Forest (Distribution)	2553664	2559787
4	Deputy Conservator of Forest (Common)	2553026	2554387

19.27.6 Port Department

SL No	Dept. Name / Officer's Name	Office	Resident
1	Port Officer - Bedi Port	2670207	2556106
2	Port Office - Okha	262001	262010

19.27.7 Railway Station

SL No	Dept. Name / Officer's Name	Office	Resident
1	Railway Inquiry - Jamnagar	2755222	-
2	Railway Inquiry - Hapa	2570410	-
3	Officer, Railway Station - Jamnagar	2755169	-
4	Officer, Railway Station - Hapa	2570410	-

19.27.8 Airport Office

SL No	Dept. Name / Officer's Name	Office	Resident
1	Airport Officer	2712187 2712413	2560252 2560262
2	Indian Airlines - Jamnagar	2550211	2554768

19.27.9 Station Transport

SL No	Dept. Name / Officer's Name	Office	Resident
1	S.T.Inquiry	2550270	-
2	Manager, S.T.Depo	2676904	-
3	Divisional Director - Jamnagar	2570608	2570486

19.27.10 Hospitals, Ambulance Sevas, Blood Banks & NGO's

Sr No	Dept. Name / Officer's Name	Telephone No	
		Office	Residence
Hospital			
1	Guru Govindsinh Hospital (Emergency)	2661087 2550204-06	------
2	Samarpan Hospital	25566423 2712728	------
3	Mental Hospital	2712728	------
4	Dental Hospital	2750218	------
5	Ayurvedic Hospital	2550368	------
6	City Dispensary – Ranjit Road	2676456	------
7	Oswal Hospital	2562705 2566833 2676521	------
8	Adarsh Hospital	2665566	------
9	Jivandep Healthcare Pvt Ltd	2558176 2558275	------

10	KPT Primary Health Centre, Vadinar	256539	------
Ambulance Seva			
1	Fire Branch, Jamnagar Mahan agar Palikir	102	------
2	Aaryasamaj	2550220	------
3	Guru Govindsinh Hospital	2541081	------
4	Jilla Panchayat, Jamnagar	2550221	------
5	Taxi Association, Jamnagar	2560547	------
6	Mahavir Samaj Sevak Dal	2550225	------
Blood Bank			
1	Guru Govindsinh Hospital	2550227	------
2	J.H.M. Blood Bank	2550208	------
3	Deepchand Gardy Memorial Blood Bank	2672529	------
4	Omkar Charitable Trust Blood Bank	2673339	------
NGO			
1	Aandabawa Seva Sanstha	2540155	------
2	Kabir Ashram	2558049	------
3	Shree Pranami Seva Sanstha	2551353	------
4	Nawanagar Chamber of Commerce	2550250	------
5	Youth Hostel Association of India	2558040	------
6	Jamnagar Factory Owners Association	2560002	------
7	Jamnagar Brass Foundry Association	2730271	------
8	M.P.Shah Udyognagar Association	2550960	------
9	Kasturba Stree Vikasgruh	2751730	------
10	Indian Road Cross Society	2553583	------
11	Rotary Club	2550348	------
12	Lions Club	2673193	------
13	Jamnagar Vepari Mahamandal	2533185	------

19.28 Mutual Aid Members

Sr.No	Name of Mutal-Aid-Scheme Member	Telephone No. Office	Residence/ Mobile Nos.
1	Chairman - Collector	2555869 9978406210	2554059
2	Addl. Collector	2550284 99784 05182	2672131
3	Jt.Chairman - Commissioner,JMC	2552321	2552372
4	MR Prajapati - Secretary, MAS, GSFC	2432216	2712768/ 9979853306
5	RN Shah - Treasurer-MAS, GSFC	2432242	9979862520

6	MAS OFFICE	2542764	
7	Office of Supdt. of Police	2554203	2555868
8	Police Control Room - Jamnagar	2550200	2344249(Sikka) 2846125(Padana)
9	District Disaster Control Room	2553404 / 2541485/ 1077 (Toll Free)	9426950783 (DDMO) Mr.Yaswant Sinh Parmar
10	PB Shah ,Asst. DISH - Jamnagar	2678206	9824583767
11	Mr. Desai -Home Guard - Jamnagar	2553862	
12	Dr. Gosai RMO - GG Hospital	2550240 /2541081	2551689 / 9824258885
13	Control Room GMB - Jamnagar	2711805 / 2756909	
14	KK Bisnoi - JMC CFO	2550340/101 (2662691)	9879531101
15	Indian Coast Guard - Vadinar	02833 - 256579	1090 (Terror Helpline Toll free)
16	Sanjay Goyal -IOCL Vadinar	02833 - 256330	9909909016
17	P Palanivelu- Jt. Secretary MAS,EOL	02833 - 241892	9825210517
18	PK Prasad - IOCL Theba	2570712	9426911475
19	HS Modha - Fire Officer	2344116	9925214054
20	Chetansinh Jadeja - Fire Officer, SDCC	2344272 -75/ 2439322 (Fire)	9099038083
21	V.Koti, VP(Fire) RIL	6611193	9998972008
22	D K Thakur Jt. Secretary-MAS-TCL	02892 - 665247	9227676113
23	Mr. Dipak Roy, Mgr.(O&M) - K Kumar AM - GSPL	9925013159 9879599464	
24	MJ Sunaria - Digjam Ltd.	2712972/73/74	
25	PB Sakharkar -GAIL	6611437	9624089696
26	Indian Navy- Valsura	2550263-357	
27	Indian Air Force, Jamnagar	2720007, Extn.4222(fire)	2550245
28	PR Thatte, VP Bharat Oman Refinery	02833 -256450	9427206501
29	MU Khan - Cairn India		966253945

30	For any Emergency Ambulance / Fire		108

19.29 Details of Fire Fighting Equipment at Vadinar

Sr.No	Description of system	Quantity
1	**Water Cum Foam Monitors**	
	Fixed Monitors	05 Nos.
	(1200/1500/1800/2580/3840) LPM	2138 lpm (475 gpm)
	Portable Monitors	02 Nos. (Fire Station)
	(1200/1500/2580/3840) LPM	1000 gpm (4500 lpm)
	Foam trolley tank capacity and Qty of AFFF in it.	3 No. of trolleys with 200 liters each.
2	**Hoses /Nozzles /Accessories**	
	Hose	152 No.
	Type	Type B
	Nozzles	
	Universal (Triple purpose) nozzle	33 No. Diffuser branches
	Jet nozzle (Standard branch)	60 Nos. of Aluminium and 6 no. of Gunmetal
	Fog nozzle	11 Nos.
	Foam branch (FB-5X)	07 Nos.
	Water curtain nozzle	01, Good
	Hose Boxes	64 Nos.
	Foam Concentrate (AFFF)	28000Ltrs(Min)
	FIRE SIREN	
	Hand operated	02 Nos
	Electrical	03 Nos.
	Sand buckets with cover	30 Nos.
	Manual fire call points	13 Nos.
3	**Safety Equipment**	
	Explosimeter (make)	02 Nos (ENDEE GP200L)
	Fire proximity suit	11 Nos.
	Water gel blanket (expiry date)	01 No. (Expiry date Feb. 2010)
	Safety torch	10 Nos.
	Safety goggles	30 Nos.
	Red and Green Flags for drill	01 No each
	Breathing Apparatus Set (Indicate make)	07 Nos make DRAGER
	Spare Breathing Apparatus cylinder	06 Nos
4	**Fire Extinguishers**	
	CO_2 Type	66 Nos.

	2.0 Kg	28 Nos
	3.2Kg	10 Nos.
	4.5 Kg.	23 Nos.
	6.8 Kg.	05 Nos.
	DCP Type	148 Nos.
	5.0 Kg	28 Nos.
	10.0 Kg	116 Nos.
	75 Kg	04 Nos.
5	**Fixed Fire Fighitng Facilities**	
	Fire water pond/tank (no. and capacity)	3 no. ponds 6000 KL each.
	Foam tender with accessories	3 Nos
6	**Fire Fighting Engines**	
	Engine driven FF pump a) 385KL/Hr @ 88m b) 350 KL/Hr @ 88m	4 Nos 2 Nos
	Motor Driven FF pumpa) 385 KL/Hr @ 91mb) 350 KL/Hr @ 91m	1 No 2 Nos
	Jockey Pump 60 KL/Hr @ 120m	2 Nos

19.30 Details of Fire Fighting Equipment at Jamnagar

Sr.No	Description of system	Quantity
1	**Water Cum Foam Monitors**	
	Fixed Water Monitors	03 Nos.
	(1200/1500/1800/2580/3840) LPM	3500 lpm
	Fixed Water Cum Foam Monitors	03 Nos.
	(1200/1500/2580/3840) LPM	1200 lpm
2	**Hoses /Nozzles /Accessories**	
	Hose	15 Nos.
	Type	Type B
	NOZZLES	
	Universal (Triple purpose) nozzle	04 Nos. Diffuser branches
	Jet nozzle (Standard branch)	03 Nos.
	Fog nozzle	03 Nos.
	Foam branch (FB-5X)	03 Nos.
	Water curtain nozzle	02 Nos
	Hose Boxes	10 Nos.
	Foam Concentrate (AFFF)	5100 Liters
	Fire Siren	
	Hand operated	01 No.
	Electrical	01 No.
	Sand buckets with cover	24 No.

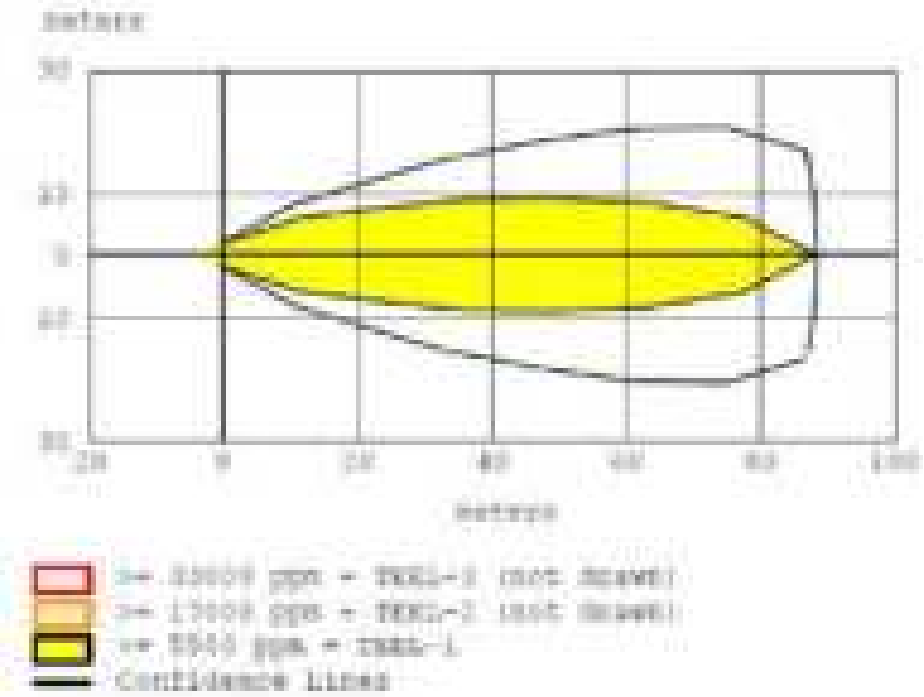
	Manual fire call points	06 Nos.
3	**Safety Equipment**	
	Explosimeter (make)	01 No. (ENDEE GP200L)
	Fire proximity suit	1 No.
	Water gel blanket (Expiry date)	01 No. (Expiry date Feb. 2010)
	Safety torch	02 Nos.
	Safety goggles	1 No.
	Red and Green Flags for drill	01 no. each
	Sand scoops	04 Nos.
	Stretcher	01 No.
	Breathing Apparatus Set (Indicate make)	01 No., make DRAGER
	Spare Breathing Apparatus cylinder	01 No.
4	**Fire Extinguishers**	
	CO_2 Type	33 Nos.
	2.0 Kg	13 Nos.
	3.2Kg	Nil
	4.5 Kg.	15 Nos.
	6.8 Kg.	05 Nos.
	DCP Type	27 Nos.
	5 Kg	01 No
	10 Kg	20 Nos.
	75 Kg	06 Nos.
5	**Fixed Fire Fighitng Facilities**	
	Fire Water Mains (size) and date of Pressure Testing	8" Dia tested on July'10
	Fire water pond/tank (no. and capacity)	2 nos above ground tanks of 700 KL each.
	Mainline pump shed fixed foam flooding system (Manual/auto)	Auto with UV/IR detectors
6	**Fire Fighting Engines**	
	Engine driven FF pumps (150 kl/hr @ 100M)	2 Nos
	Motor Driven FF pump (150 kl/hr @ 100M)	1 No
	Jockey Pump(10 kl/hr @ 100M)	1 No

20 ANNEXURES - GRAPHS

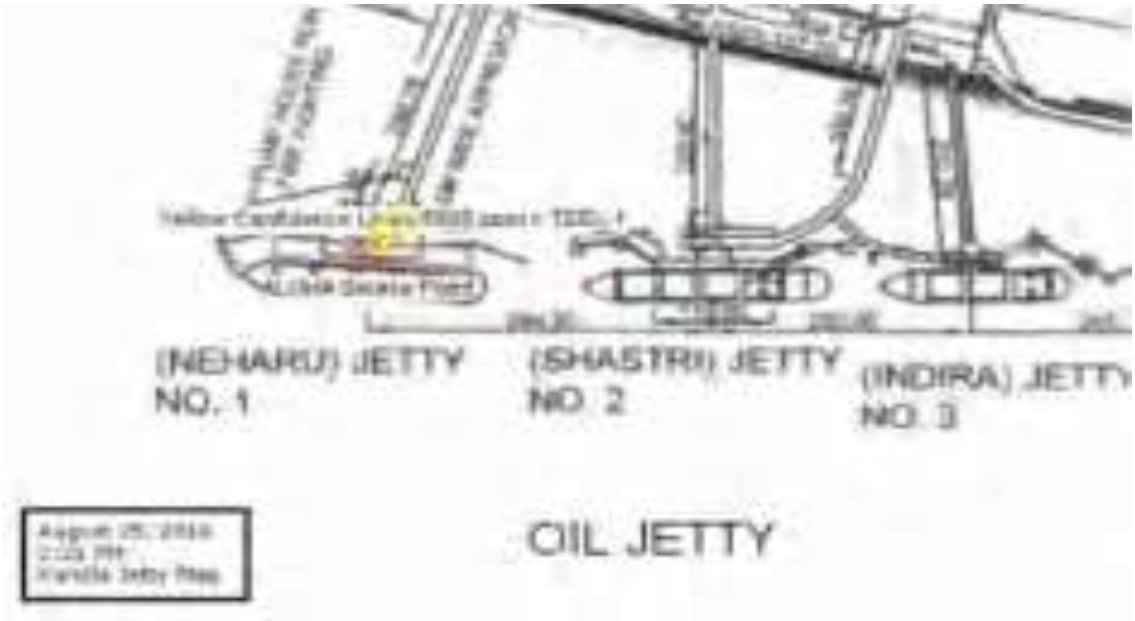
20.1 Graphs & Contours of various MCLS worked out at Jetty (Refer Chapter 4.7)

20.1.1 Jetty One – LPG

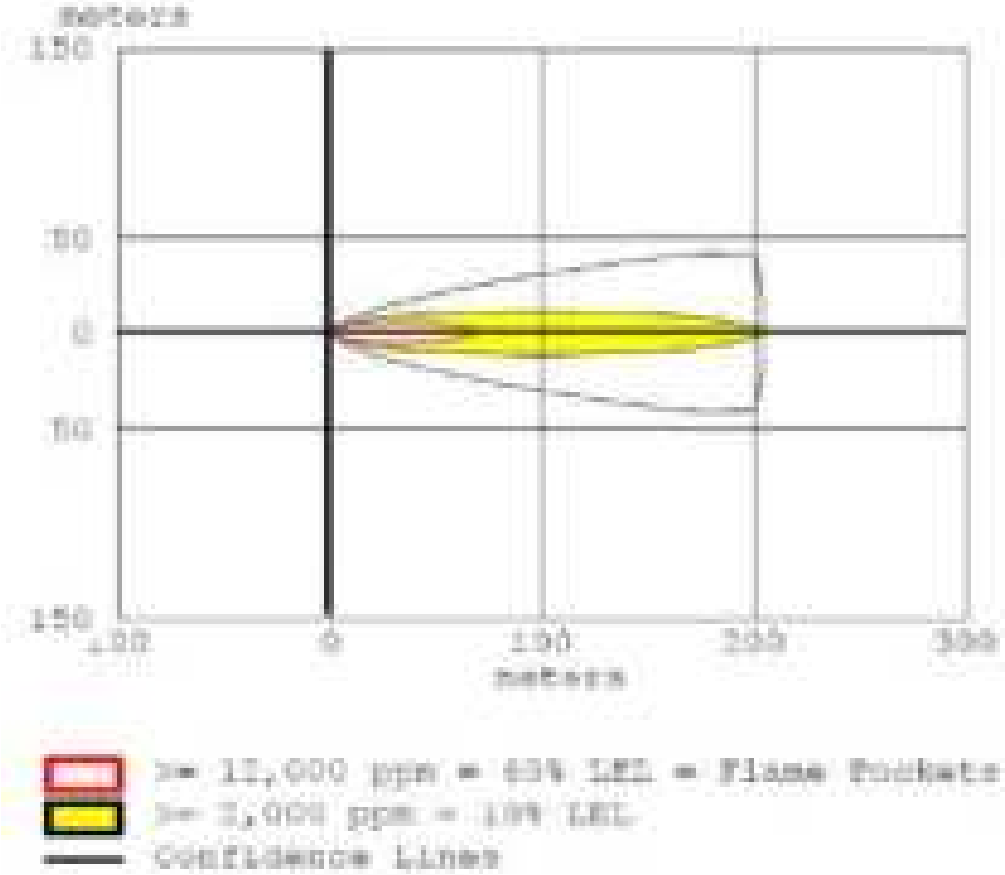
20.1.1.1 Instantaneous Release – Toxic Threat Zone (Graph)



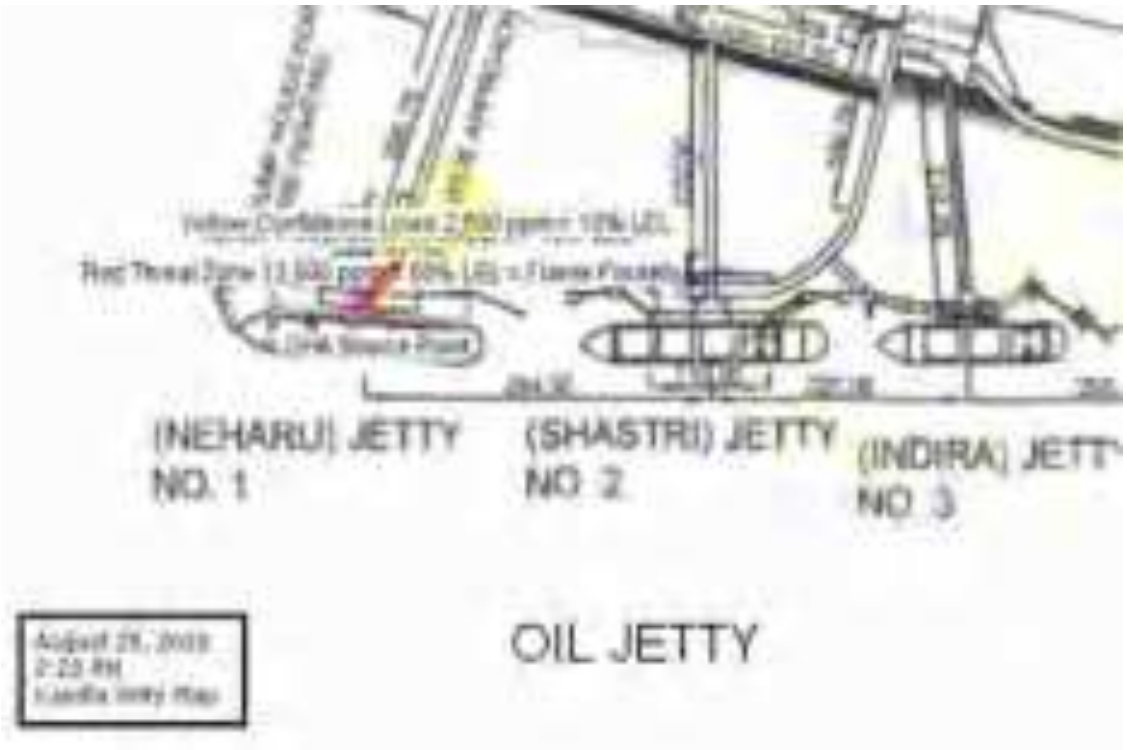
20.1.1.2 Instantaneous Release – Toxic Threat Zone (Contour)



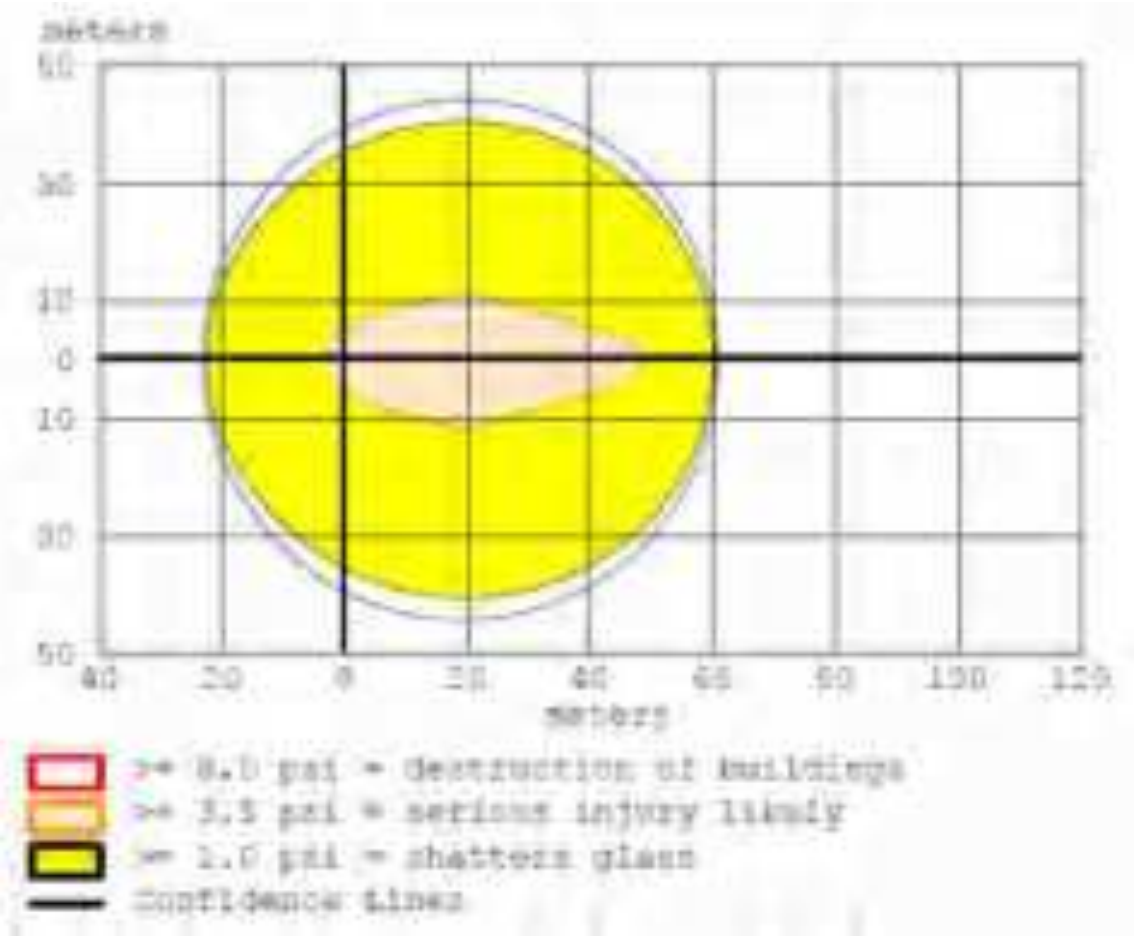
20.1.1.3 Instantaneous Release – Flammable Area of Vapor Cloud (Graph)



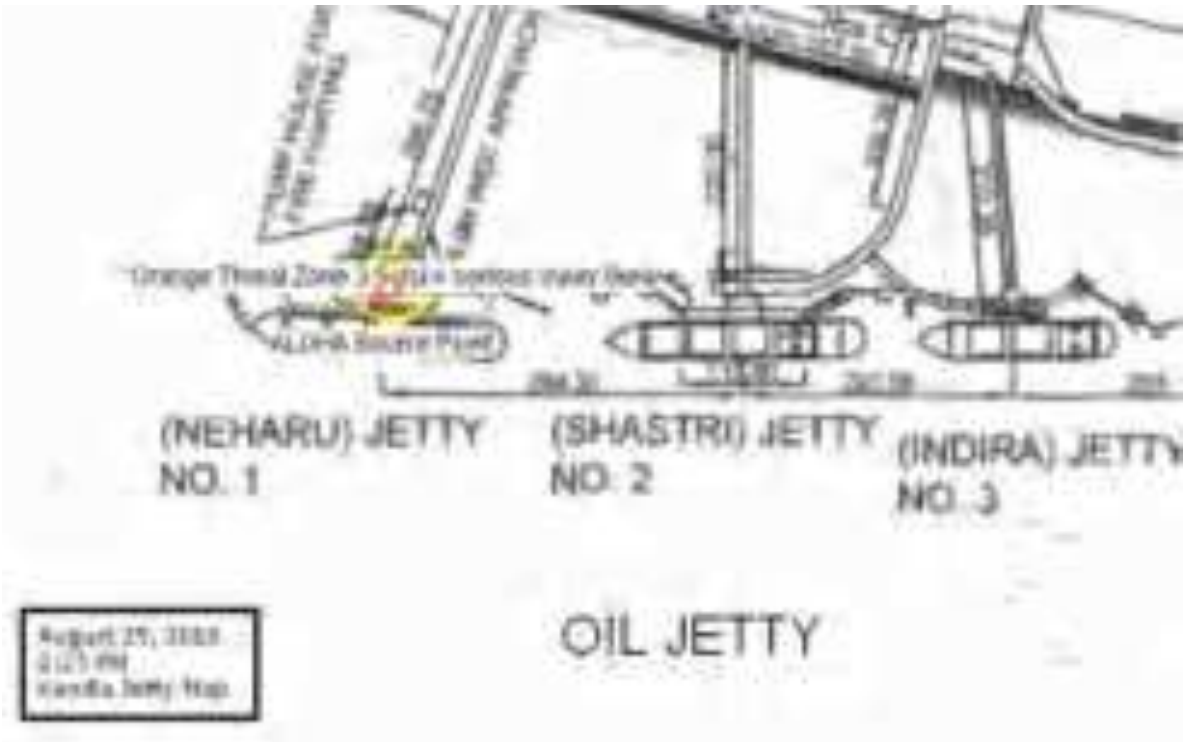
20.1.1.4 Instantaneous Release – Flammable Area of Vapor Cloud (Contour)



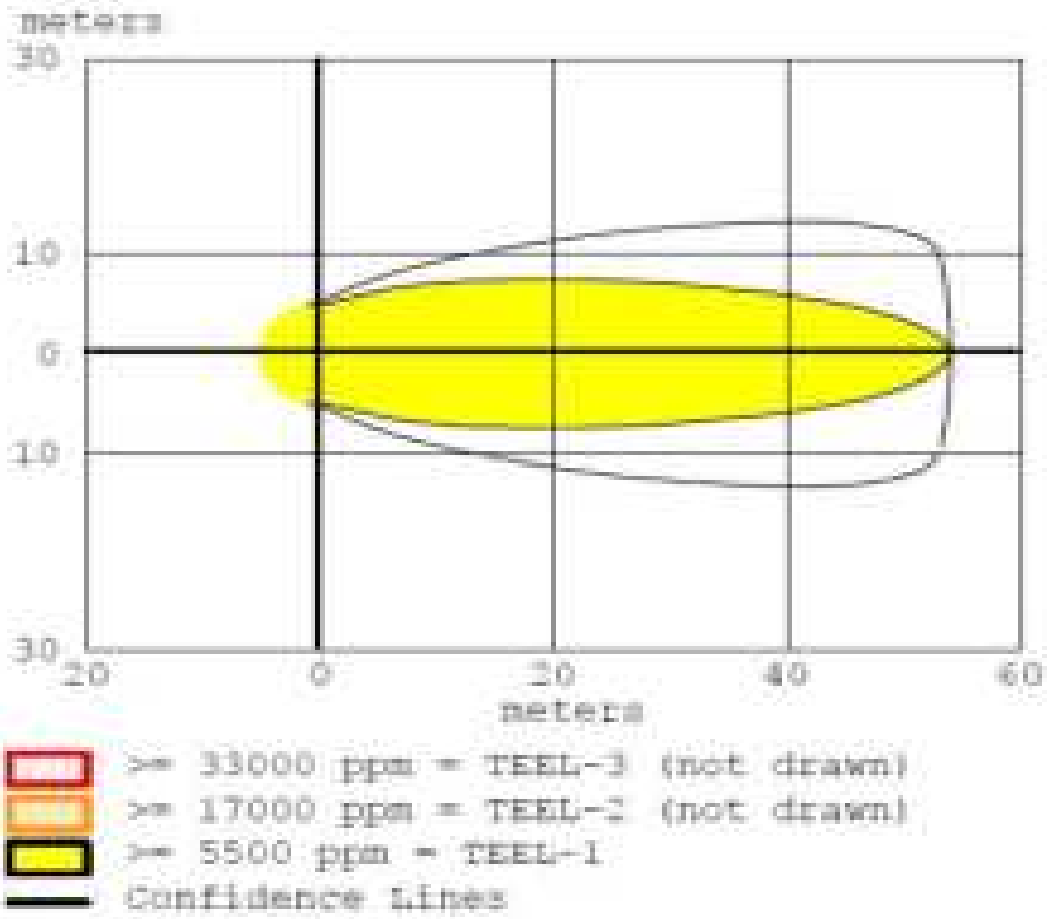
20.1.1.5 Instantaneous Release – Overpressure (Graph)



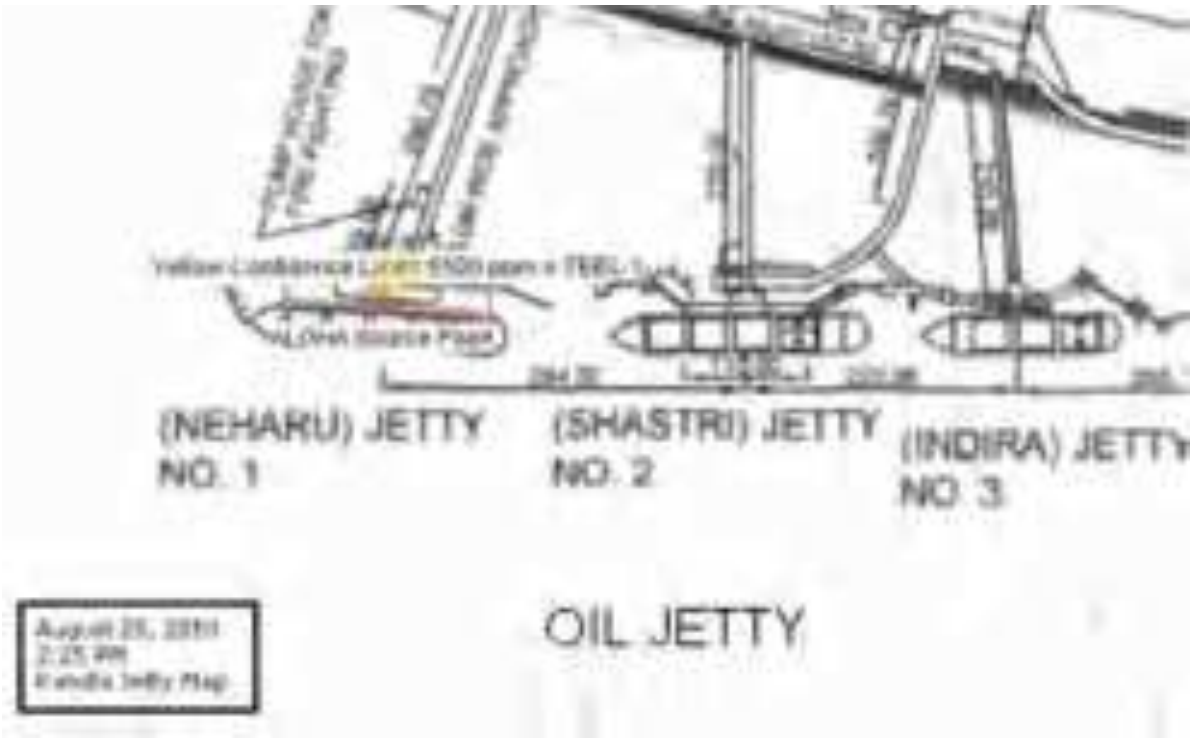
20.1.1.6 Instantaneous Release – Overpressure (Contour)



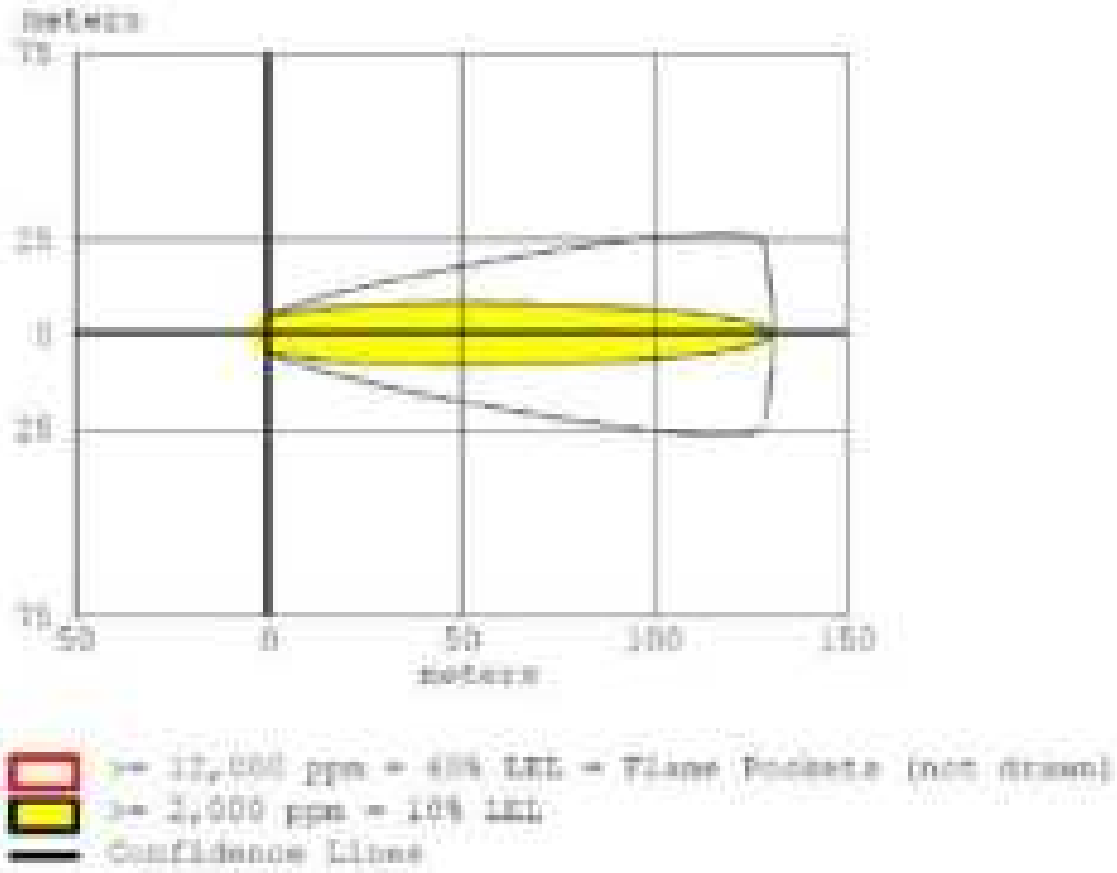
20.1.1.7 Evaporating Puddle – Toxic Threat Zone (Graph)



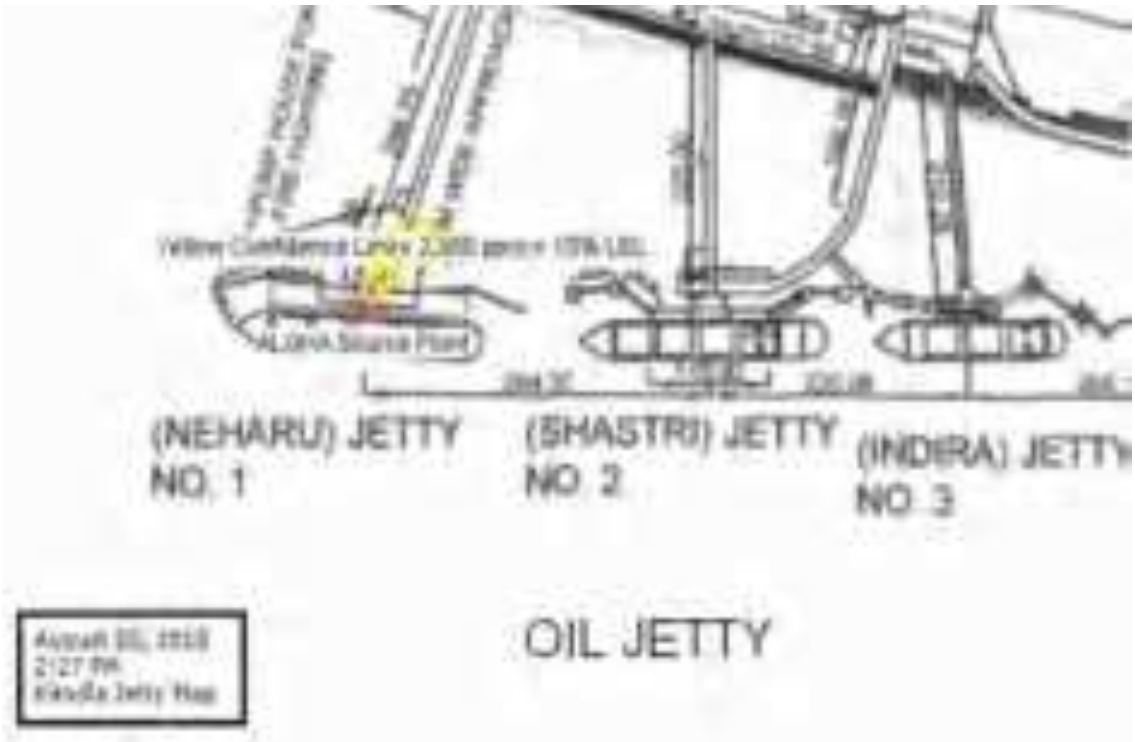
20.1.1.8 Evaporating Puddle – Toxic Threat Zone (Contour)



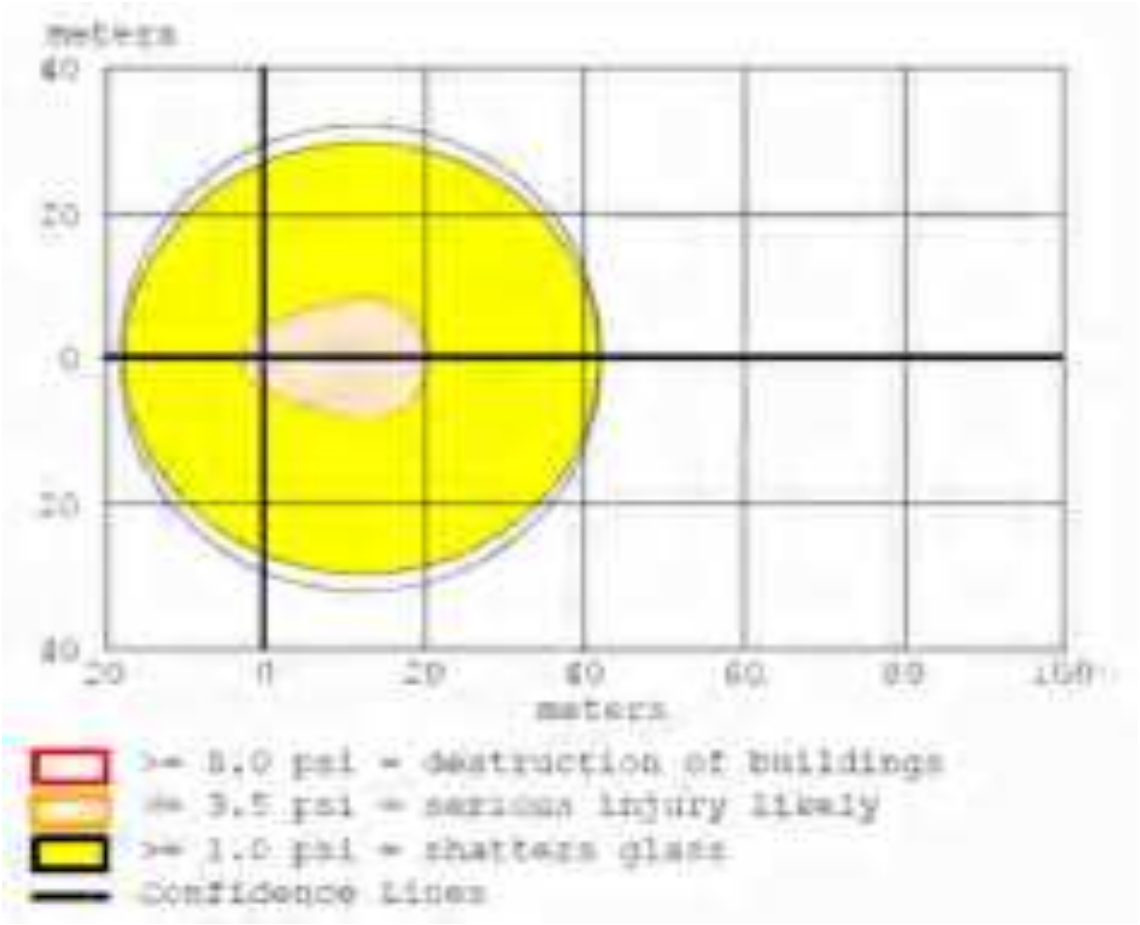
20.1.1.9 Evaporating Puddle – Flammable Area of Vapor Cloud (Graph)



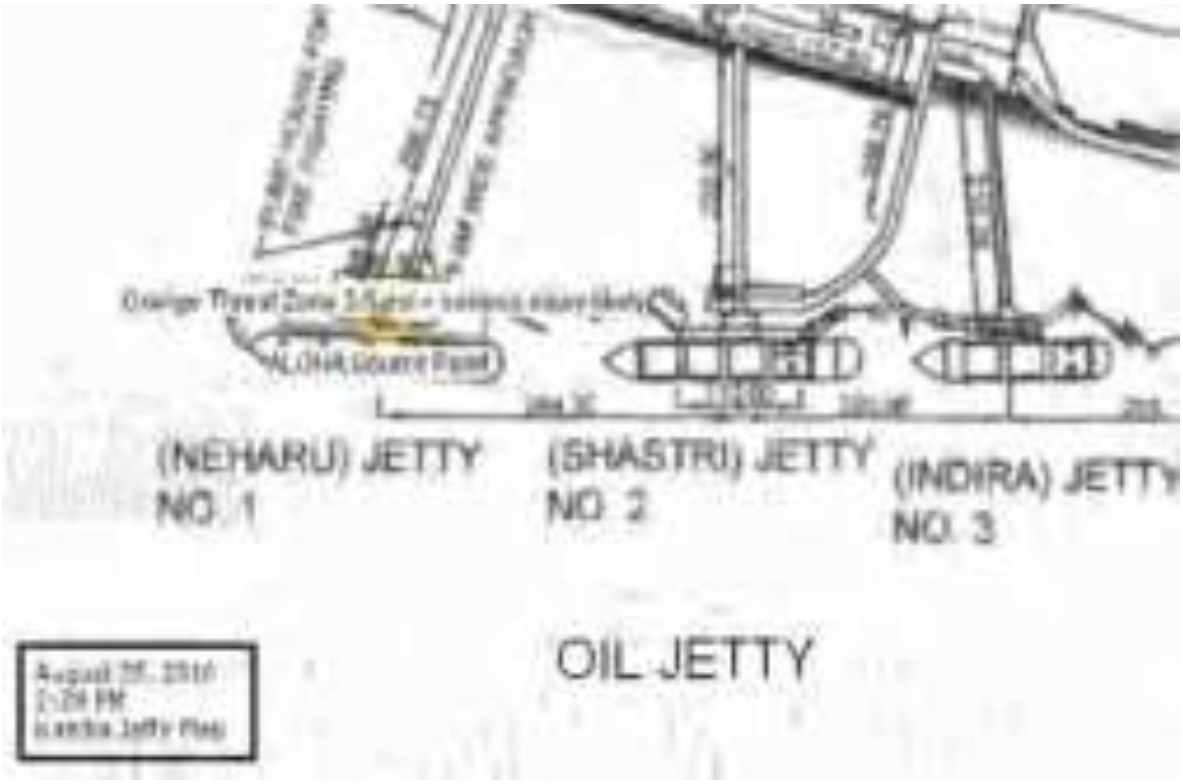
20.1.1.10 Evaporating Puddle – Flammable Area of Vapor Cloud (Contour)



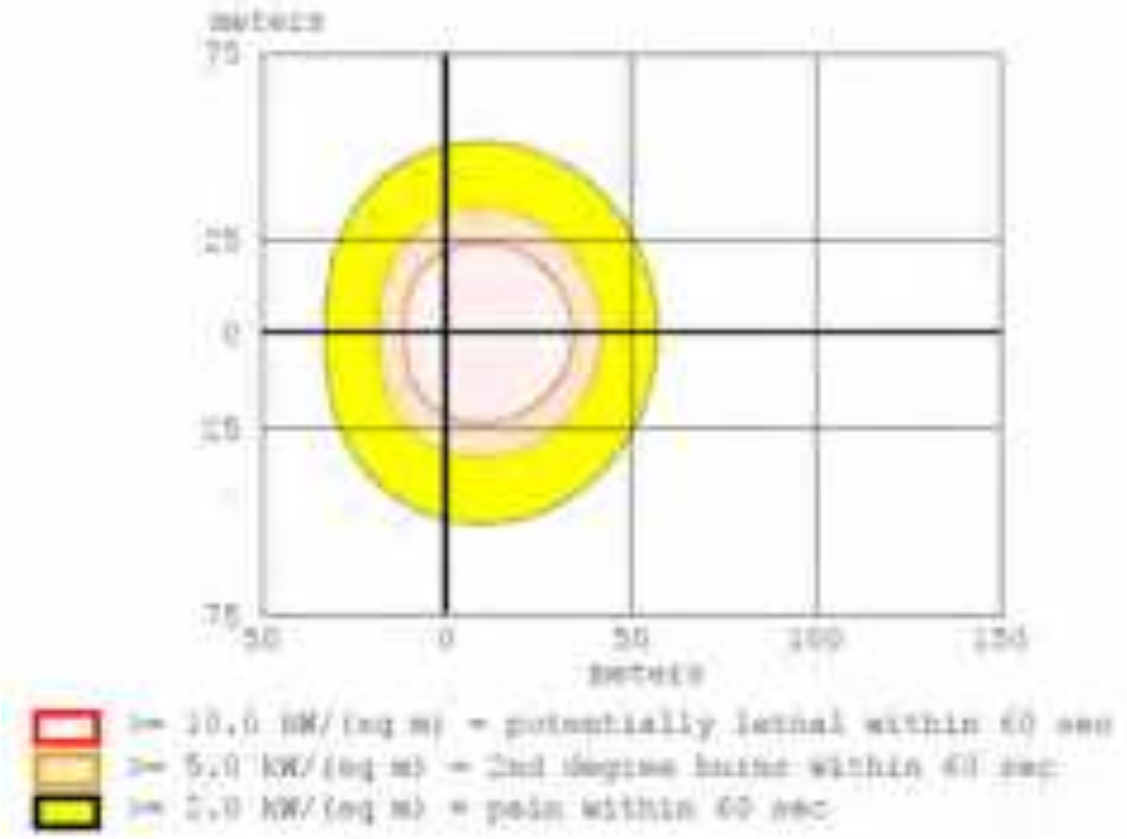
20.1.1.11 Evaporating Puddle – Overpressure (Graph)



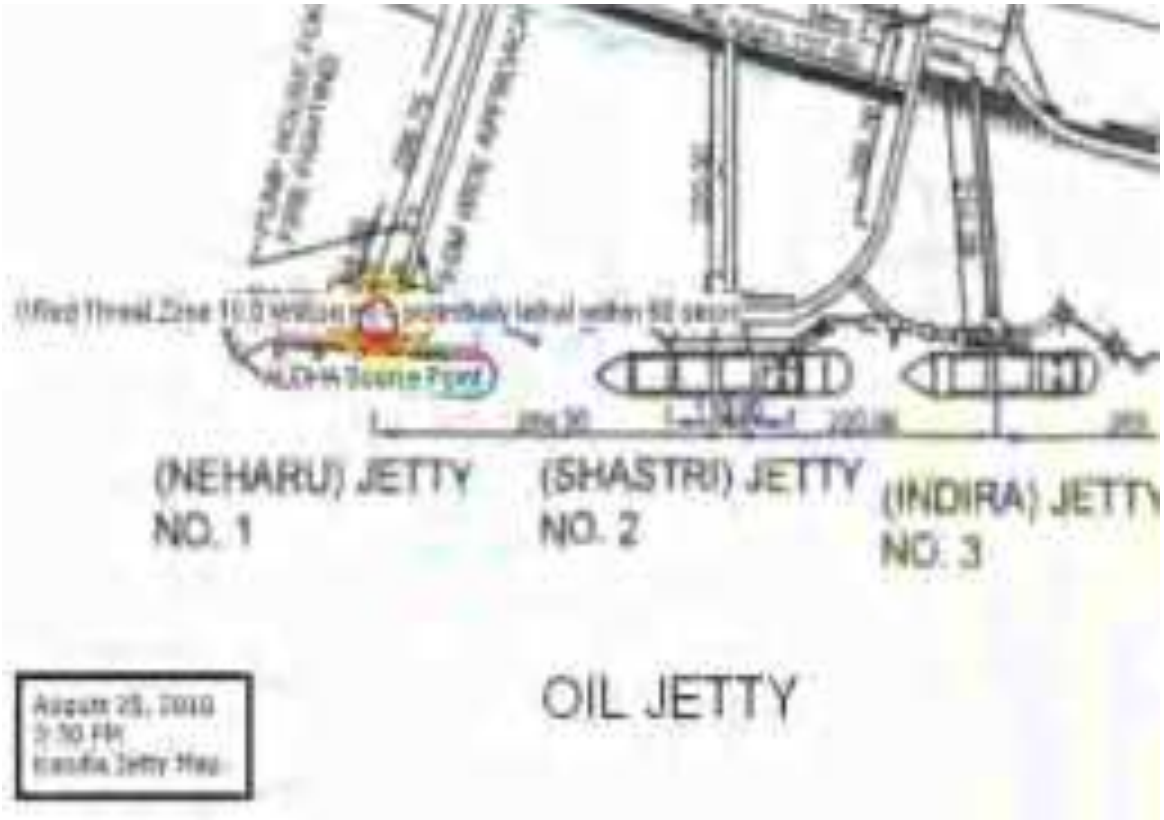
20.1.1.12 Evaporating Puddle – Overpressure (Contour)



20.1.1.13 Burning Puddle – Thermal Radiation (Graph)

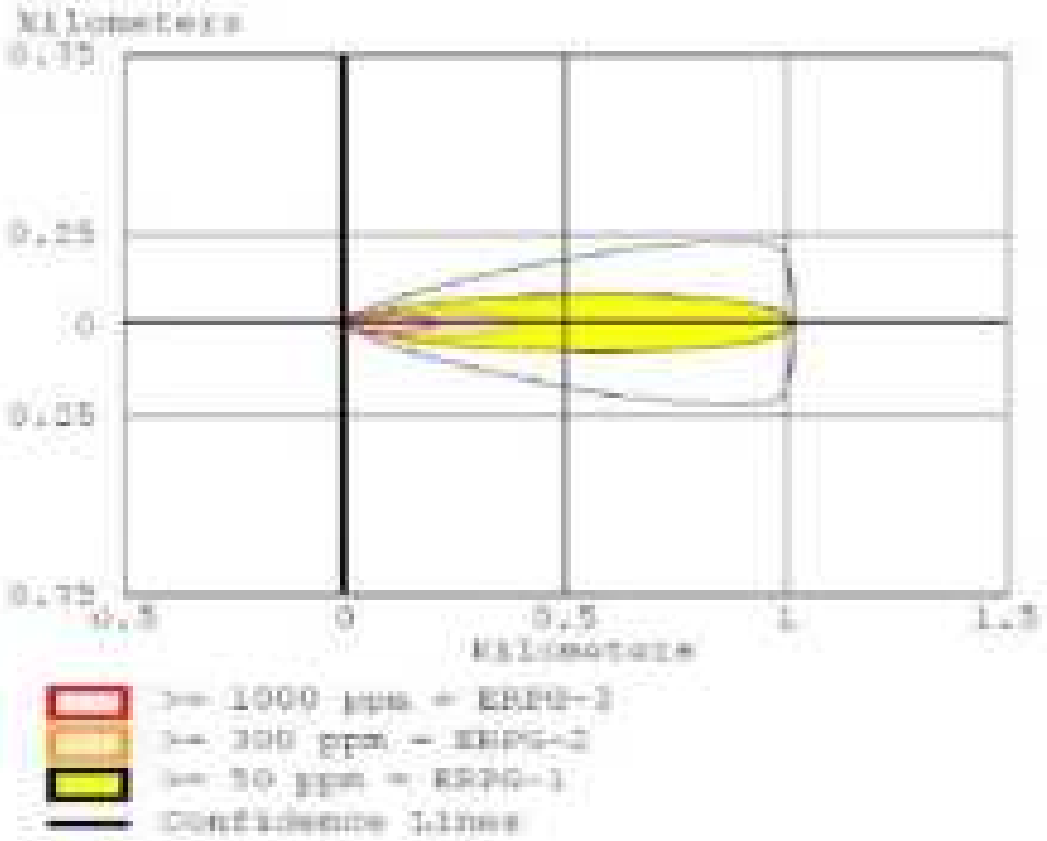


20.1.1.14 Burning Puddle – Thermal Radiation (Contour)

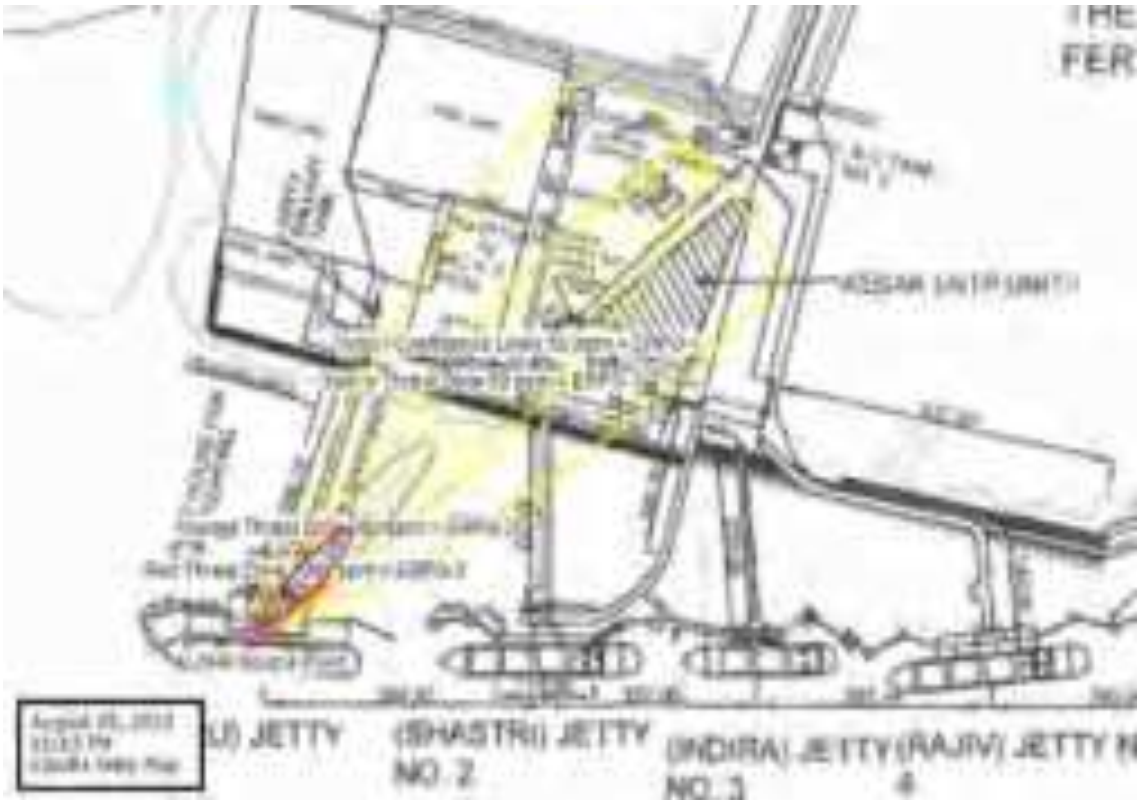


20.1.2 Jetty One – Toluene

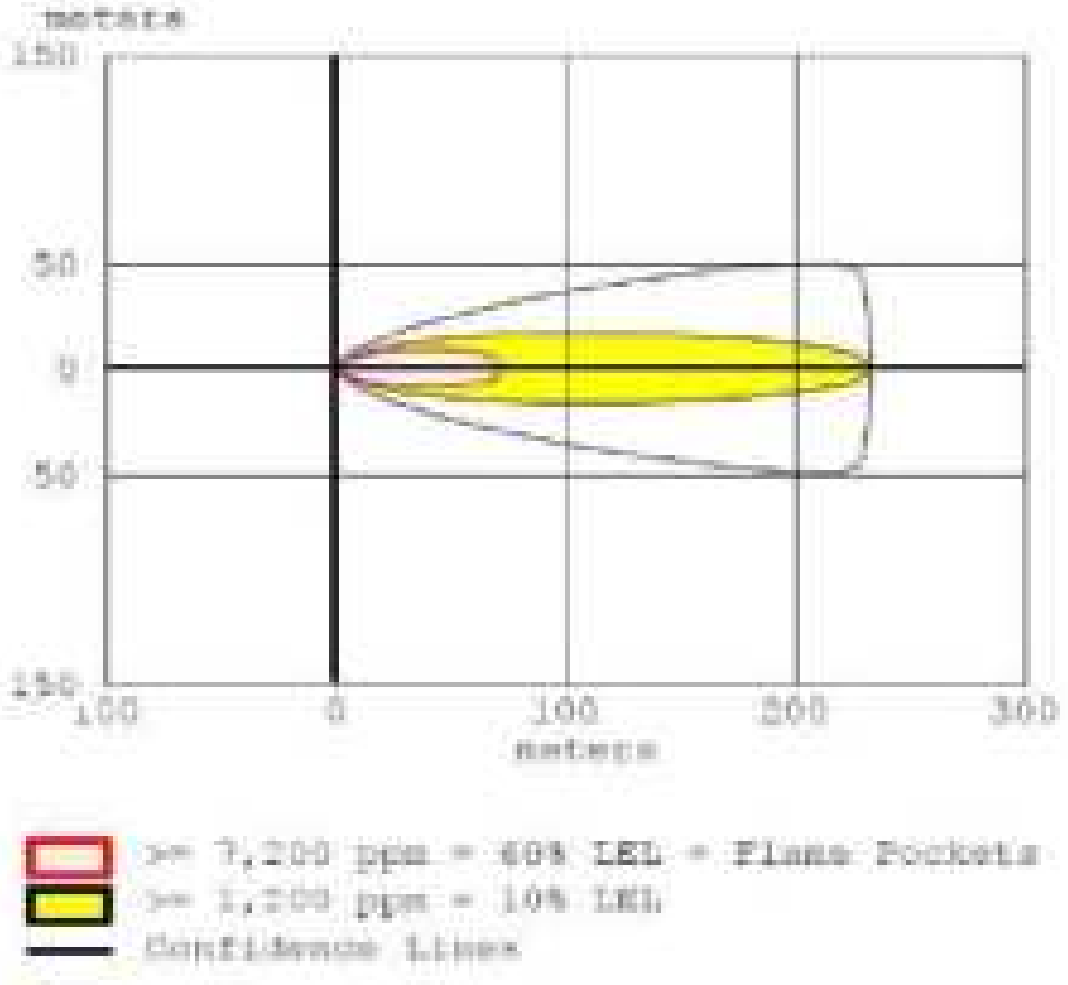
20.1.2.1 Instantaneous Release – Toxic Threat Zone (Graph)



20.1.2.2 Instantaneous Release – Toxic Threat Zone (Contour)

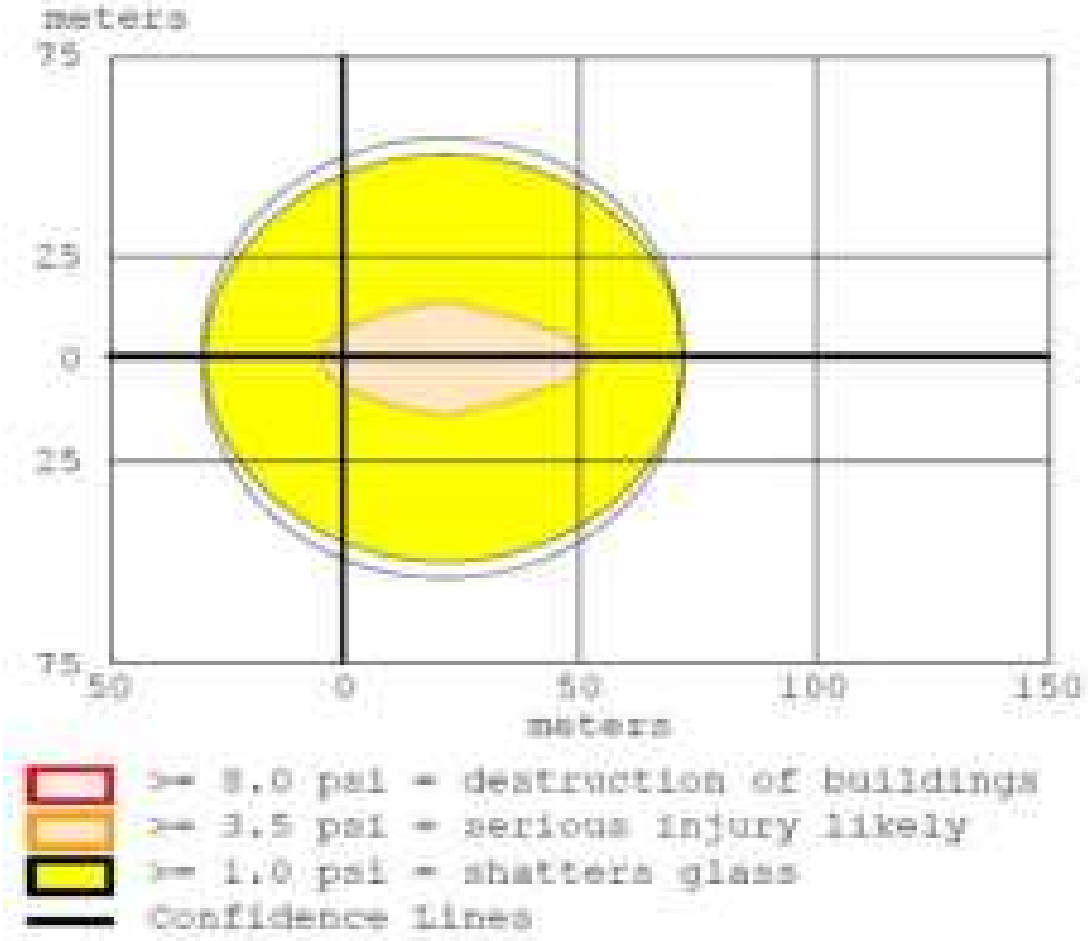


20.1.2.3 Instantaneous Release – Flammable Area of Vapor Cloud (Graph)



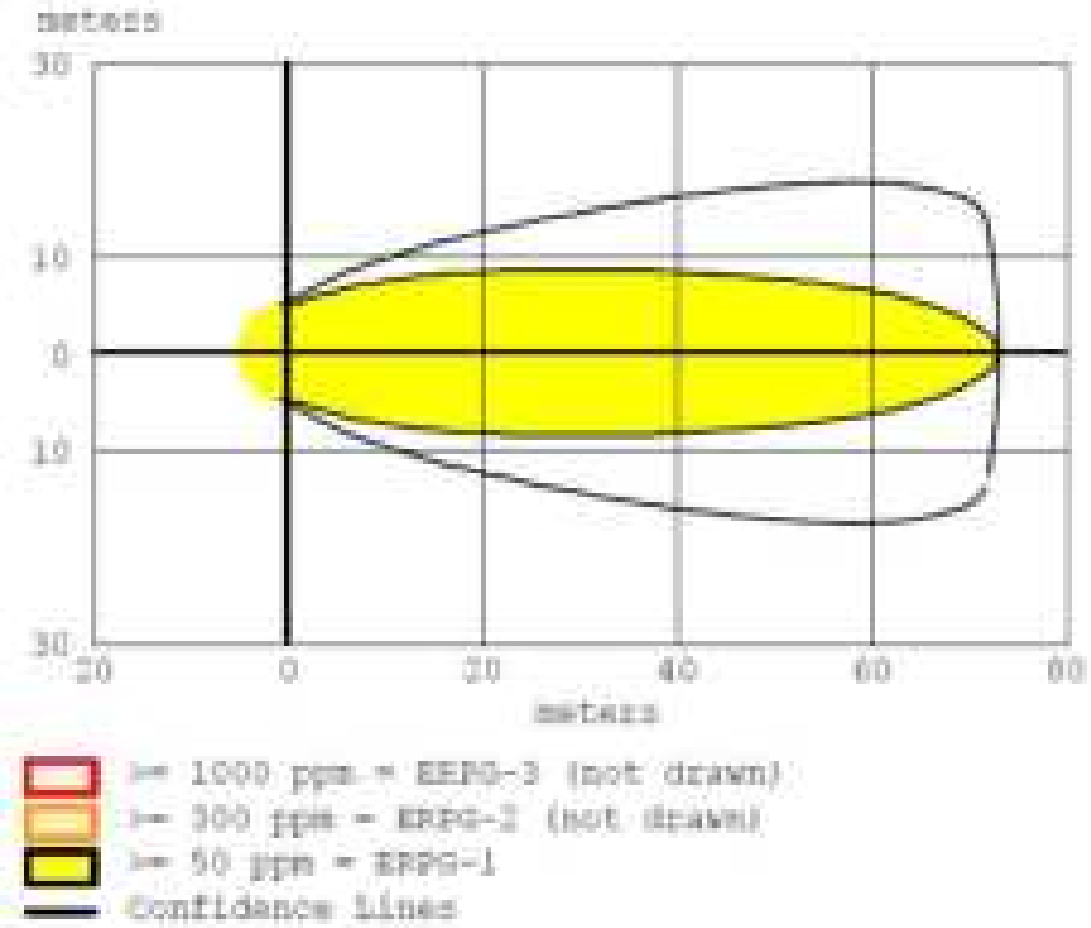
20.1.2.4 Instantaneous Release – Flammable Area of Vapor Cloud (Contour)

20.1.2.5 Instantaneous Release – Overpressure (Graph)

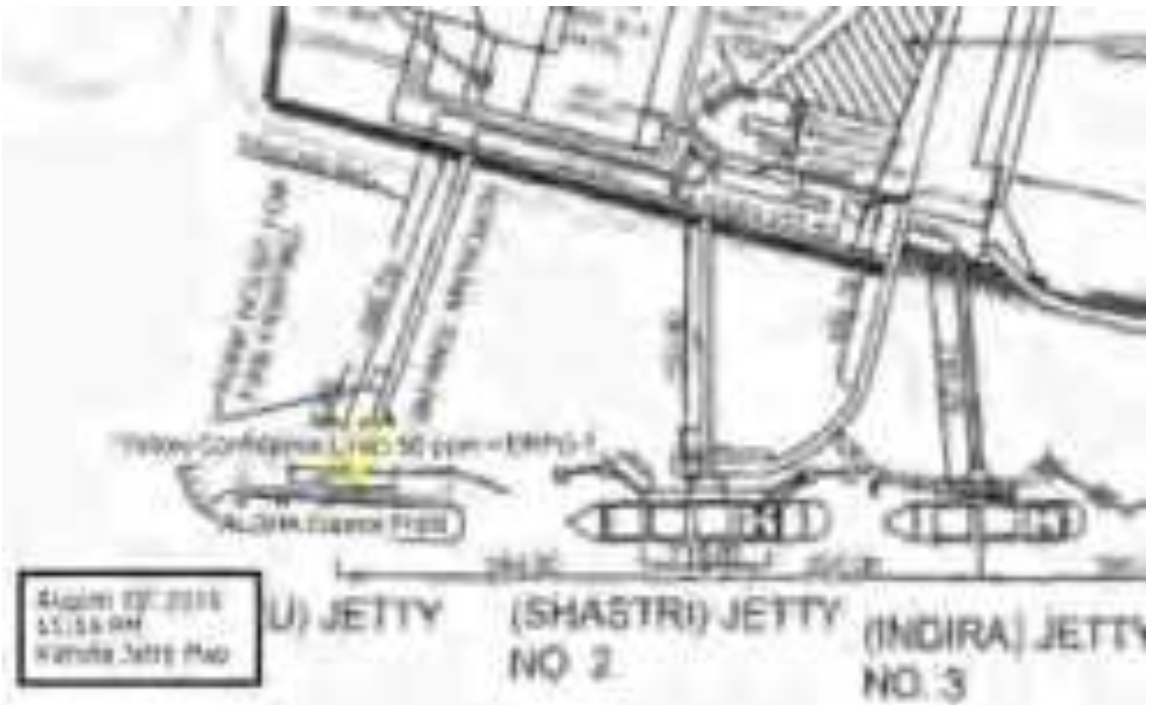


20.1.2.6 Instantaneous Release – Overpressure (Contour)

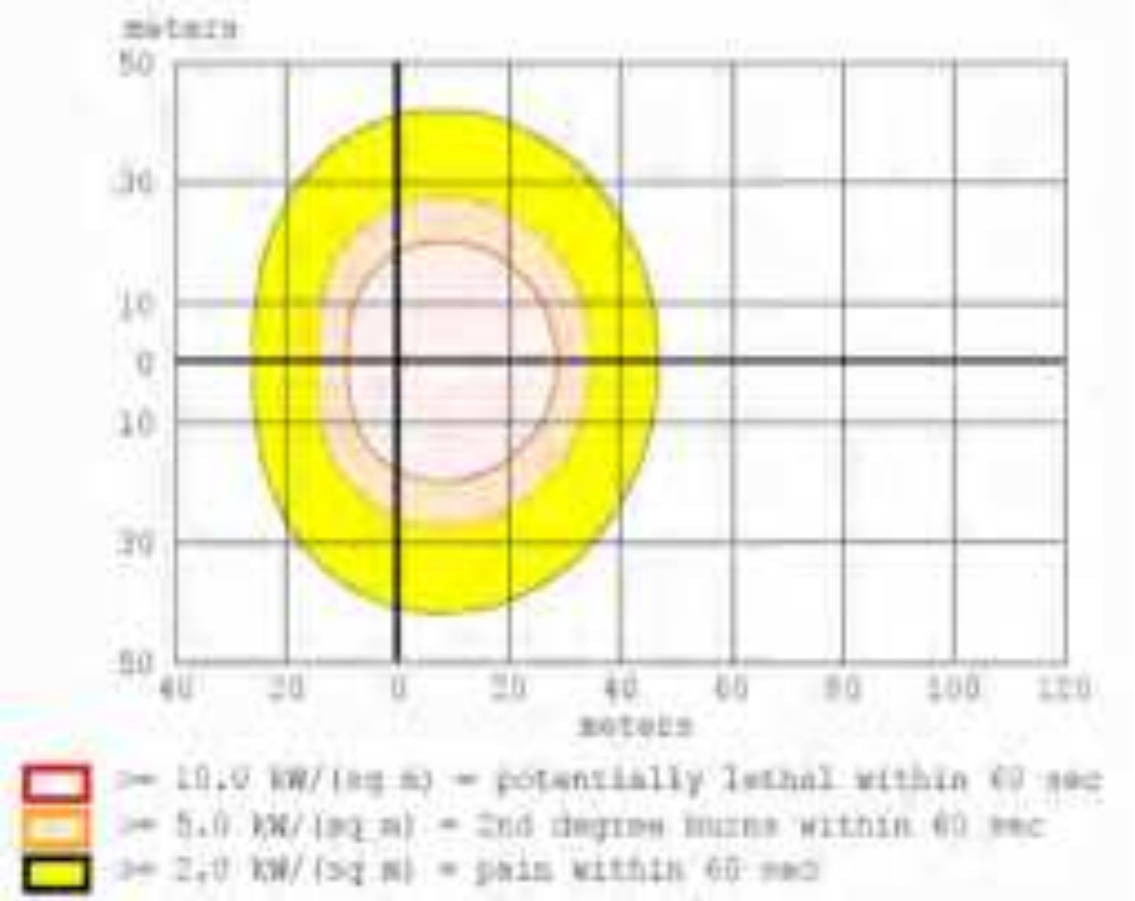
20.1.2.7 Evaporating Puddle – Toxic Threat Zone (Graph)



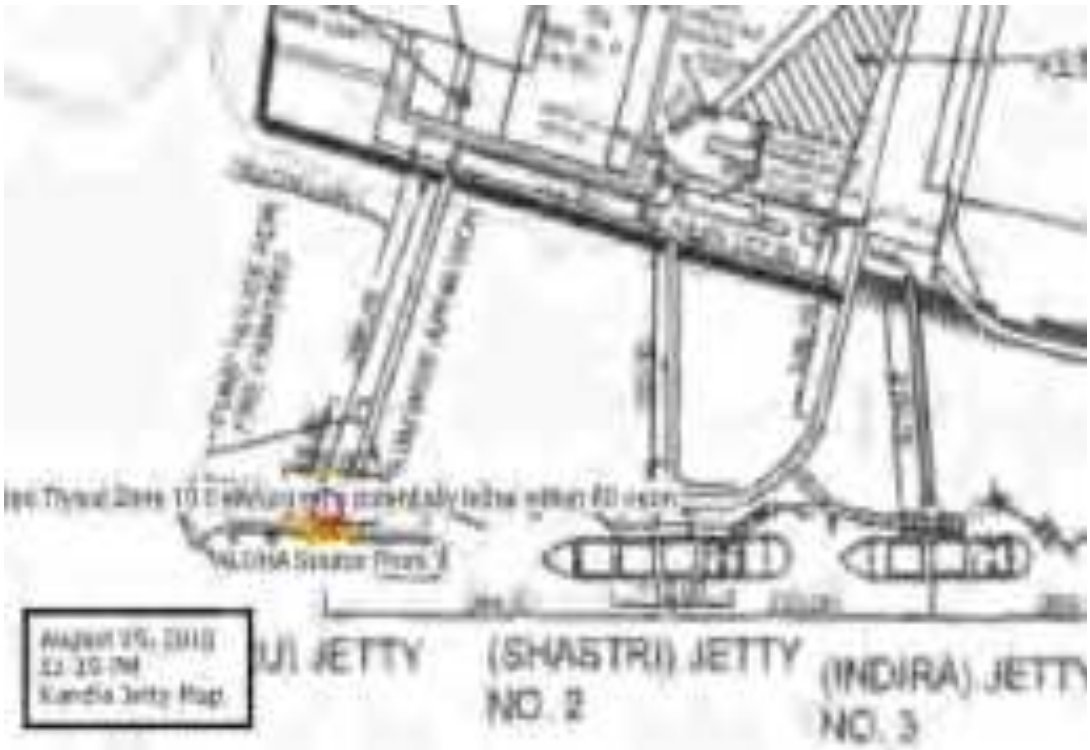
20.1.2.8 Evaporating Puddle – Toxic Threat Zone (Contour)



20.1.2.9 Burning Puddle – Thermal Radiation (Graph)

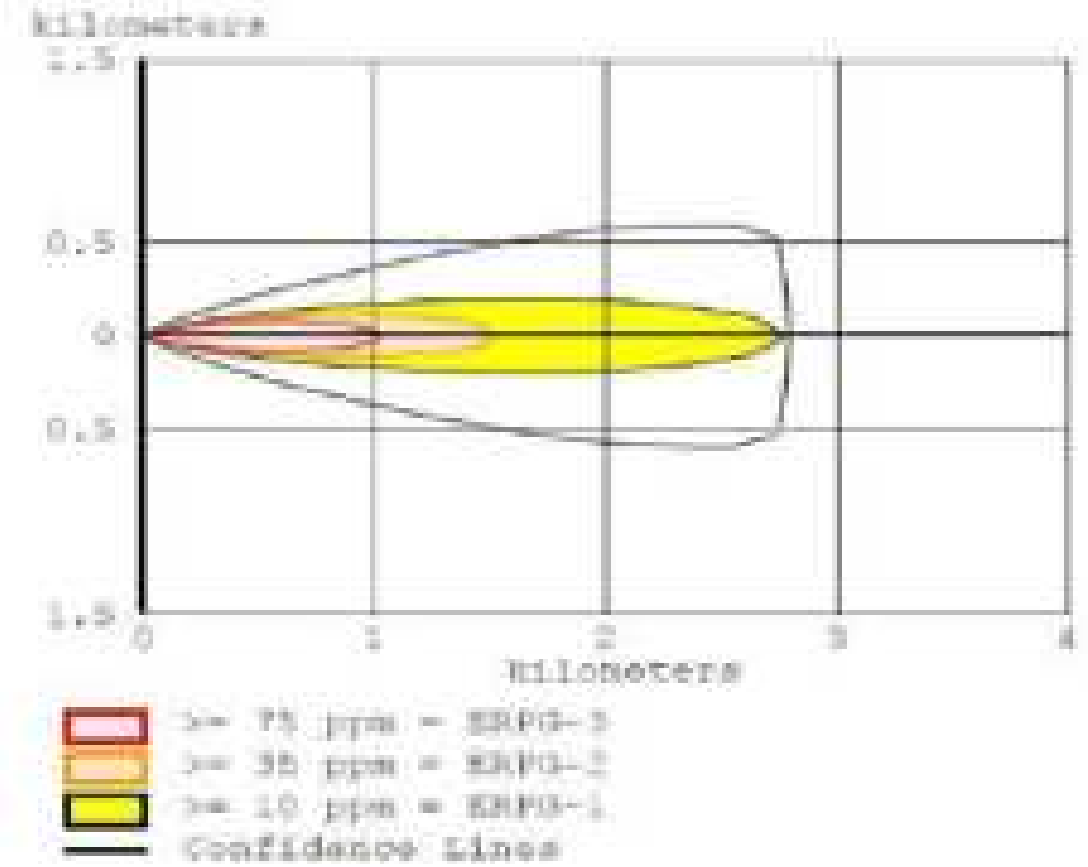


20.1.2.10 Burning Puddle – Thermal Radiation (Contour)



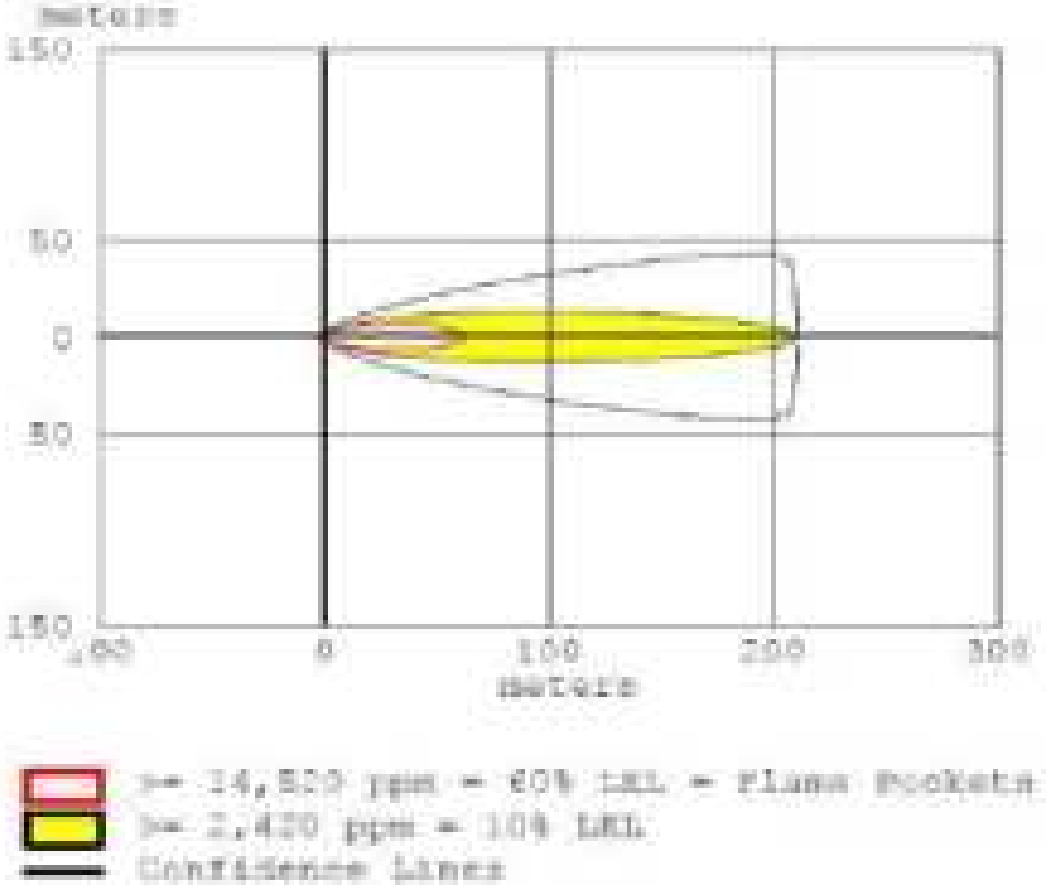
20.1.3 Jetty Two – Acrylonitrile

20.1.3.1 Instantaneous Release – Toxic Threat Zone (Graph)

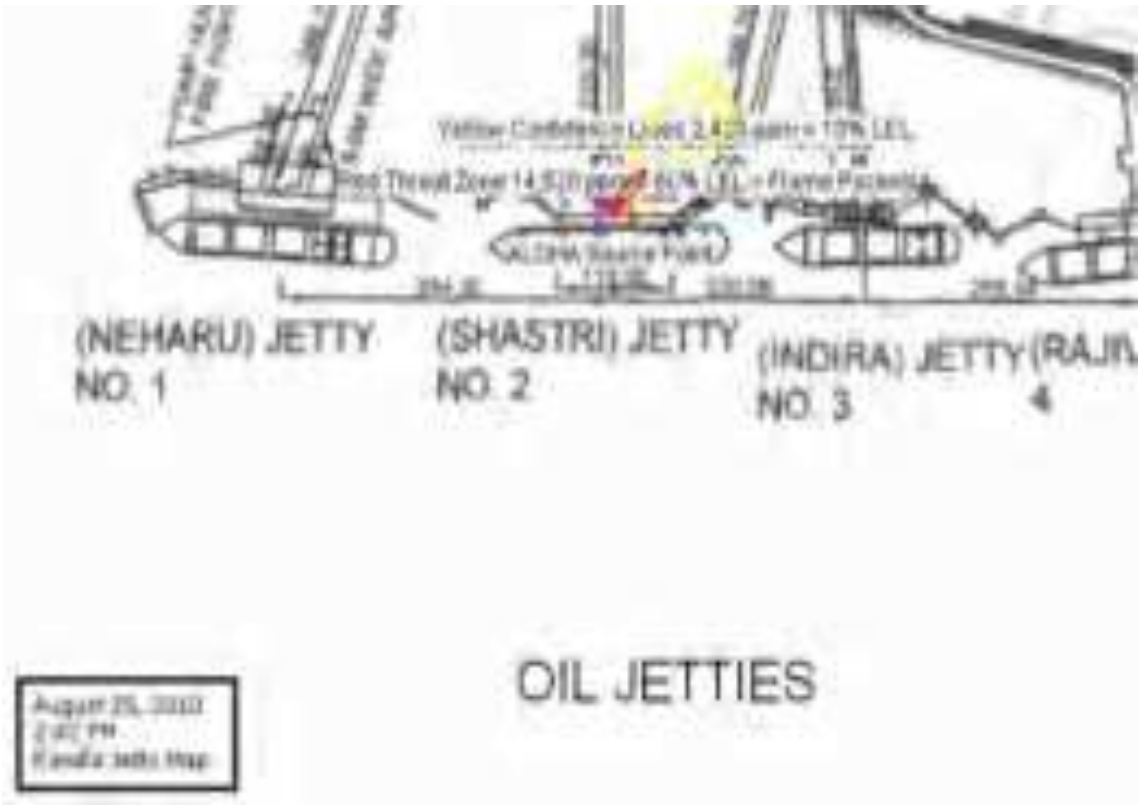


20.1.3.2 Instantaneous Release – Toxic Threat Zone (Contour)

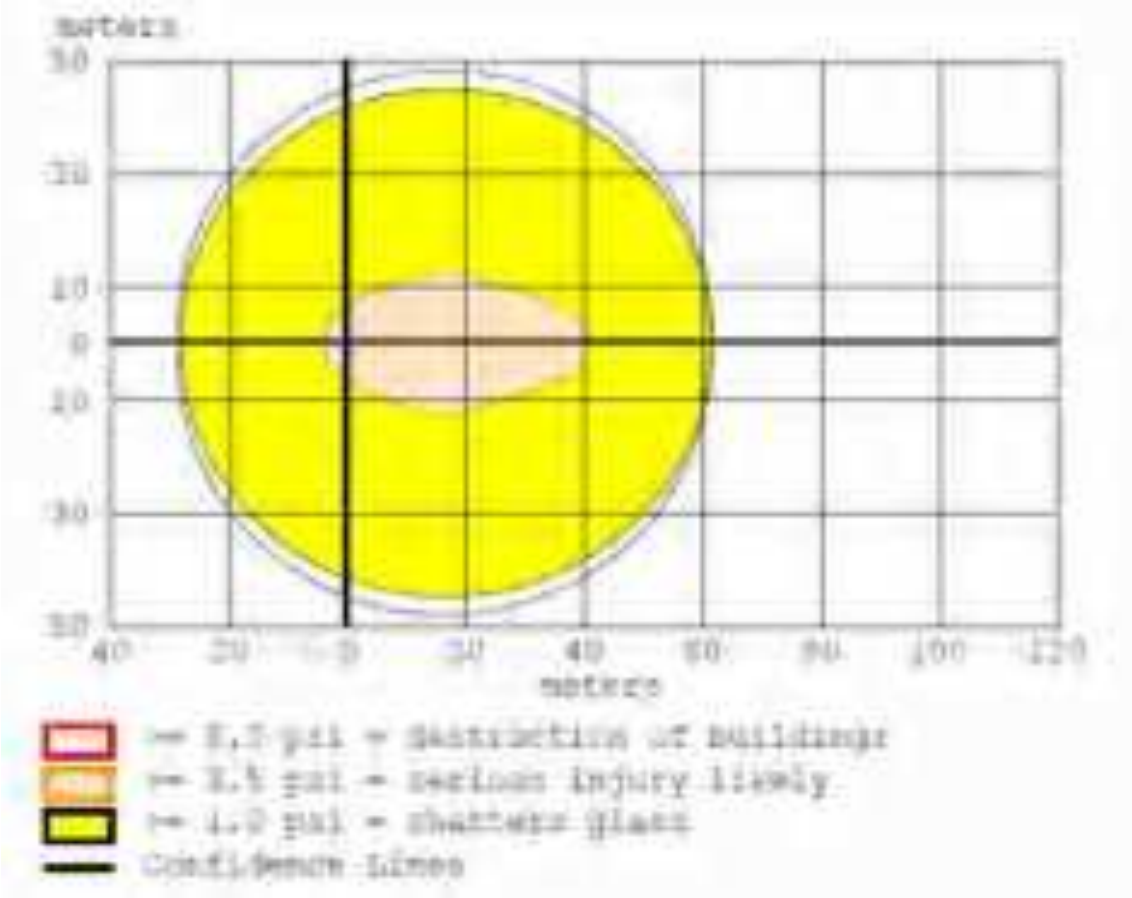
20.1.3.3 Instantaneous Release – Flammable Area of Vapor Cloud (Graph)



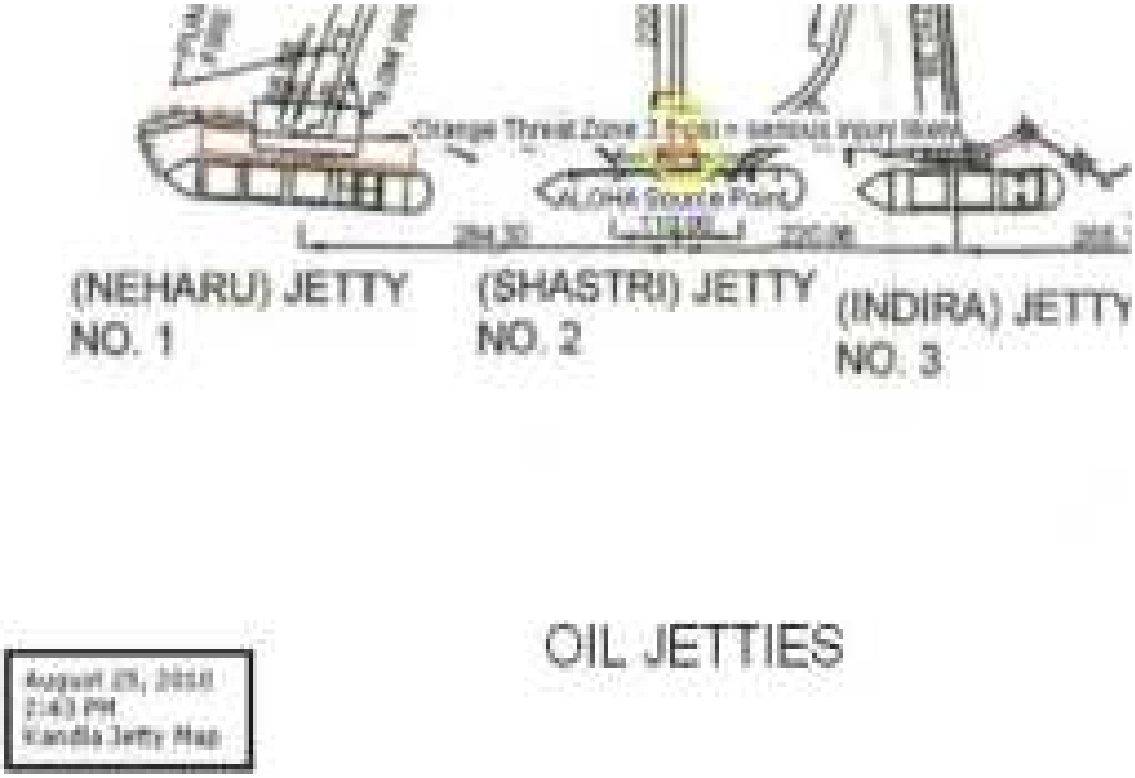
20.1.3.4 Instantaneous Release – Flammable Area of Vapor Cloud (Contour)



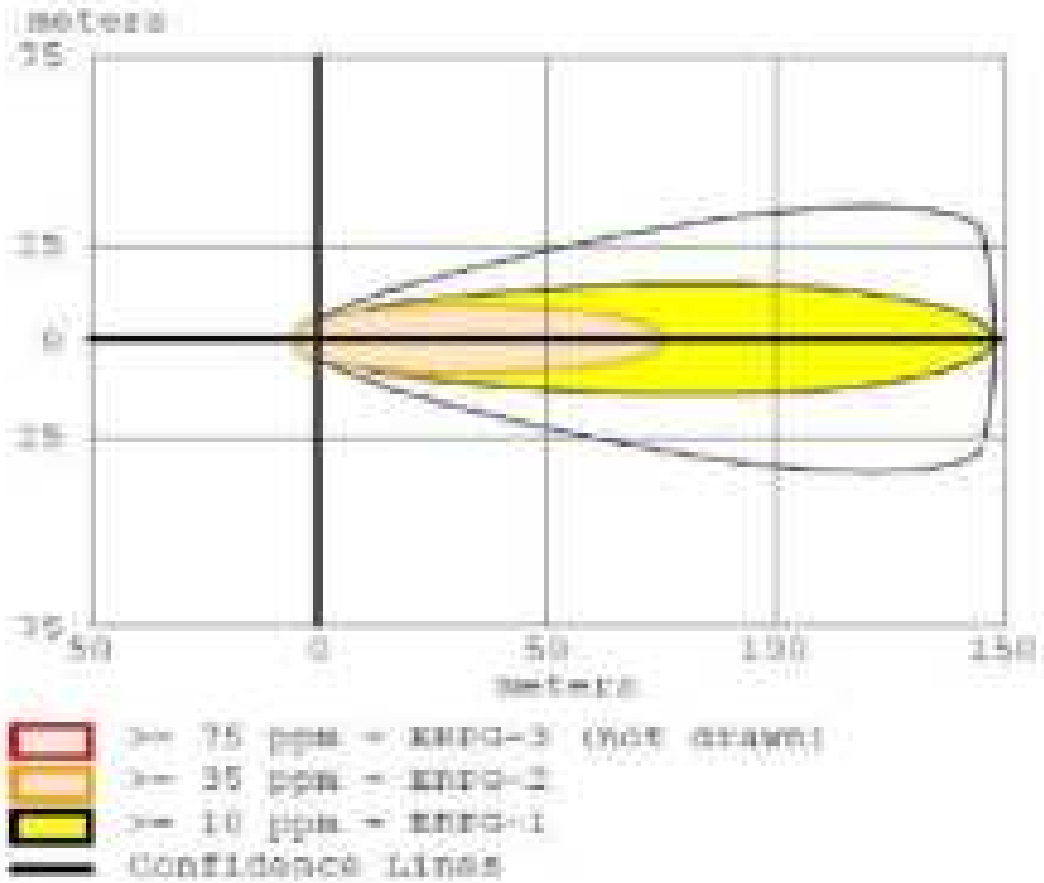
20.1.3.5 Instantaneous Release – Overpressure (Graph)



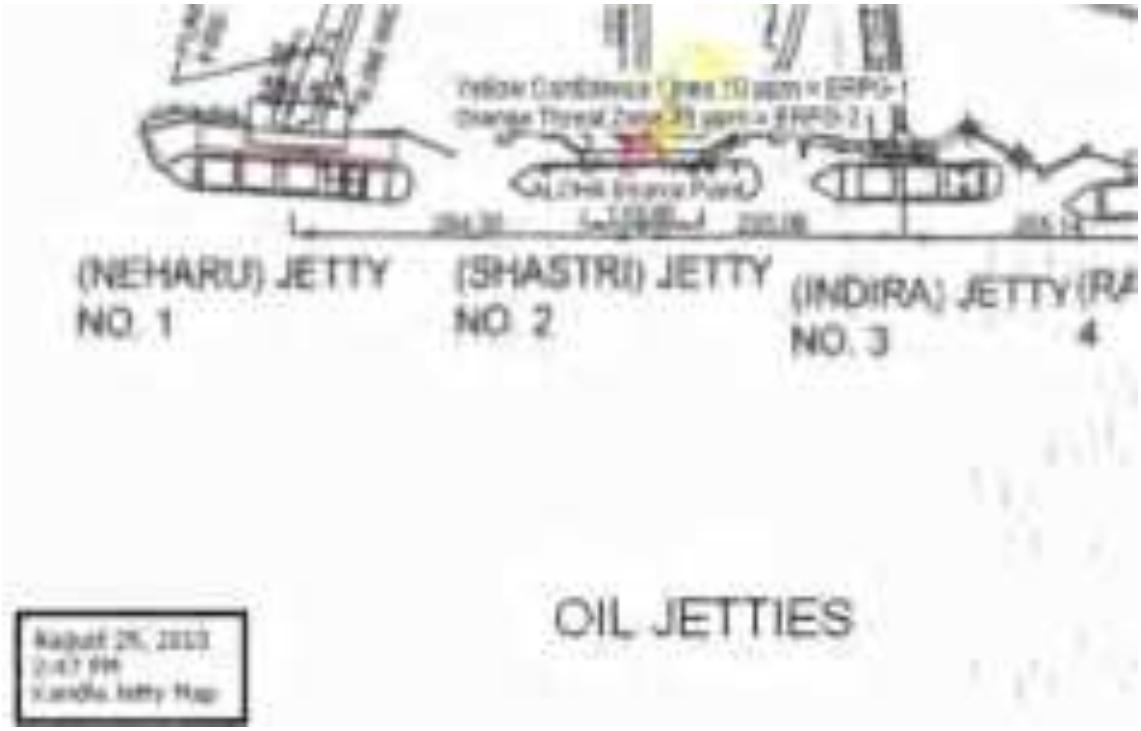
20.1.3.6 Instantaneous Release – Overpressure (Contour)



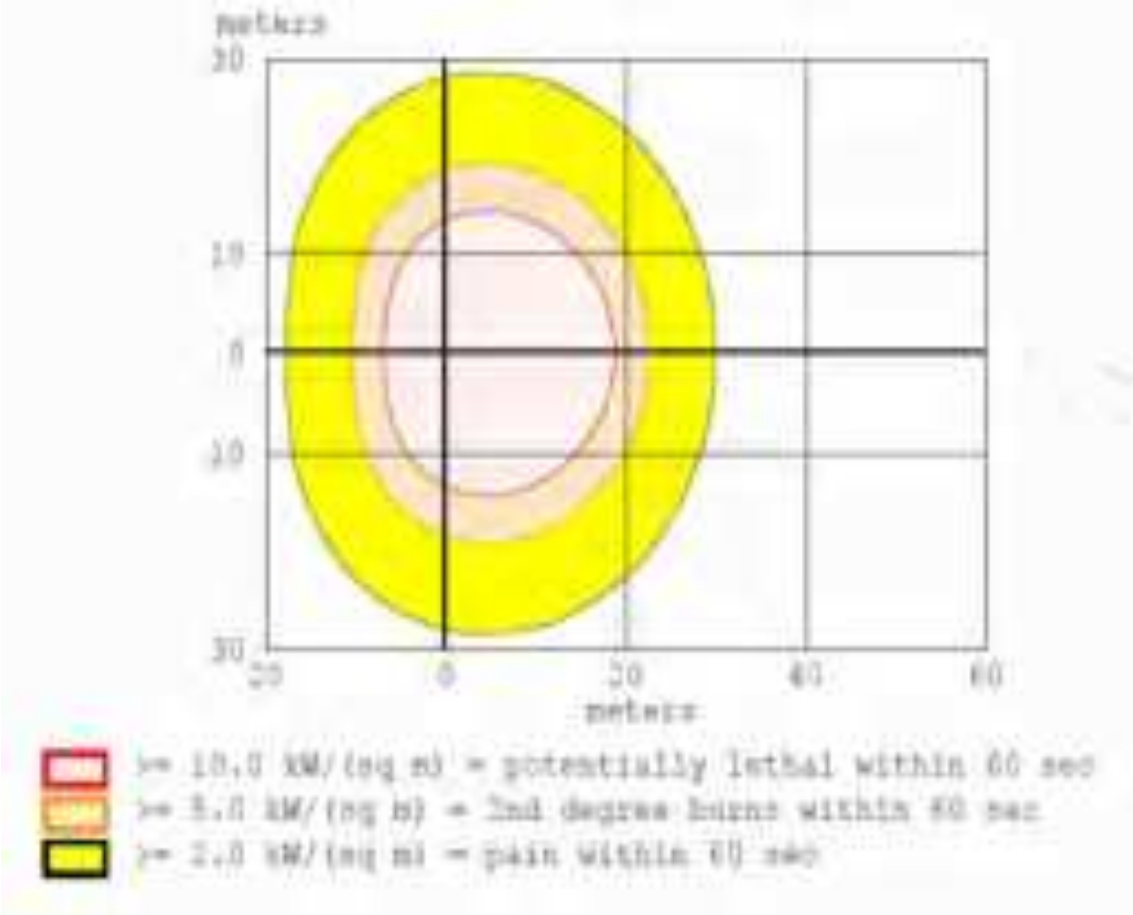
20.1.3.7 Evaporating Puddle – Toxic Threat Zone (Graph)



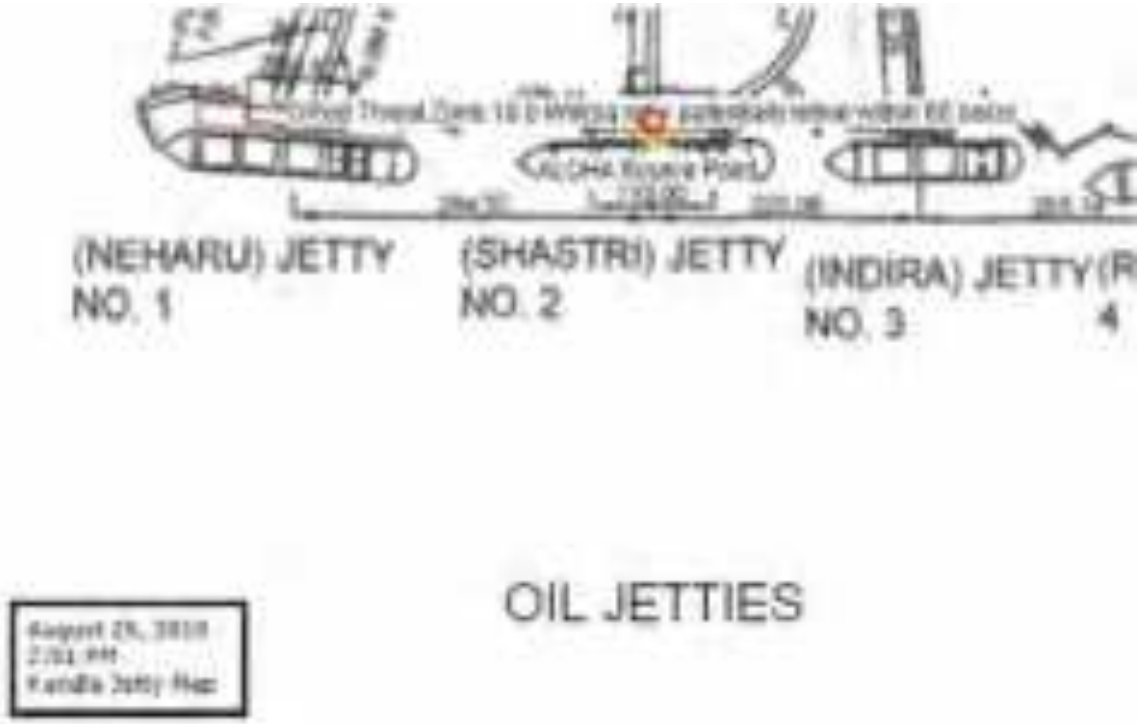
20.1.3.8 Evaporating Puddle – Toxic Threat Zone (Contour)



20.1.3.9 Burning Puddle – Thermal Radiation (Graph)

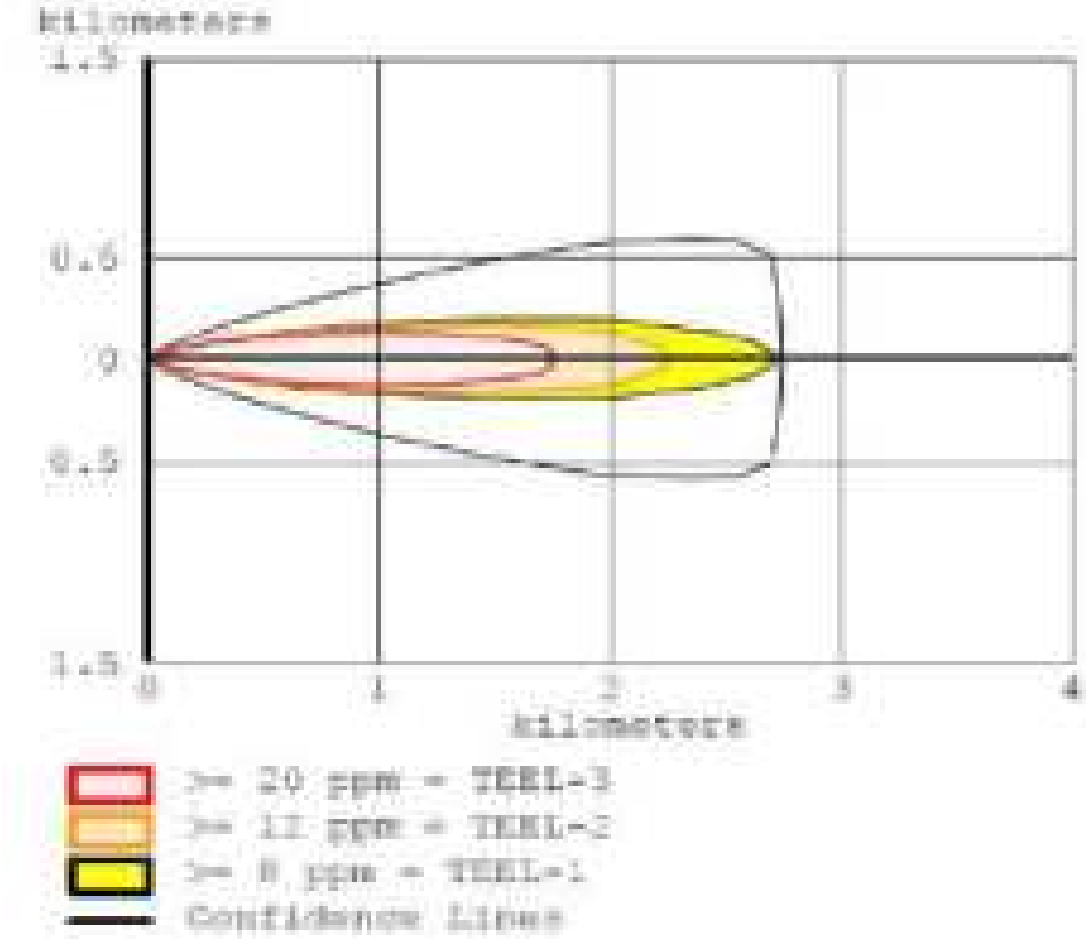


20.1.3.10 Burning Puddle – Thermal Radiation (Contour)



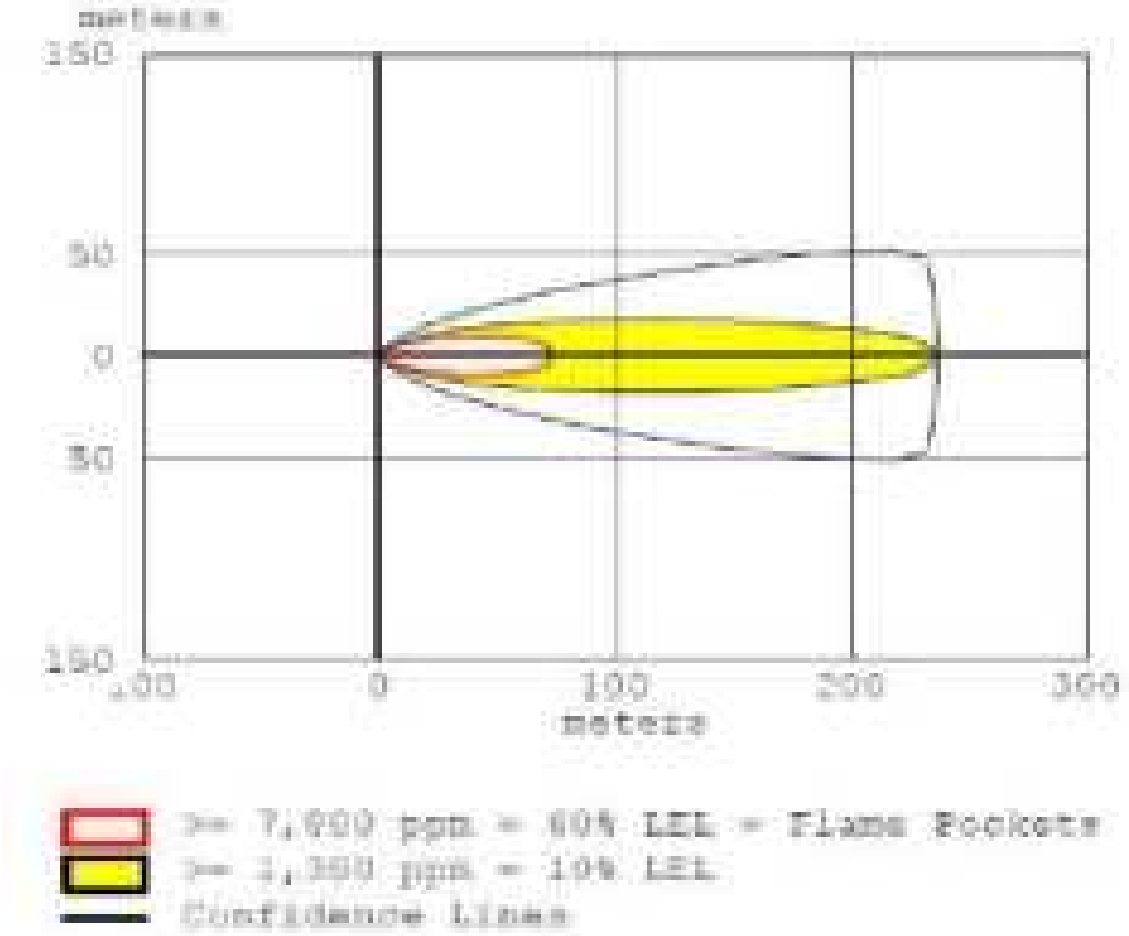
20.1.4 Jetty Two – Aniline

20.1.4.1 Instantaneous Release – Toxic Threat Zone (Graph)

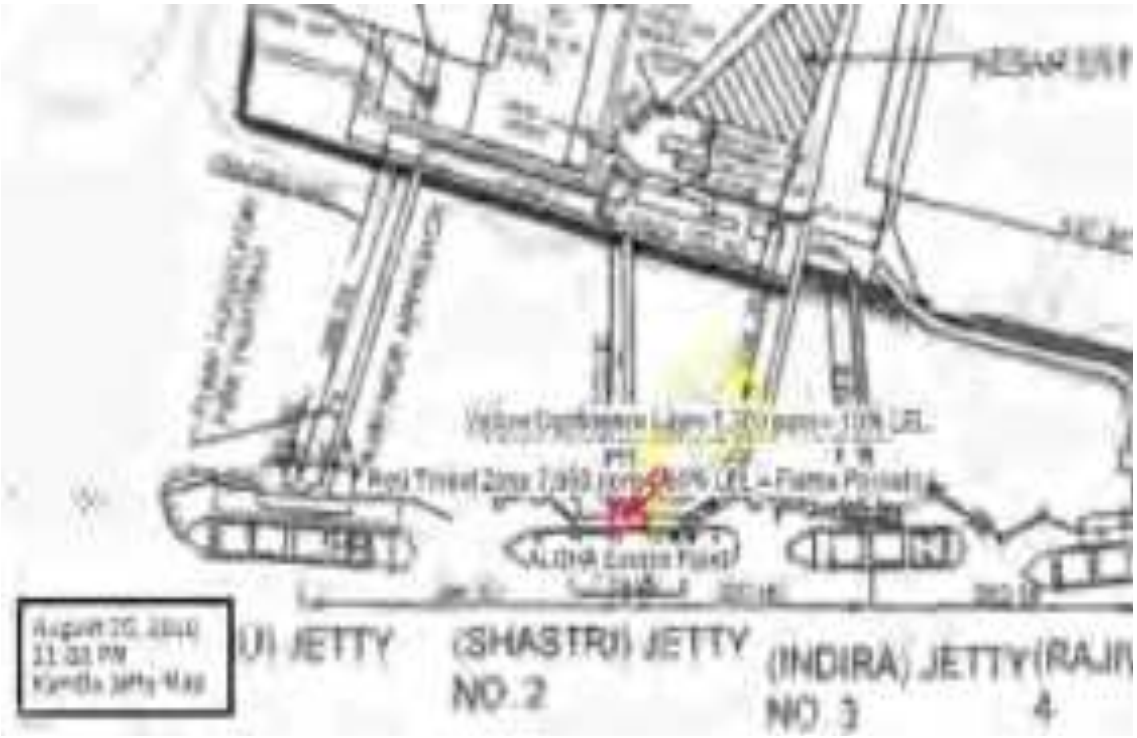


20.1.4.2 Instantaneous Release – Toxic Threat Zone (Contour)

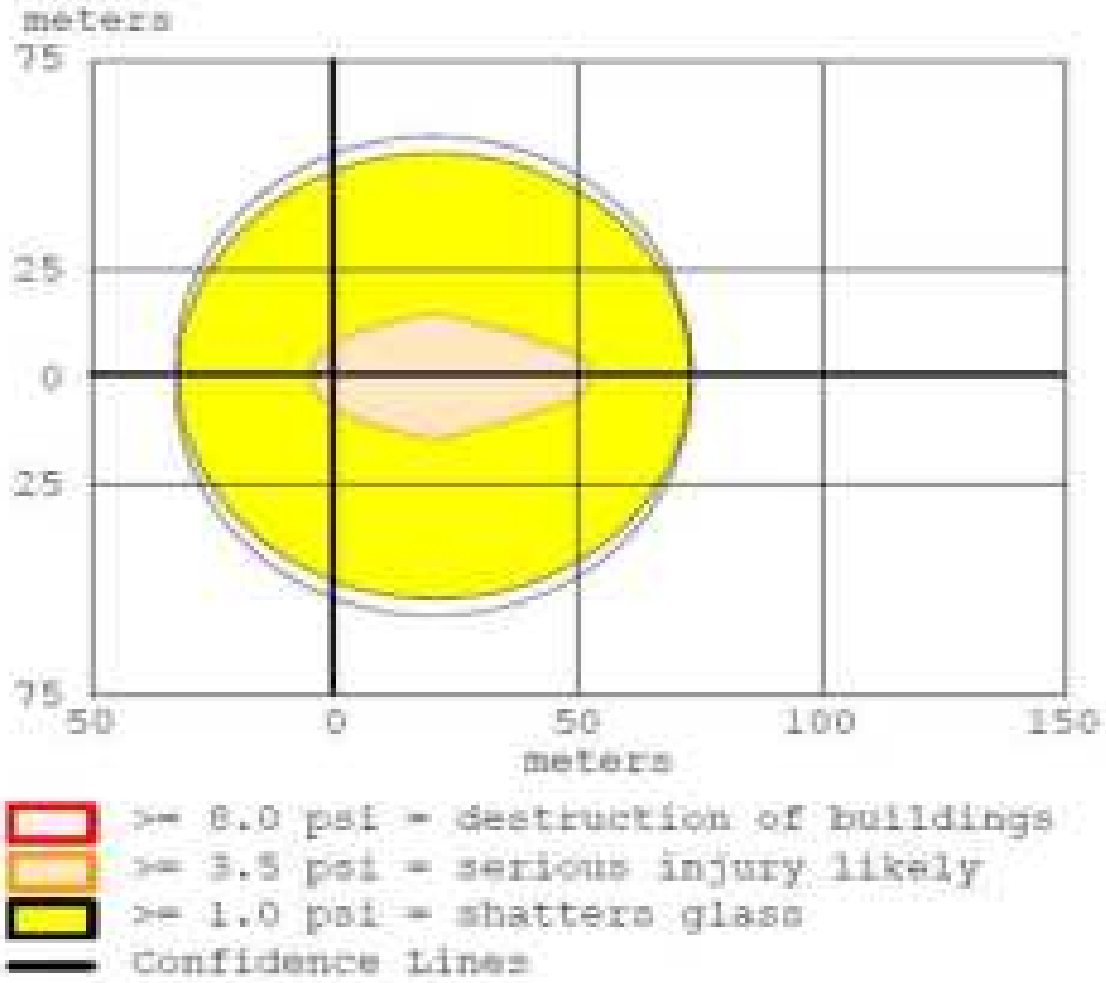
20.1.4.3 Instantaneous Release – Flammable Area of Vapor Cloud (Graph)



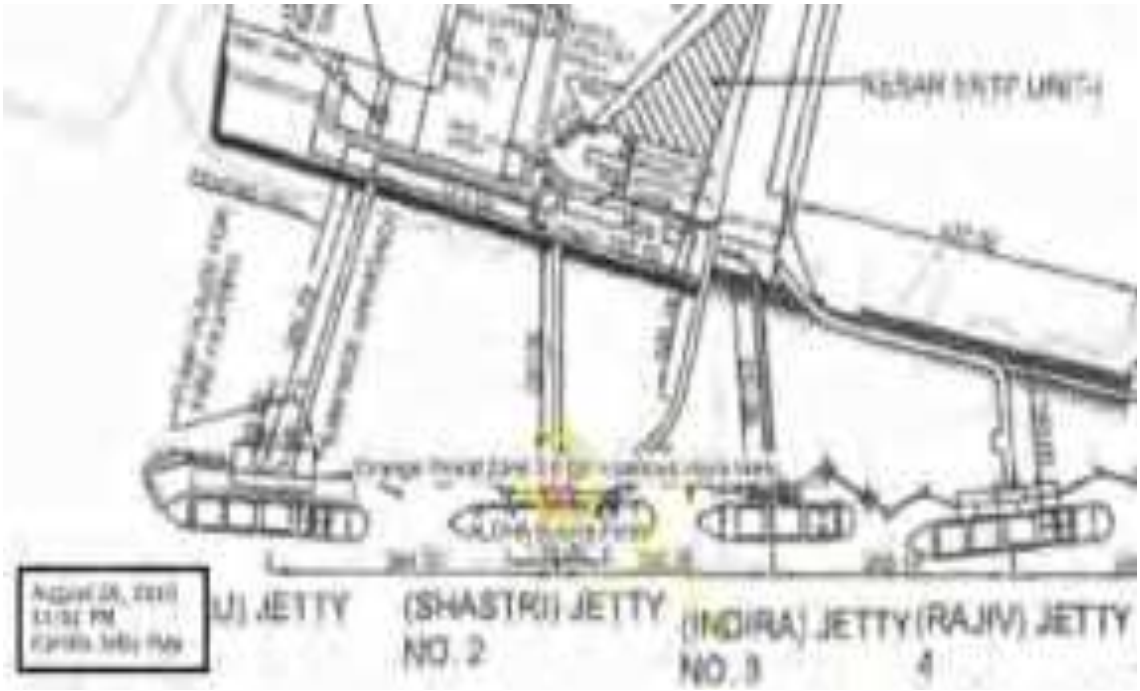
20.1.4.4 Instantaneous Release – Flammable Area of Vapor Cloud (Contour)



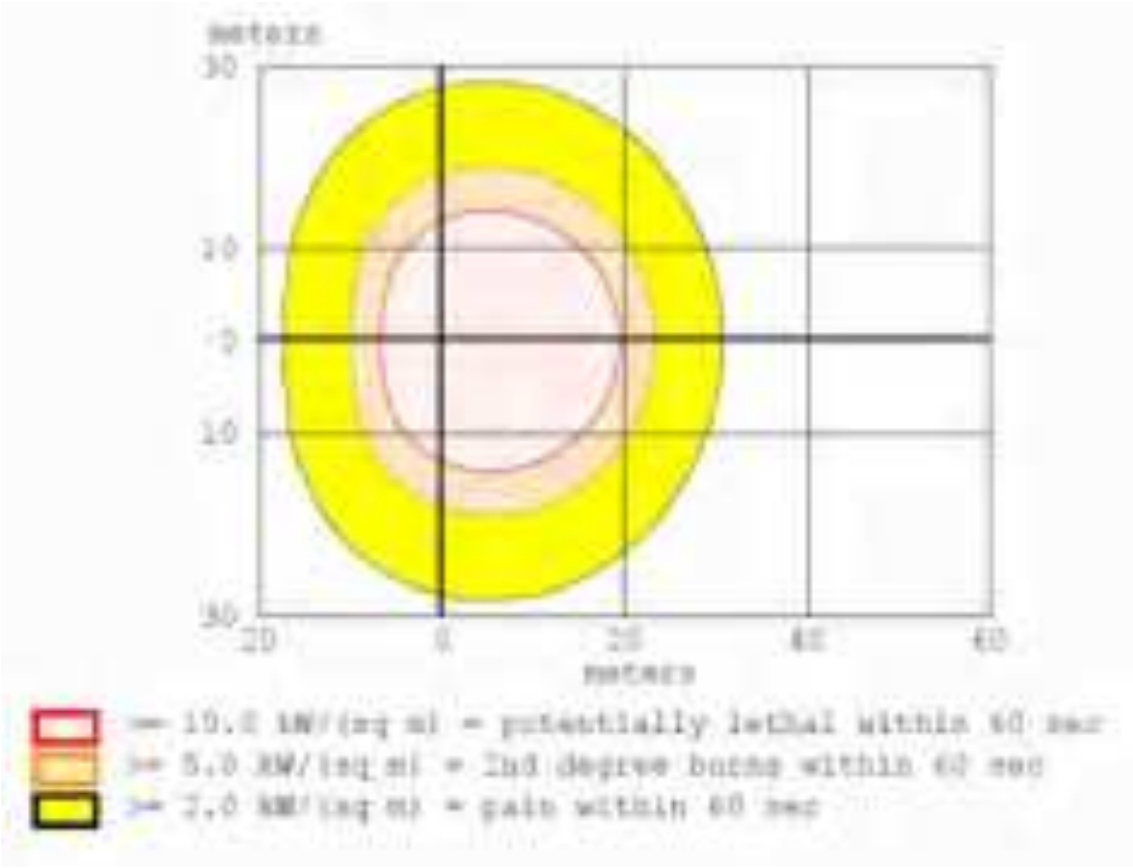
20.1.4.5 Instantaneous Release – Overpressure (Graph)



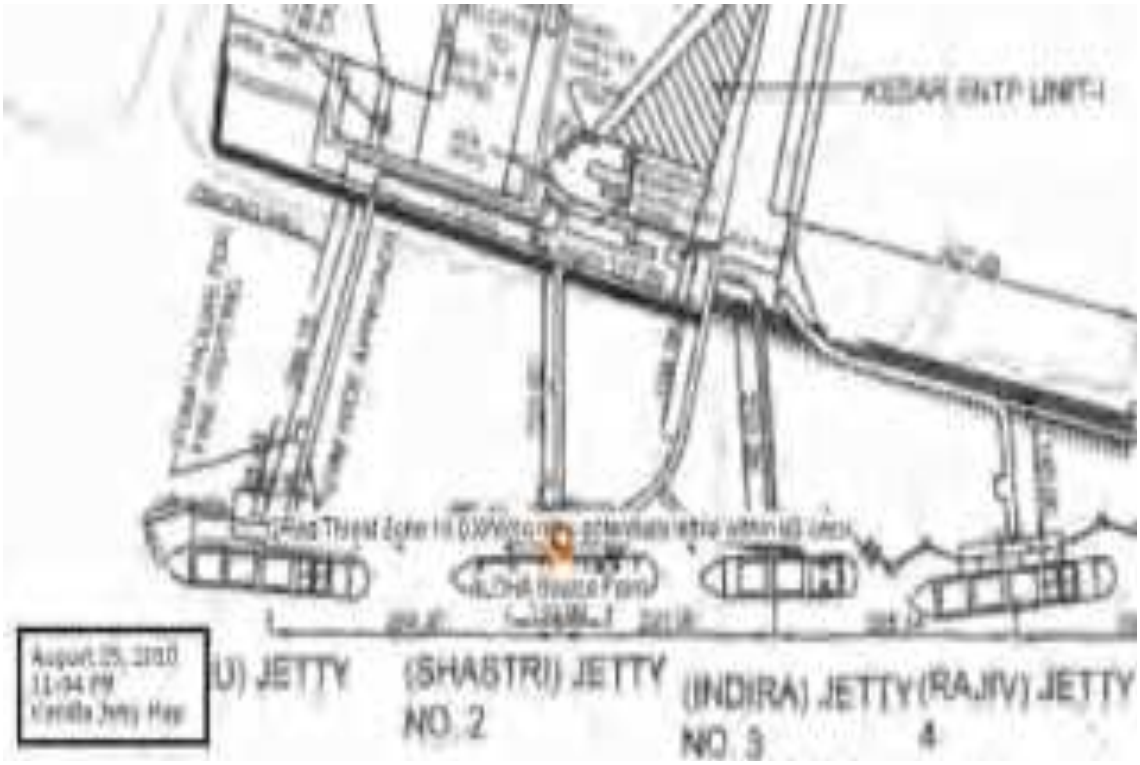
20.1.4.6 Instantaneous Release – Overpressure (Contour)



20.1.4.7 Burning Puddle – Thermal Radiation (Graph)

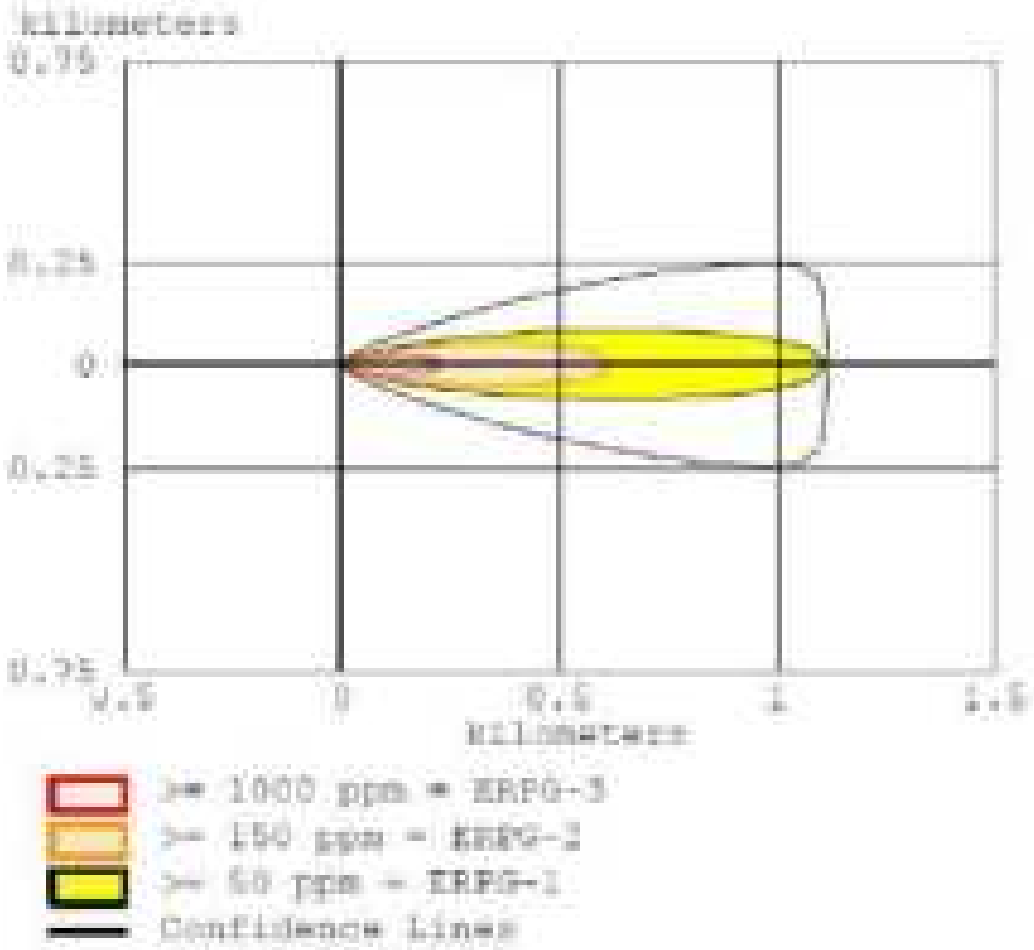


20.1.4.8 Burning Puddle – Thermal Radiation (Contour)



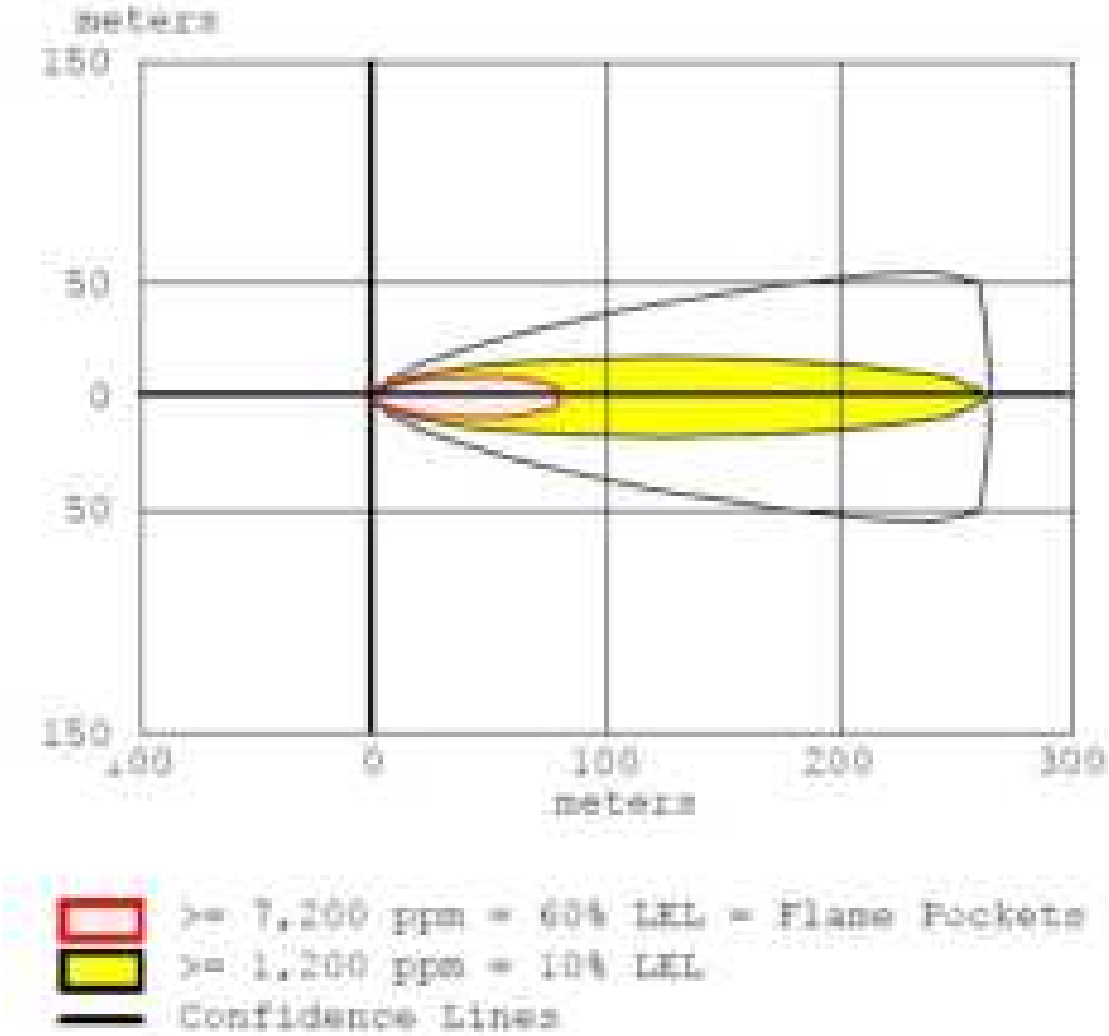
20.1.5 Jetty Two – Benzene

20.1.5.1 Instantaneous Release – Toxic Threat Zone (Graph)



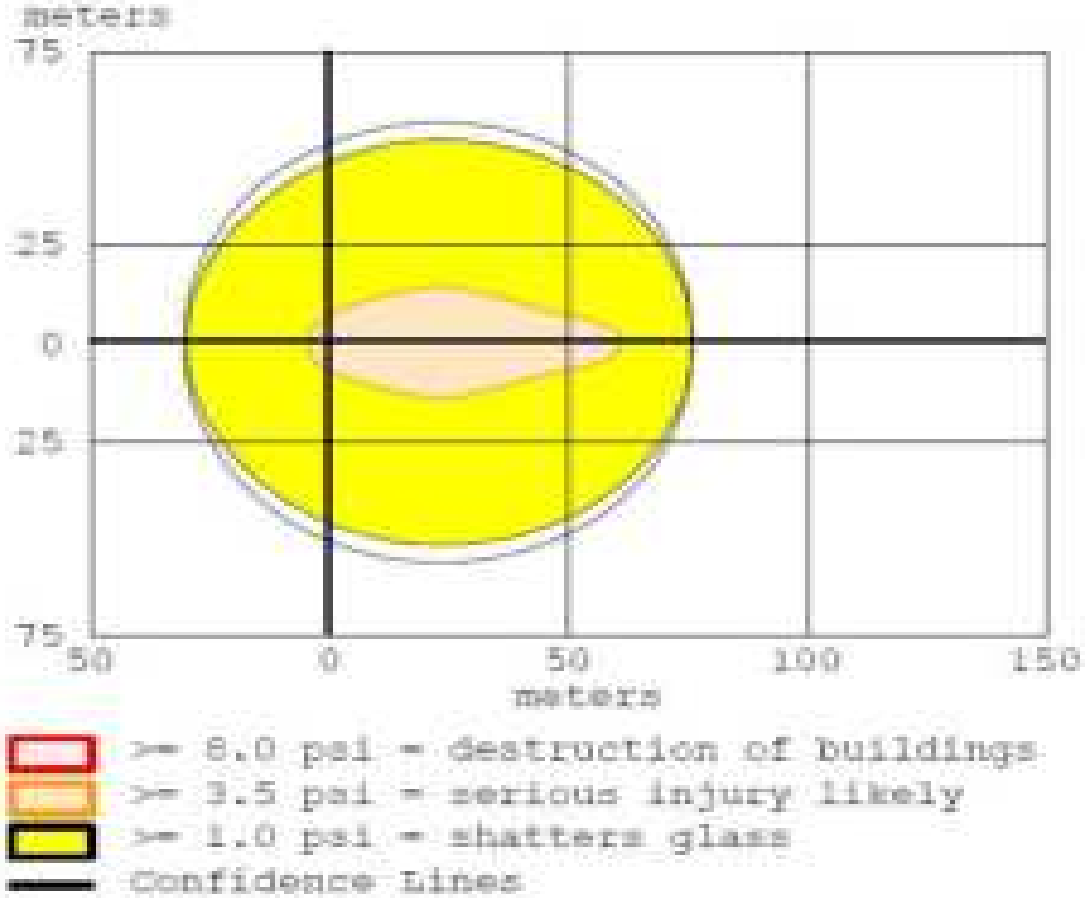
20.1.5.2 Instantaneous Release – Toxic Threat Zone (Contour)

20.1.5.3 Instantaneous Release – Flammable Area of Vapor Cloud (Graph)

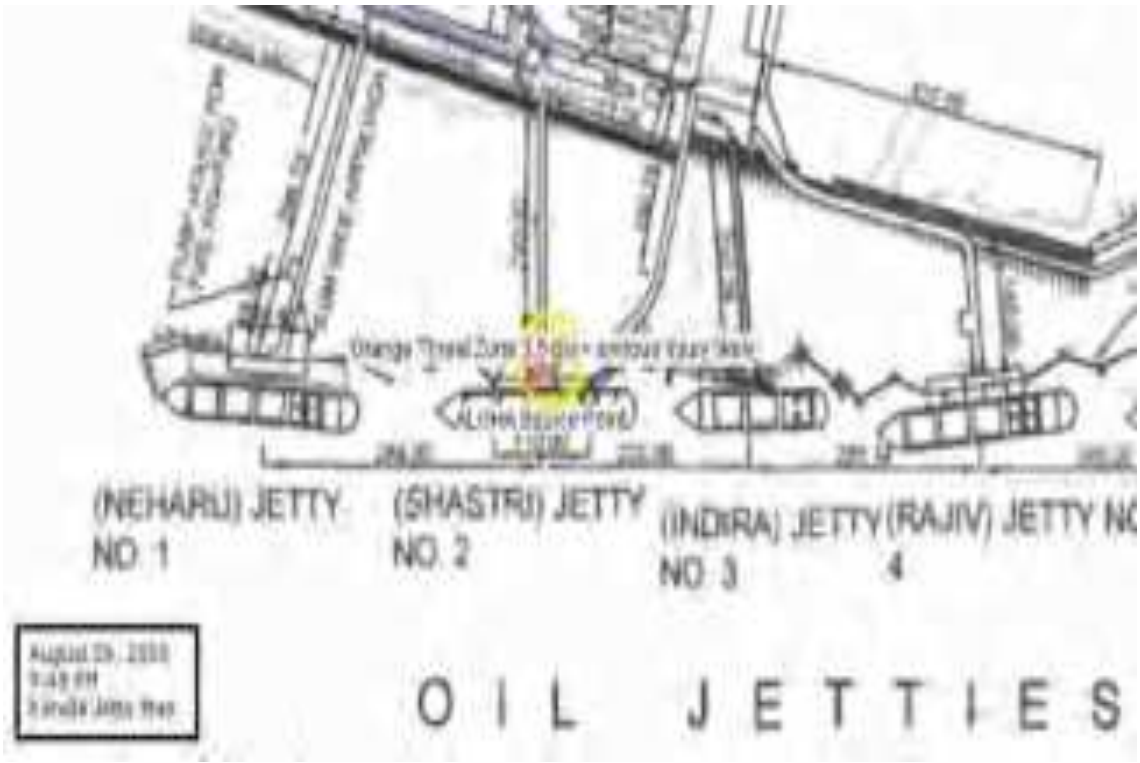


20.1.5.4 Instantaneous Release – Flammable Area of Vapor Cloud (Contour)

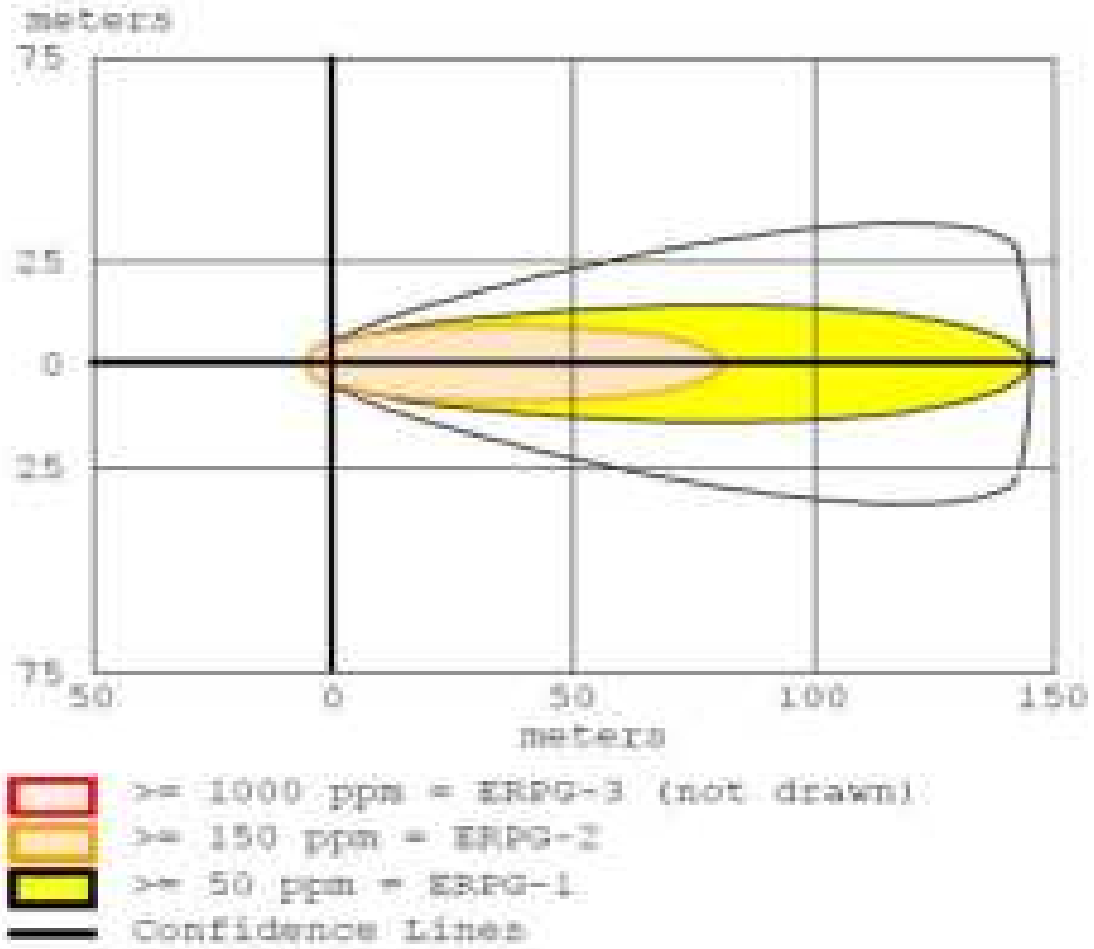
20.1.5.5 Instantaneous Release – Overpressure (Graph)



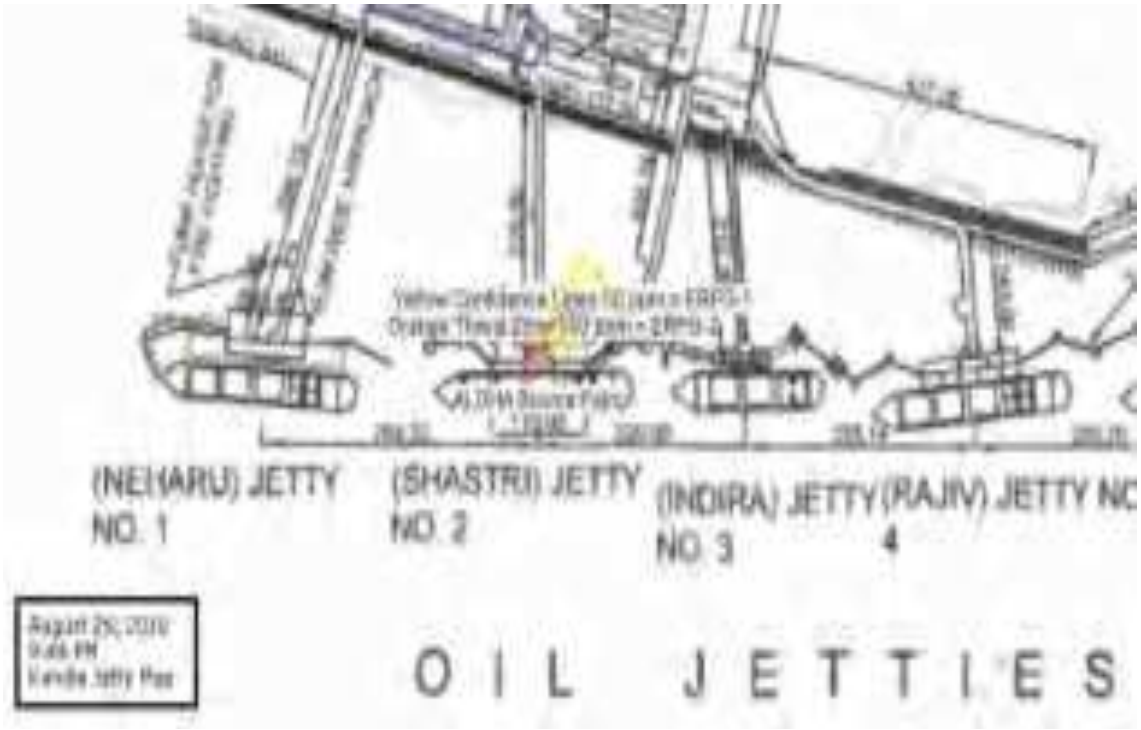
20.1.5.6 Instantaneous Release – Overpressure (Contour)



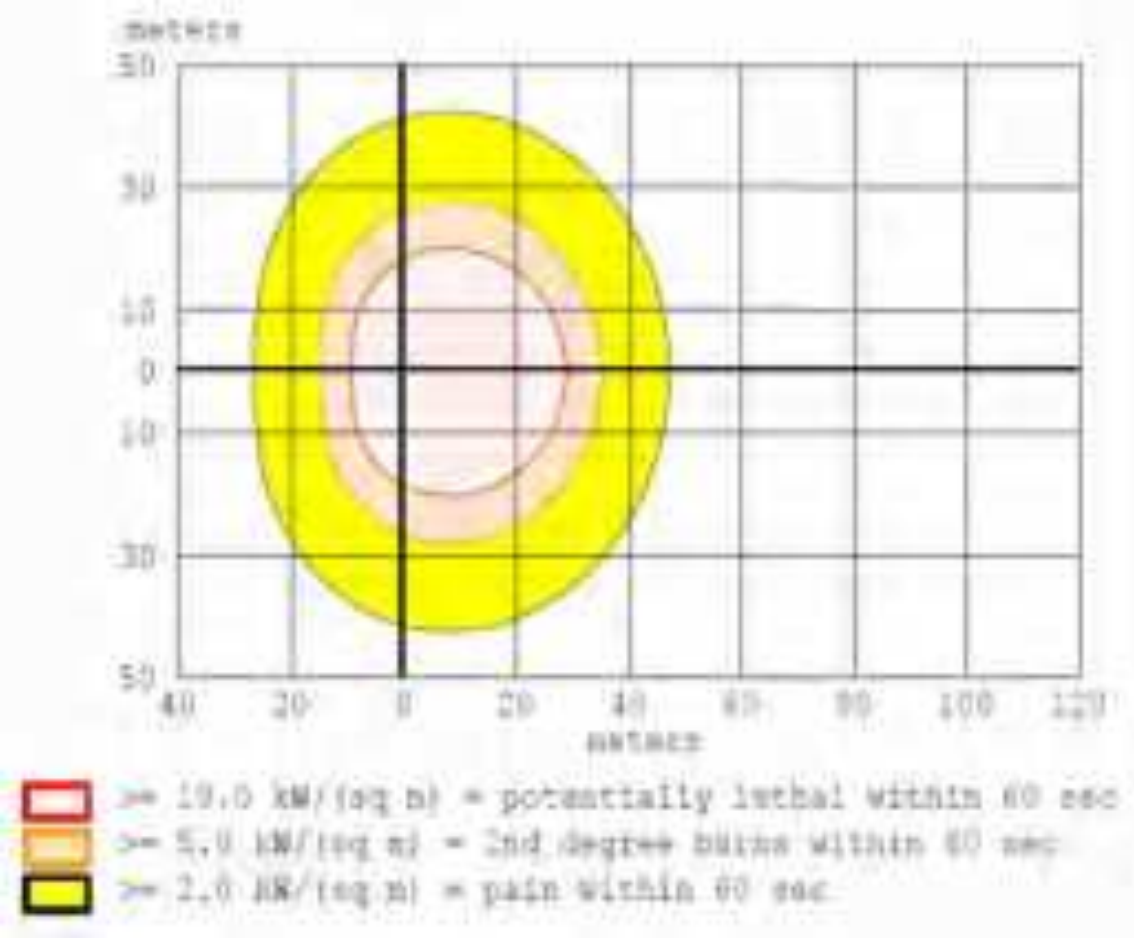
20.1.5.7 Evaporating Puddle – Toxic Threat Zone (Graph)



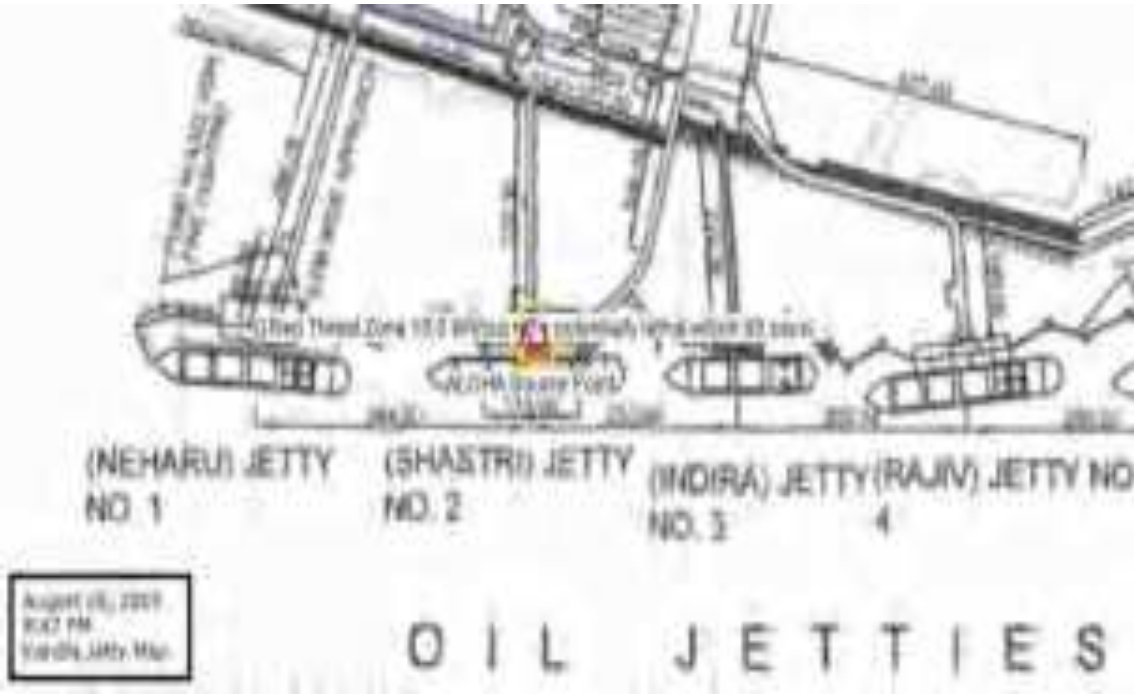
20.1.5.8 Evaporating Puddle – Toxic Threat Zone (Contour)



20.1.5.9 Burning Puddle – Thermal Radiation (Graph)

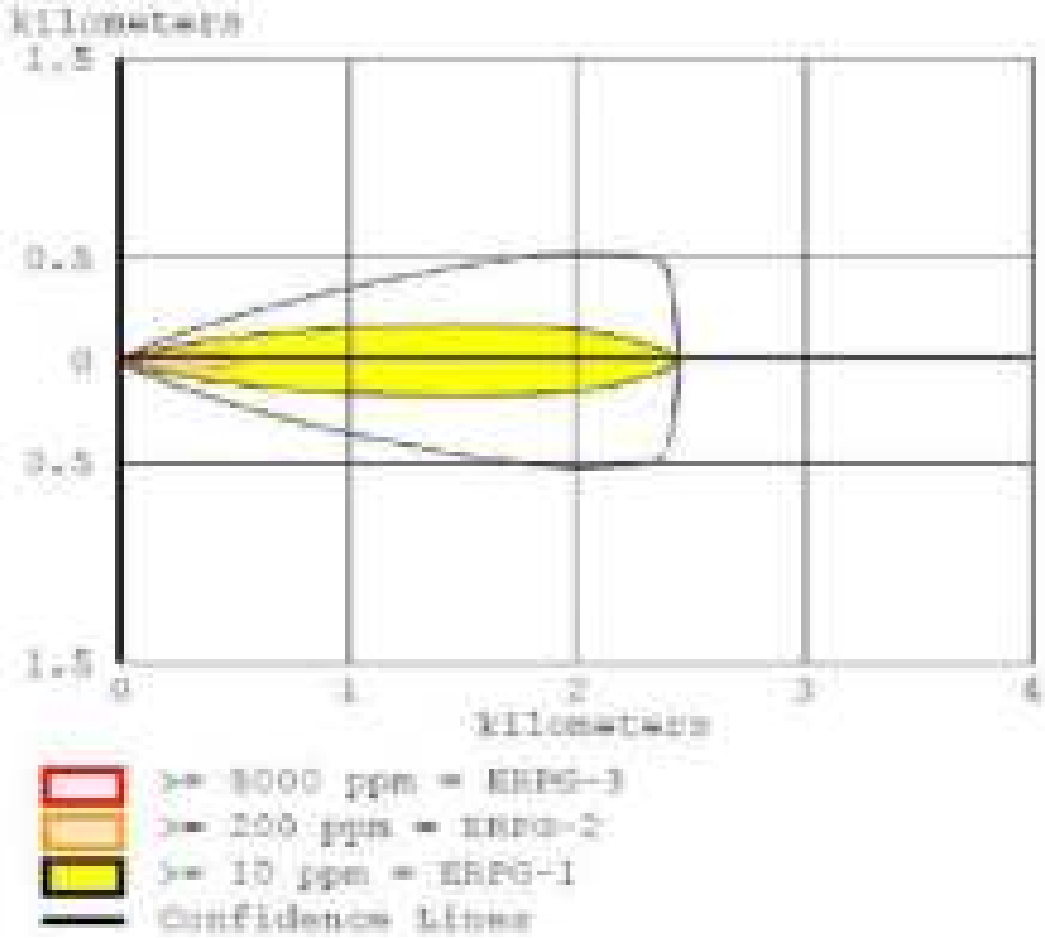


20.1.5.10 Burning Puddle – Thermal Radiation (Contour)



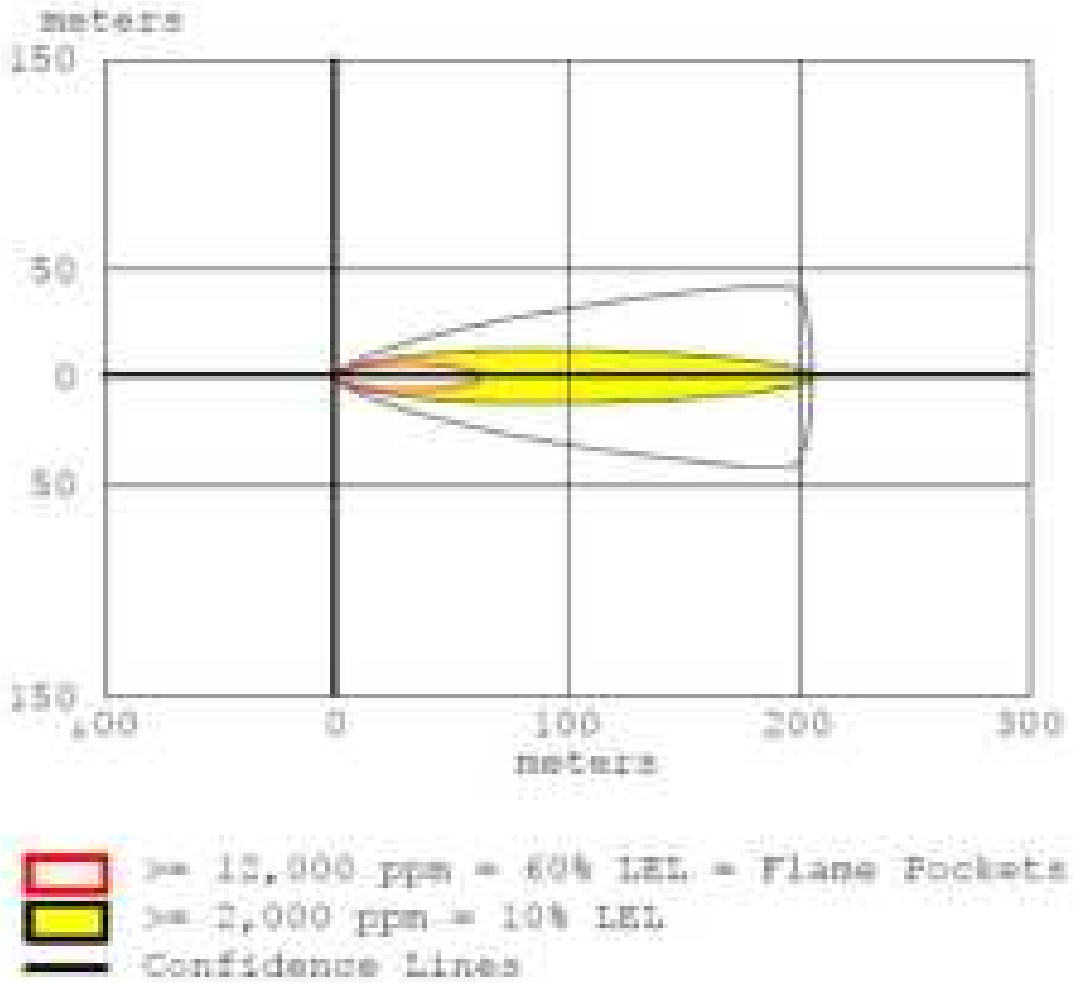
20.1.6 Jetty Three – 1:3, Butadiene

20.1.6.1 Instantaneous Release – Toxic Threat Zone (Graph)

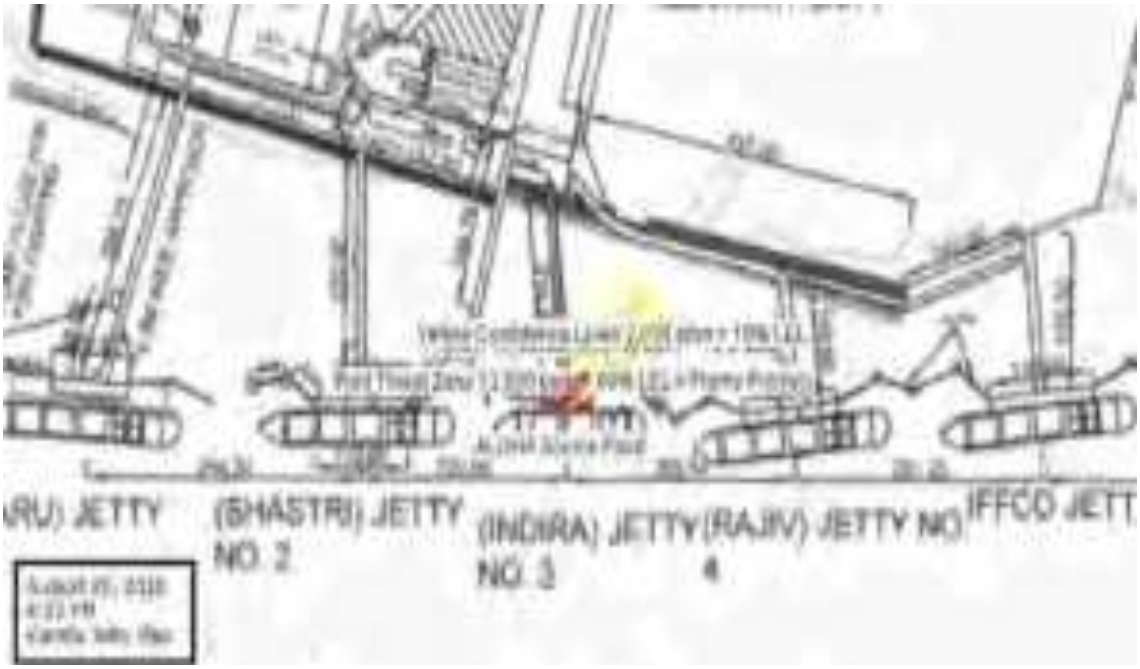


20.1.6.2 Instantaneous Release – Toxic Threat Zone (Contour)

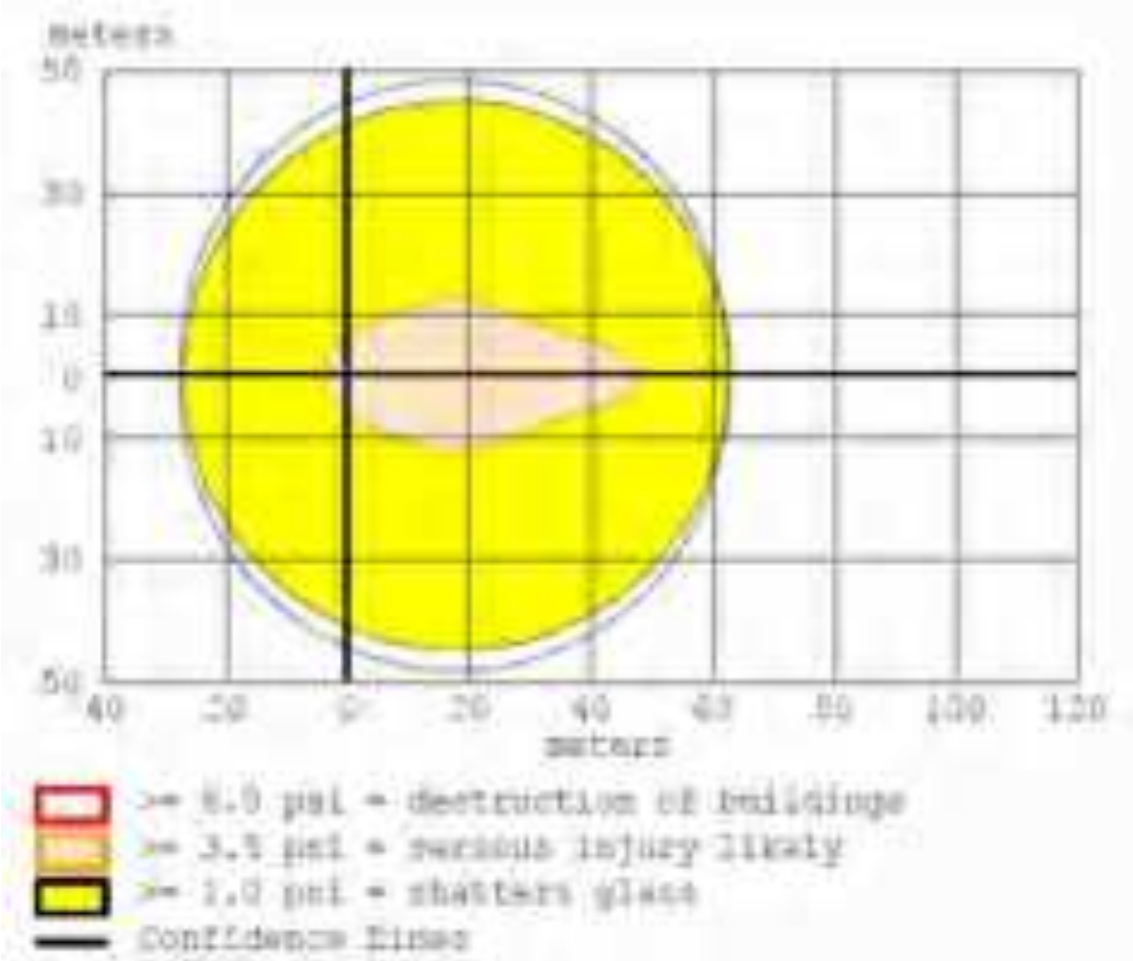
20.1.6.3 Instantaneous Release – Flammable Area of Vapor Cloud (Graph)



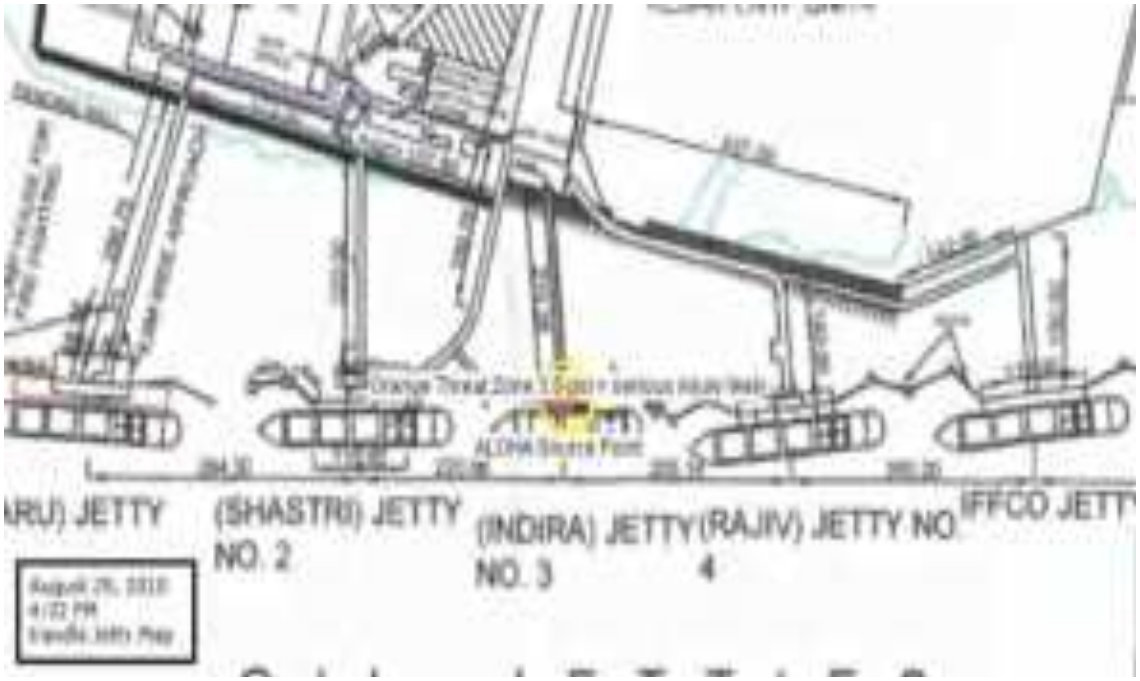
20.1.6.4 Instantaneous Release – Flammable Area of Vapor Cloud (Contour)



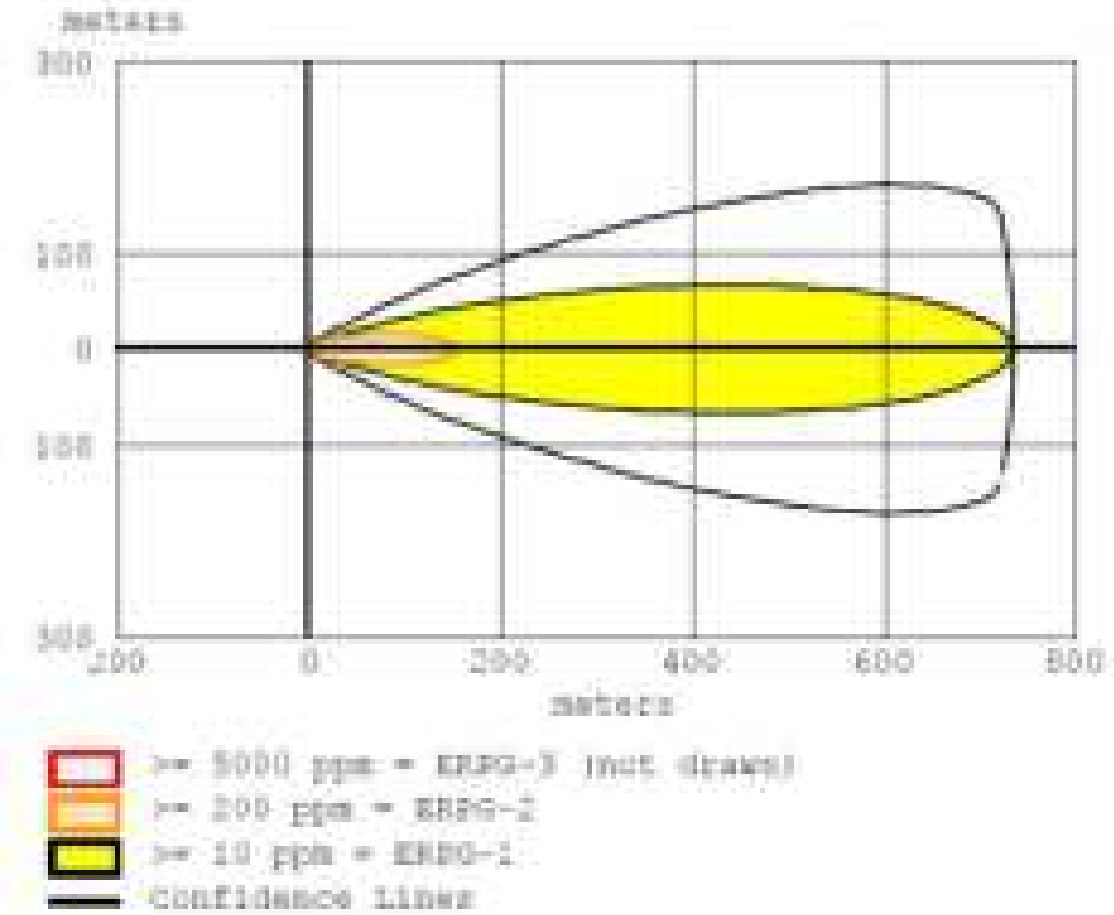
20.1.6.5 Instantaneous Release – Overpressure (Graph)



20.1.6.6 Instantaneous Release – Overpressure (Contour)

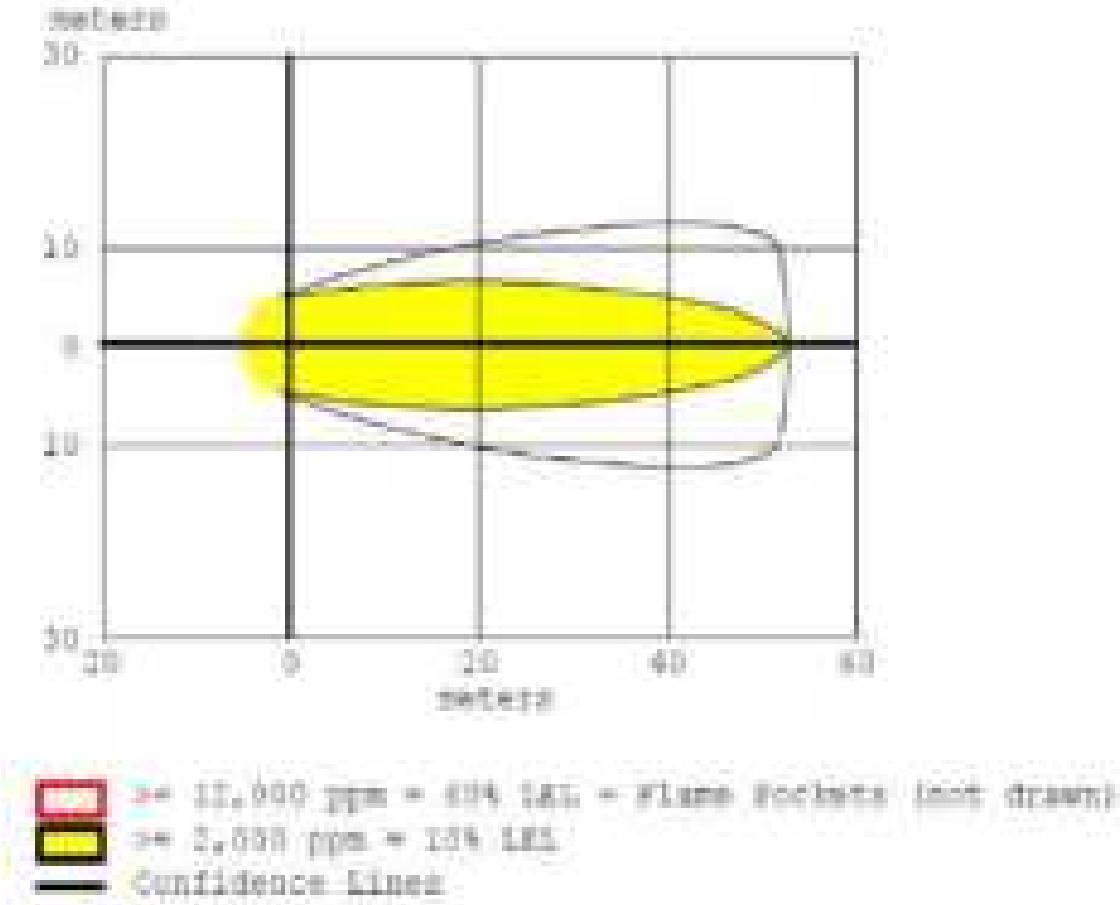


20.1.6.7 Evaporating Puddle – Toxic Threat Zone (Graph)

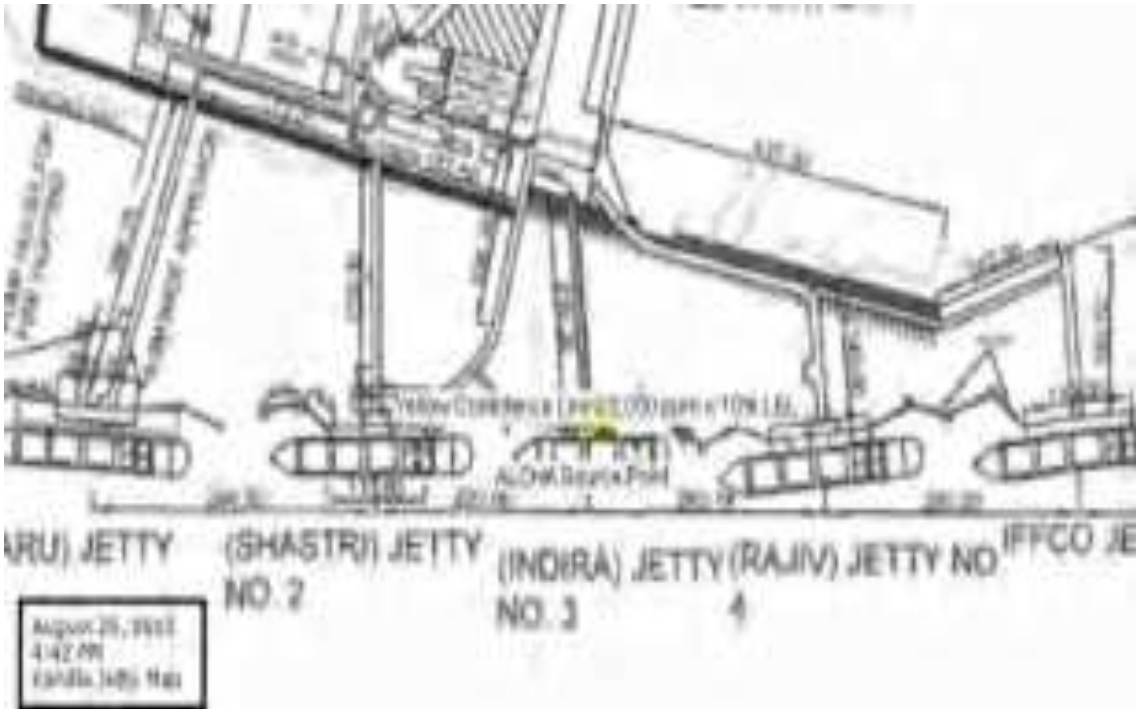


20.1.6.8 Evaporating Puddle – Toxic Threat Zone (Contour)

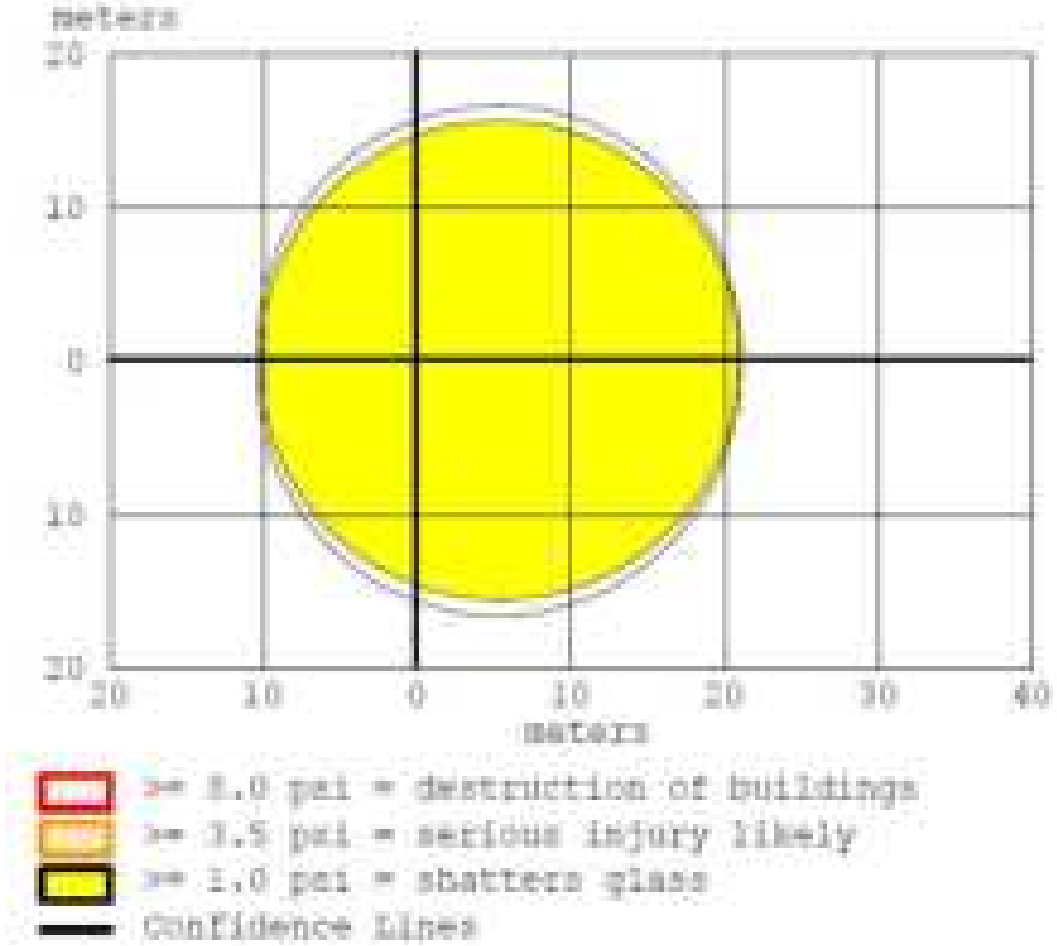
20.1.6.9 Evaporating Puddle – Flammable Area of Vapor Cloud (Graph)



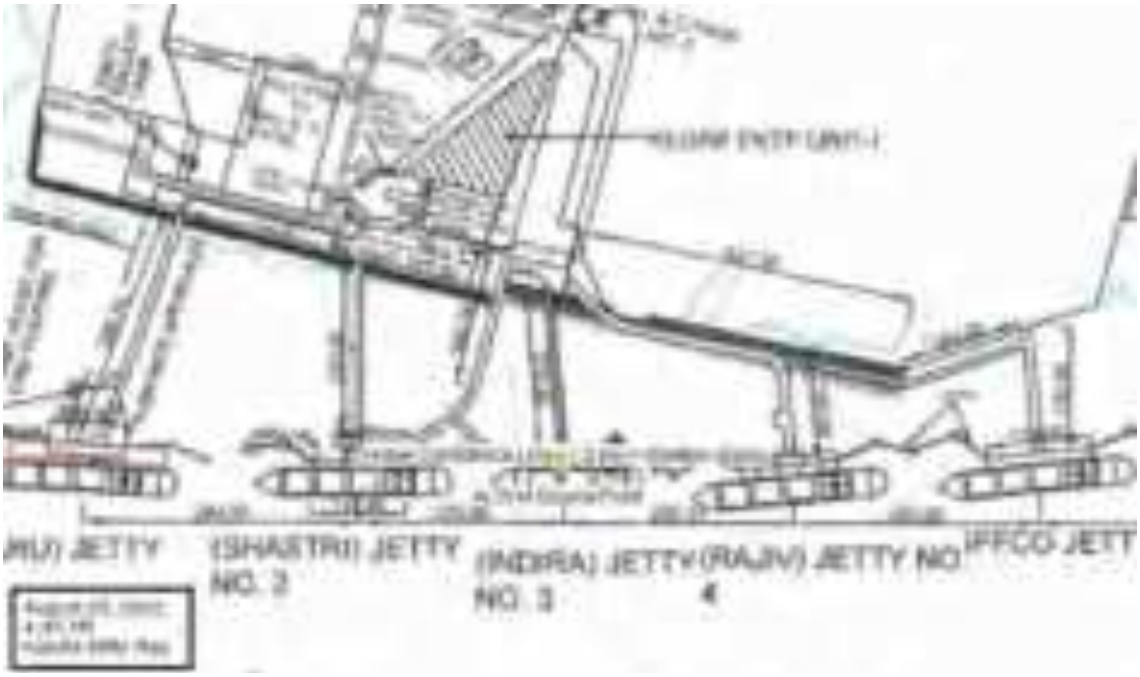
20.1.6.10 Evaporating Puddle – Flammable Area of Vapor Cloud (Contour)



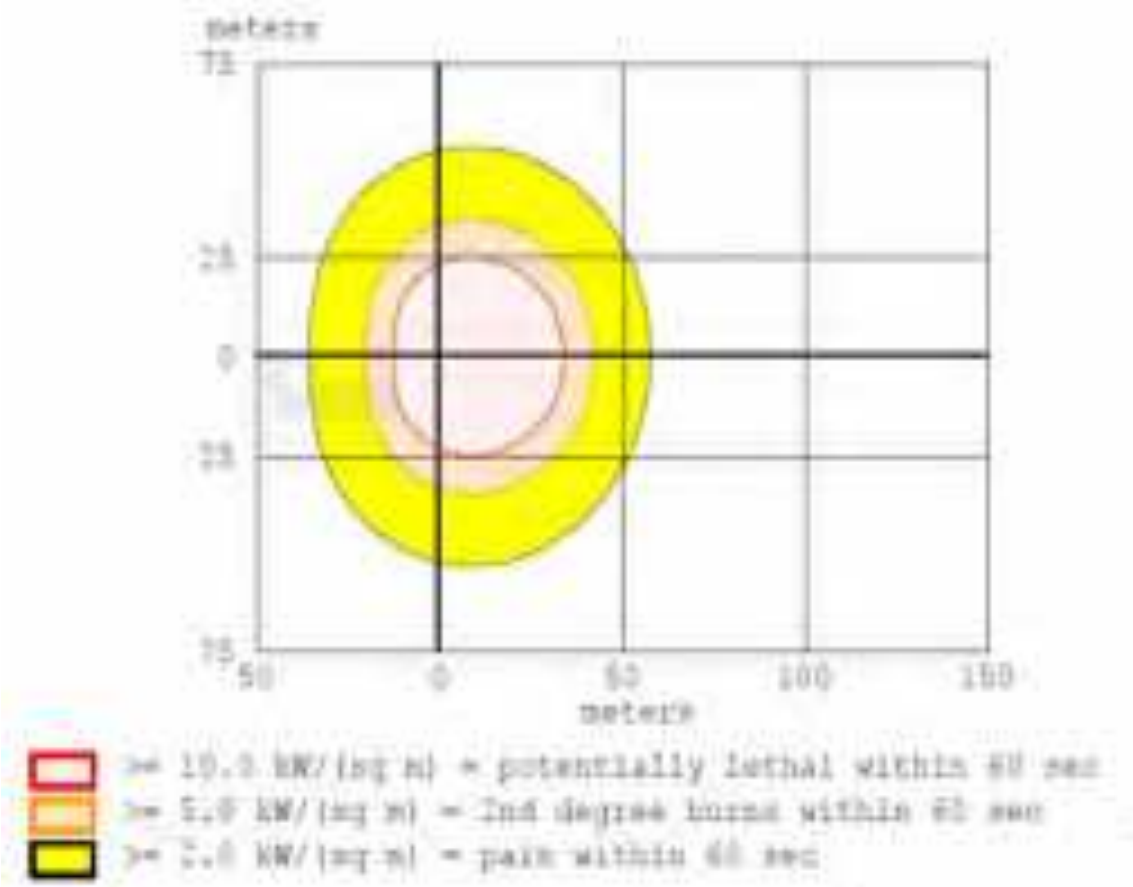
20.1.6.11 Evaporating Puddle – Overpressure (Graph)



20.1.6.12 Evaporating Puddle – Overpressure (Contour)



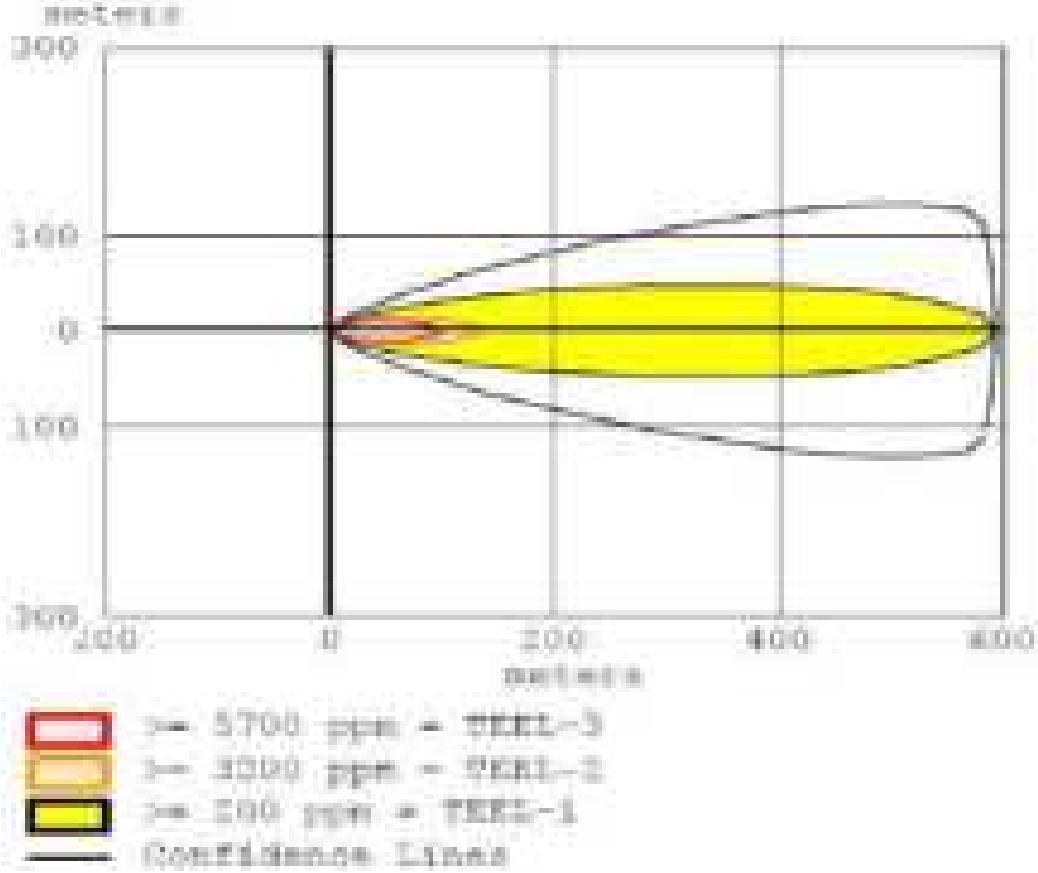
20.1.6.13 Burning Puddle – Thermal Radiation (Graph)



20.1.6.14 Burning Puddle – Thermal Radiation (Contour)

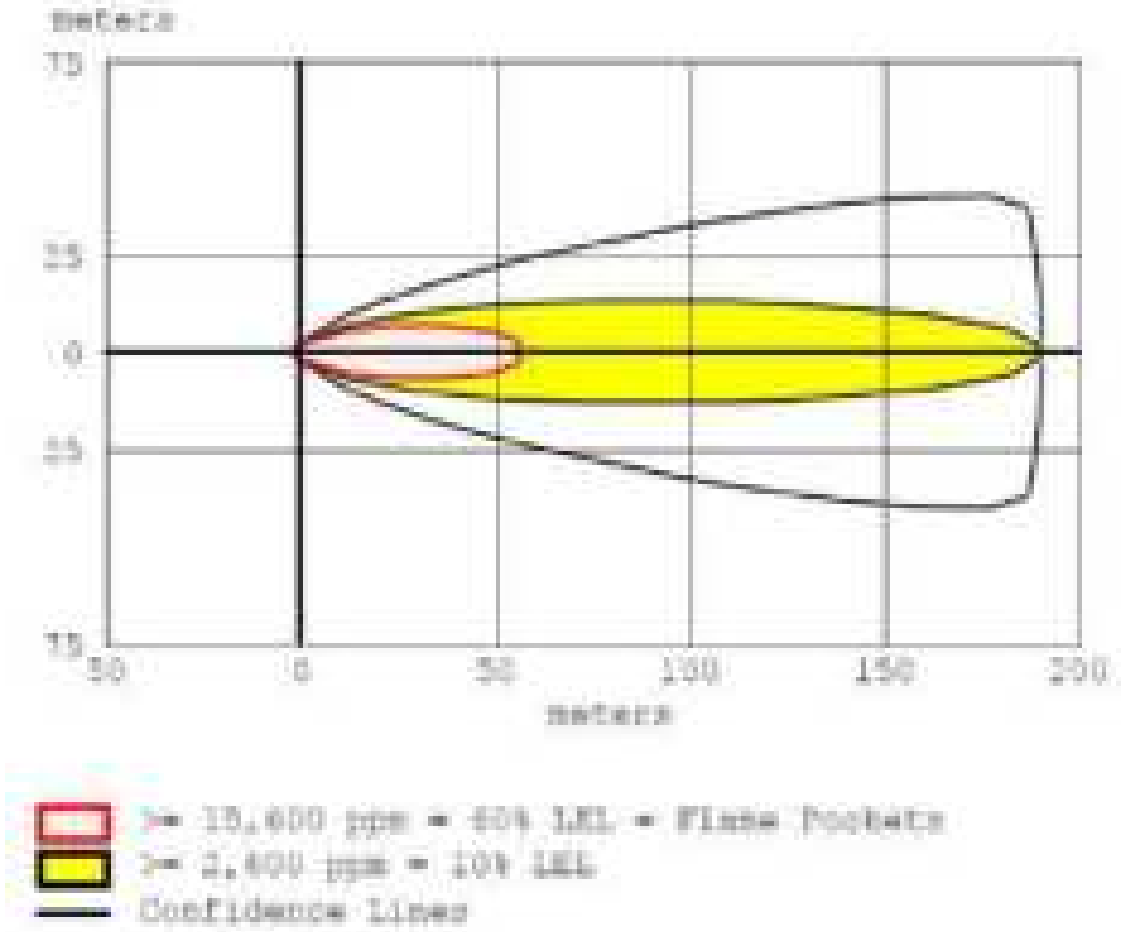
20.1.7 Jetty Three – Acetone

20.1.7.1 Instantaneous Release – Toxic Threat Zone (Graph)

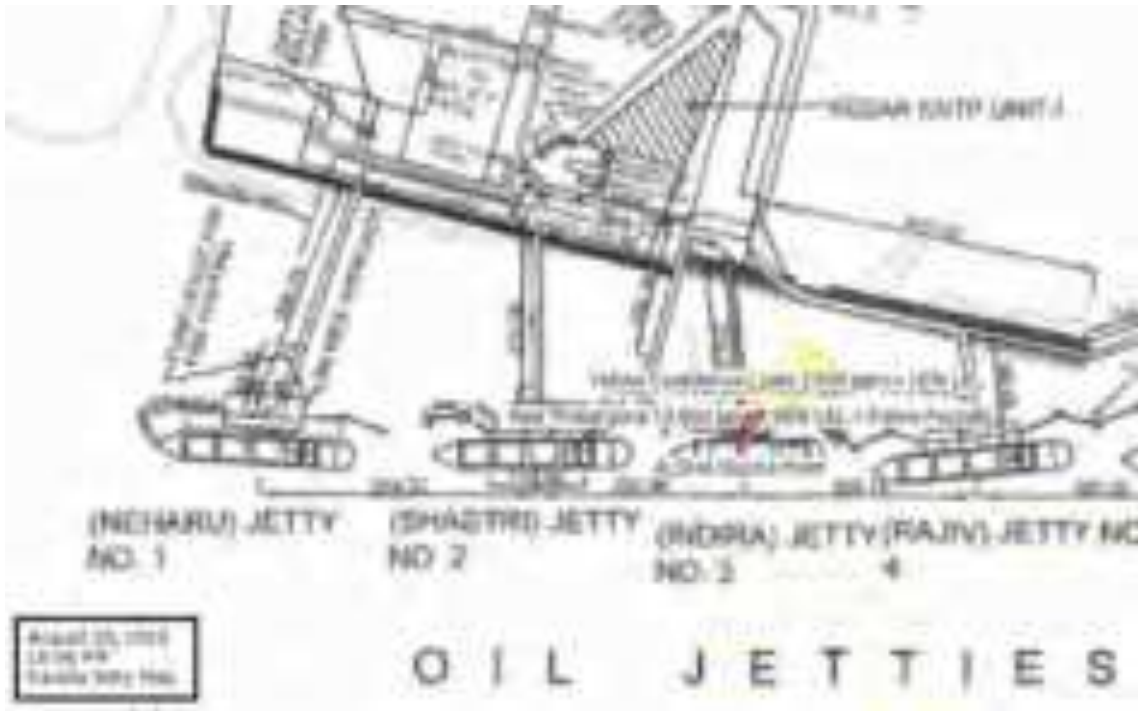


20.1.7.2 Instantaneous Release – Toxic Threat Zone (Contour)

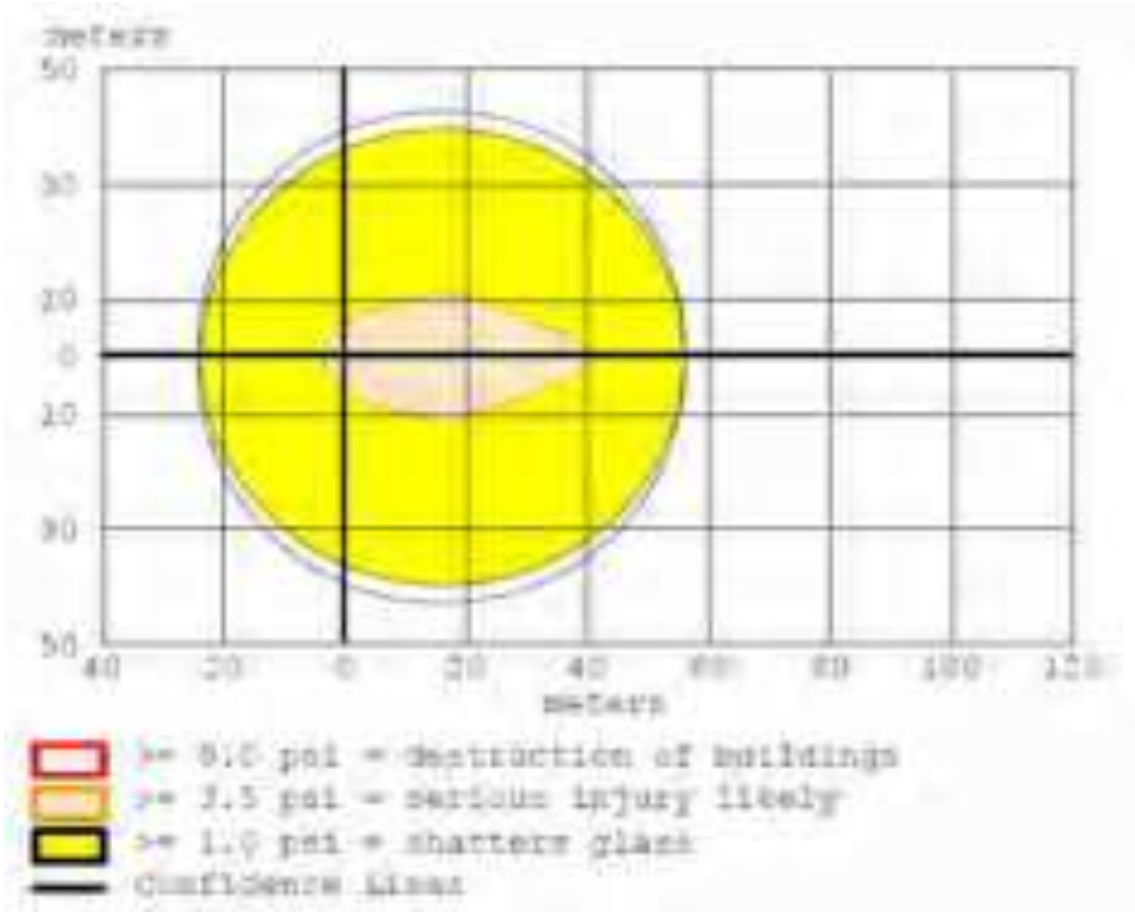
20.1.7.3 Instantaneous Release – Flammable Area of Vapor Cloud (Graph)



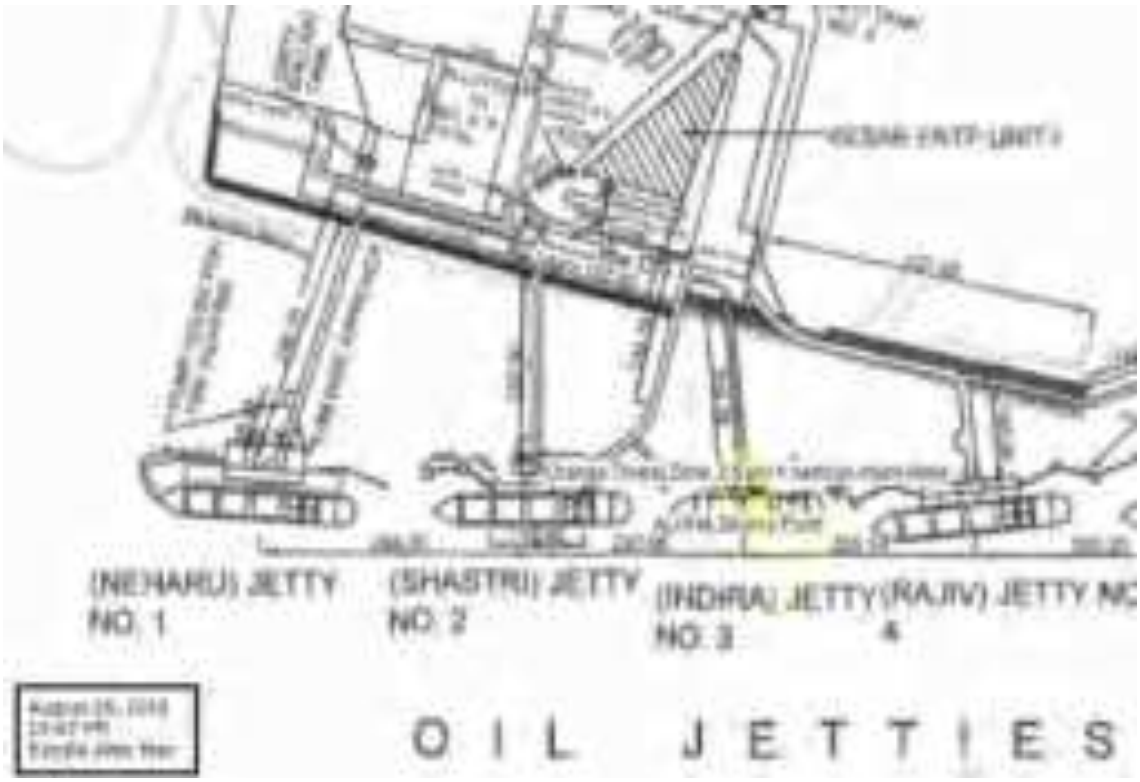
20.1.7.4 Instantaneous Release – Flammable Area of Vapor Cloud (Contour)



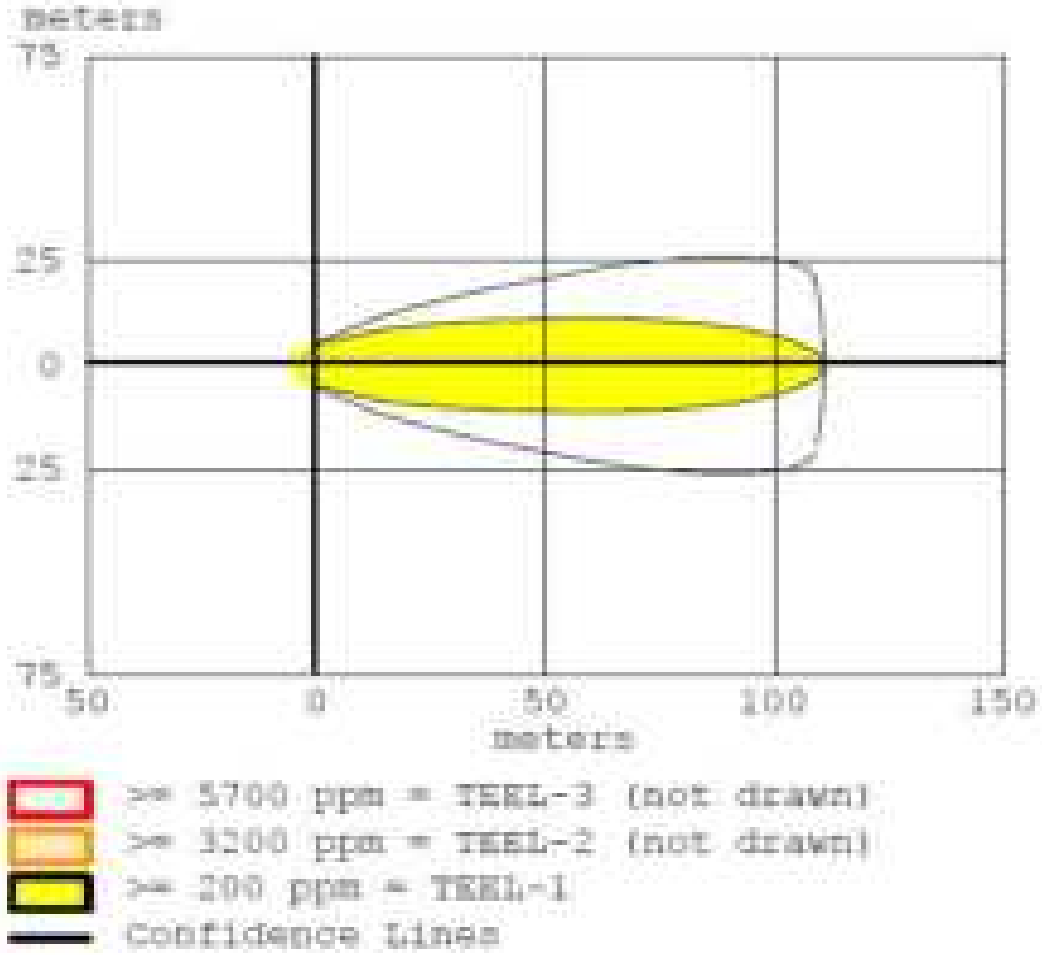
20.1.7.5 Instantaneous Release – Overpressure (Graph)



20.1.7.6 Instantaneous Release – Overpressure (Contour)

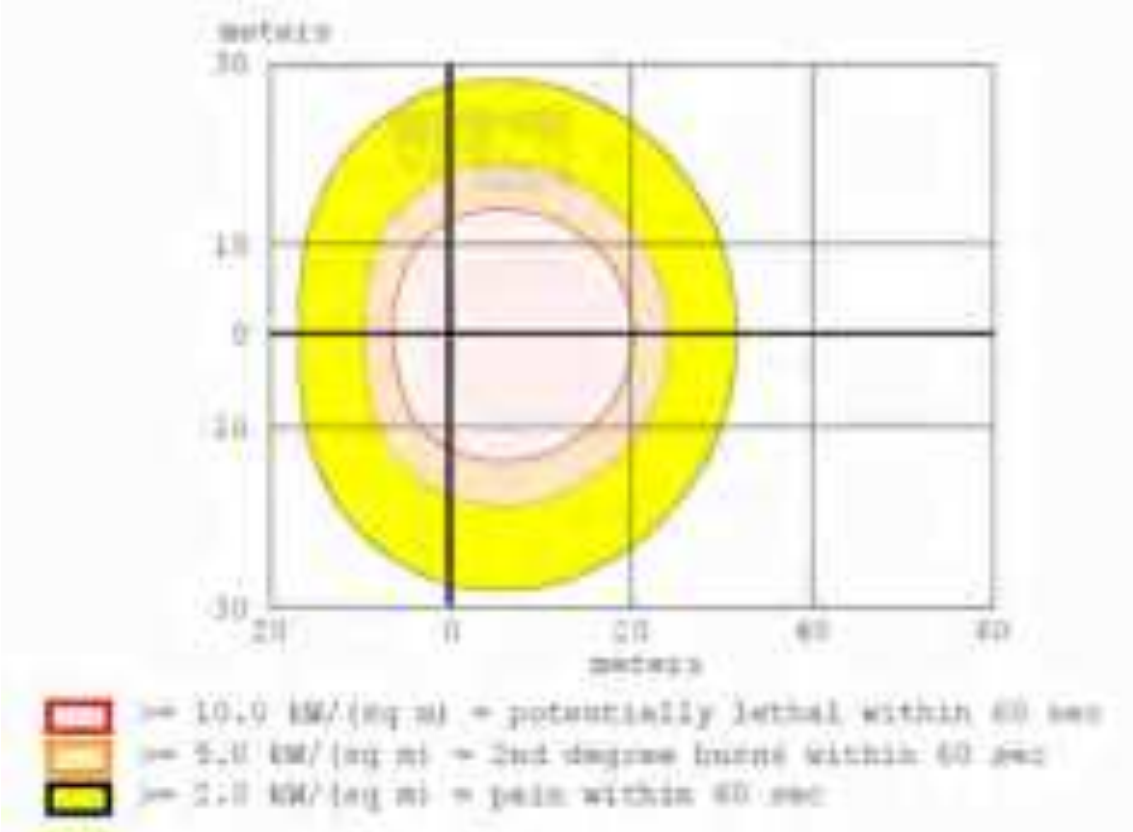


20.1.7.7 Evaporating Puddle – Toxic Threat Zone (Graph)

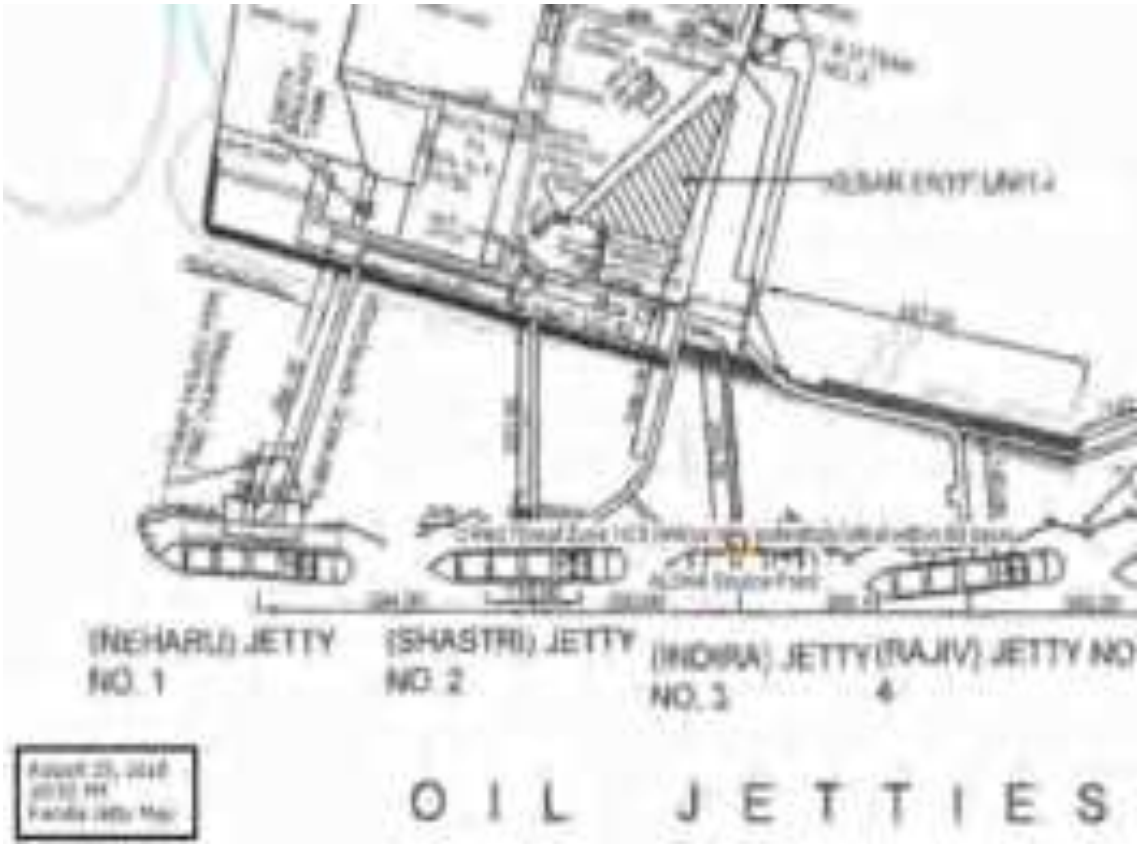


20.1.7.8 Evaporating Puddle – Toxic Threat Zone (Contour)

20.1.7.9 Burning Puddle – Thermal Radiation (Graph)

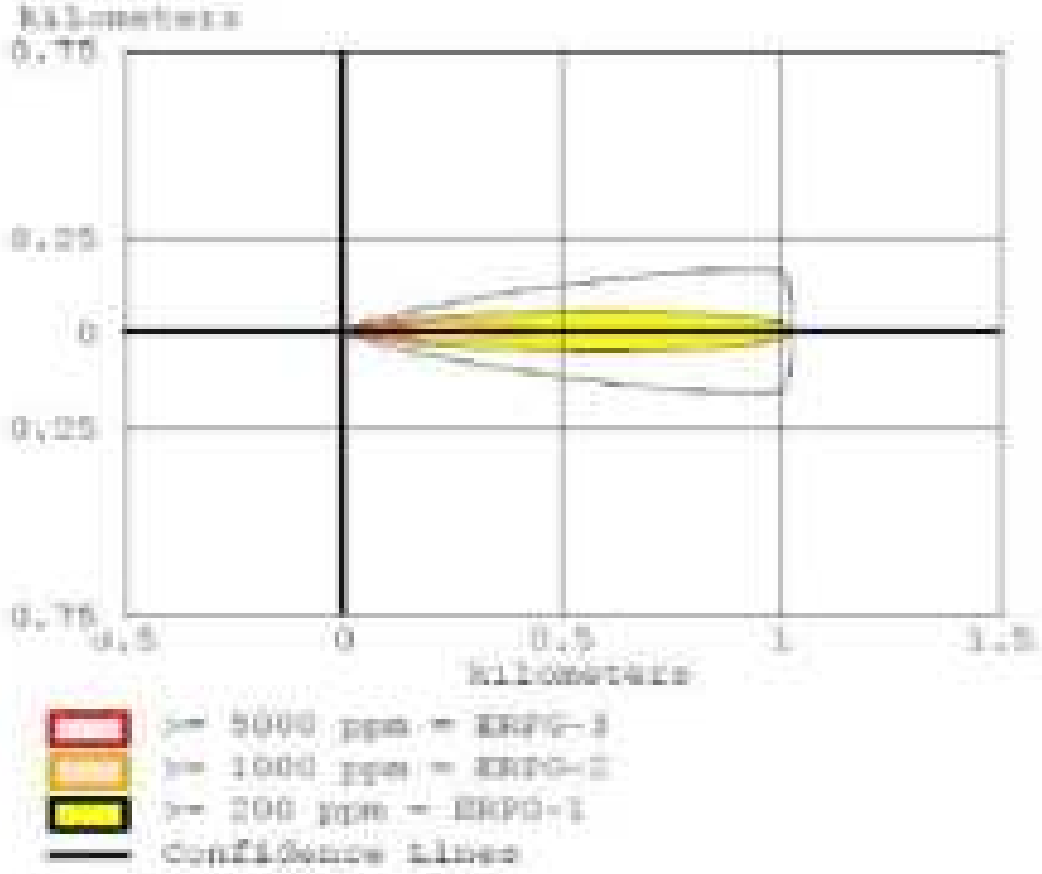


20.1.7.10 Burning Puddle – Thermal Radiation (Contour)



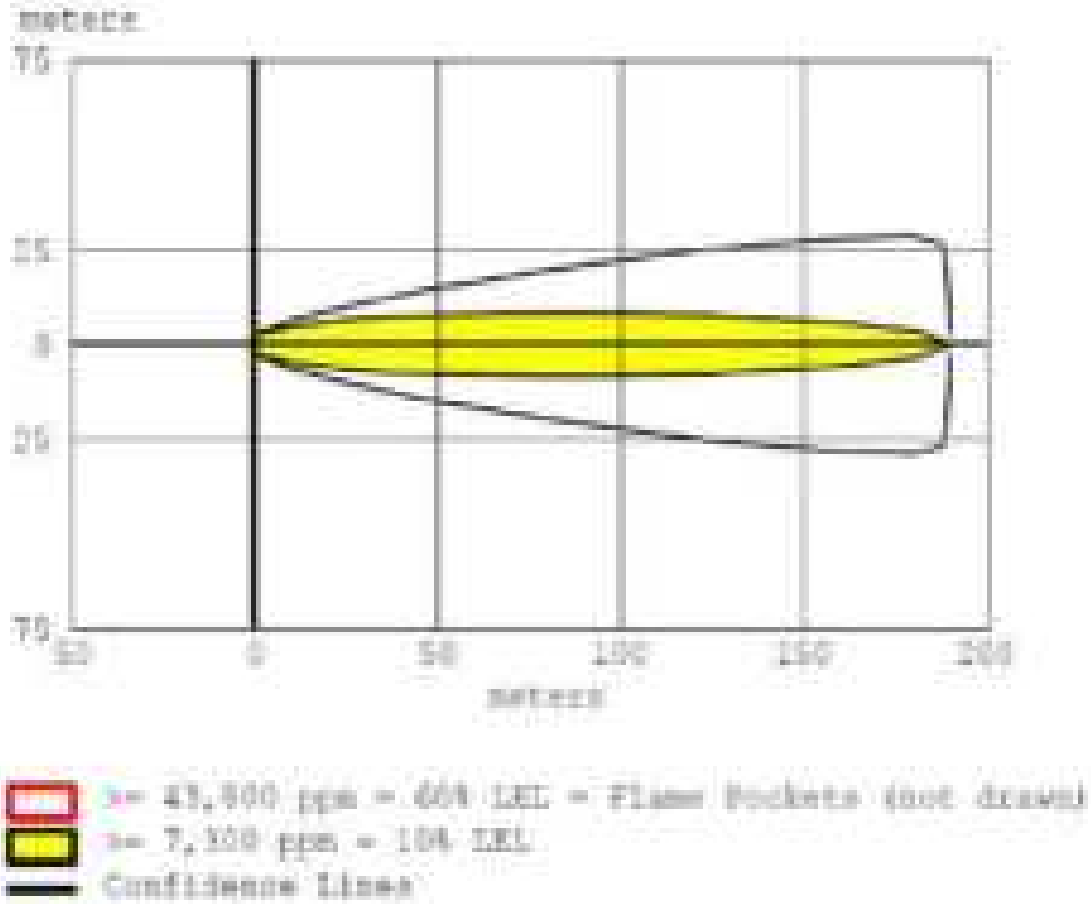
20.1.8 Jetty Three – Methanol

20.1.8.1 Instantaneous Release – Toxic Threat Zone (Graph)

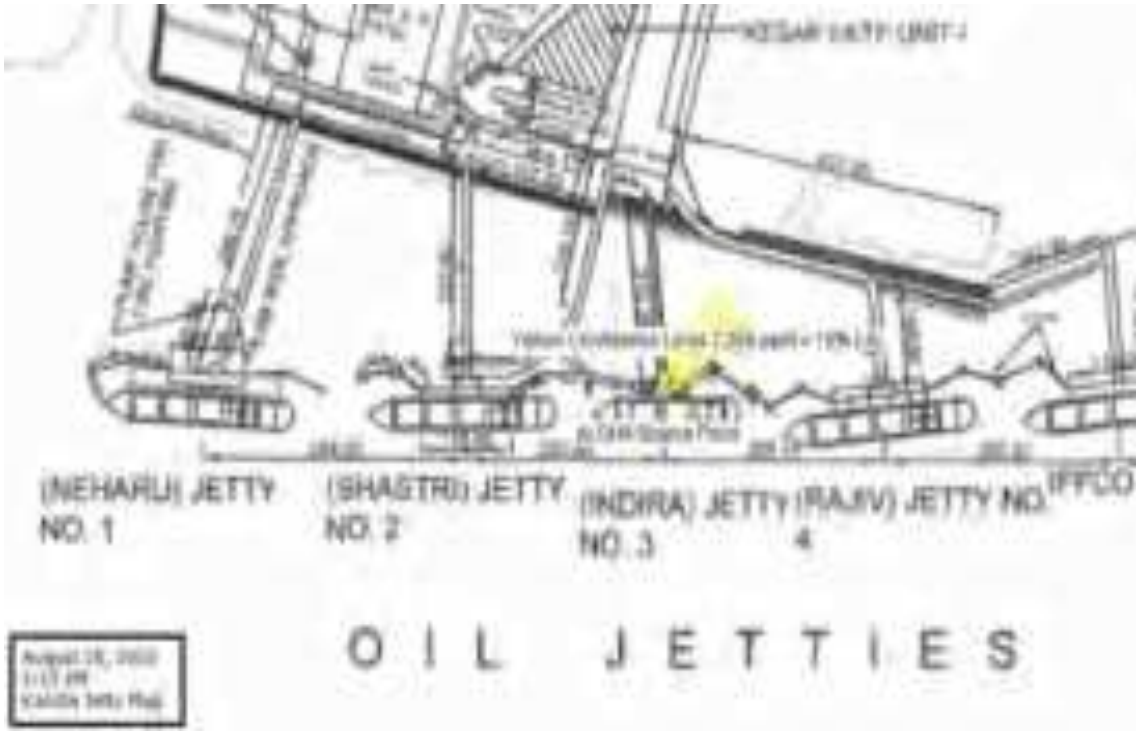


20.1.8.2 Instantaneous Release – Toxic Threat Zone (Contour)

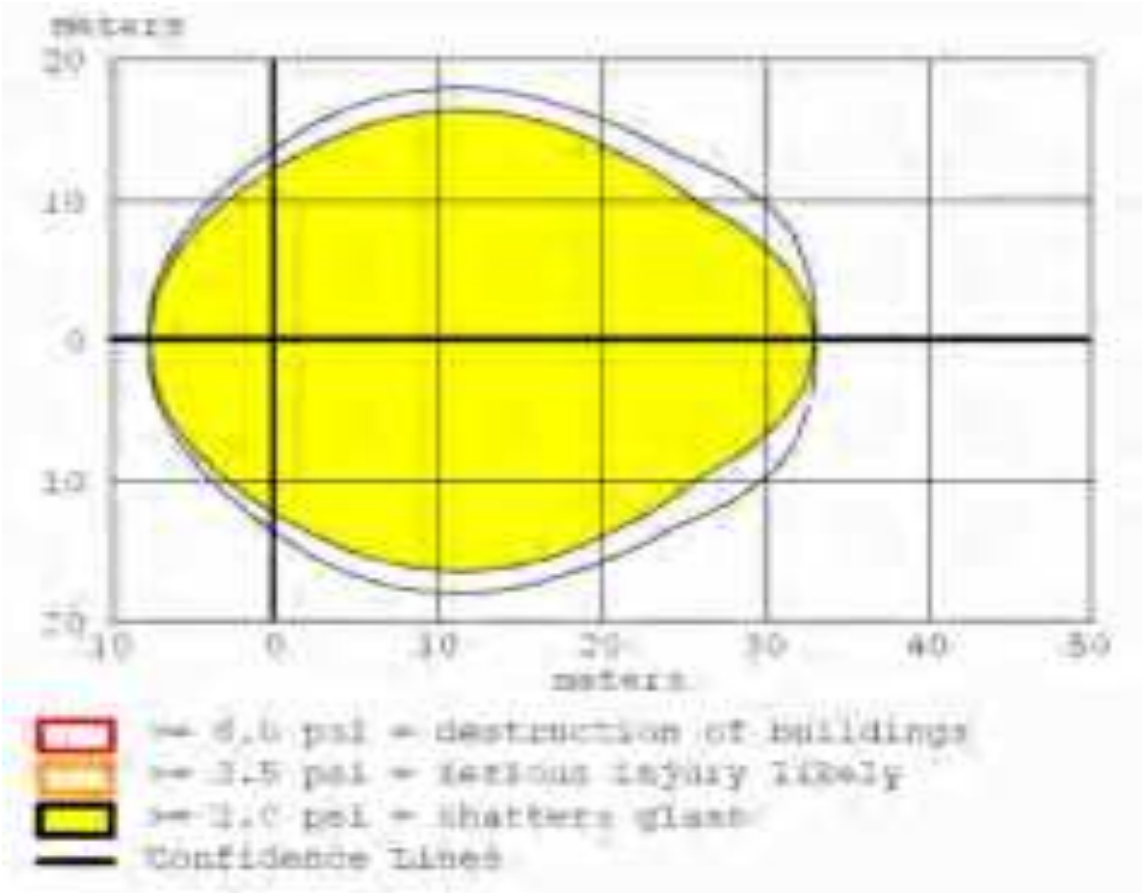
20.1.8.3 Instantaneous Release – Flammable Area of Vapor Cloud (Graph)



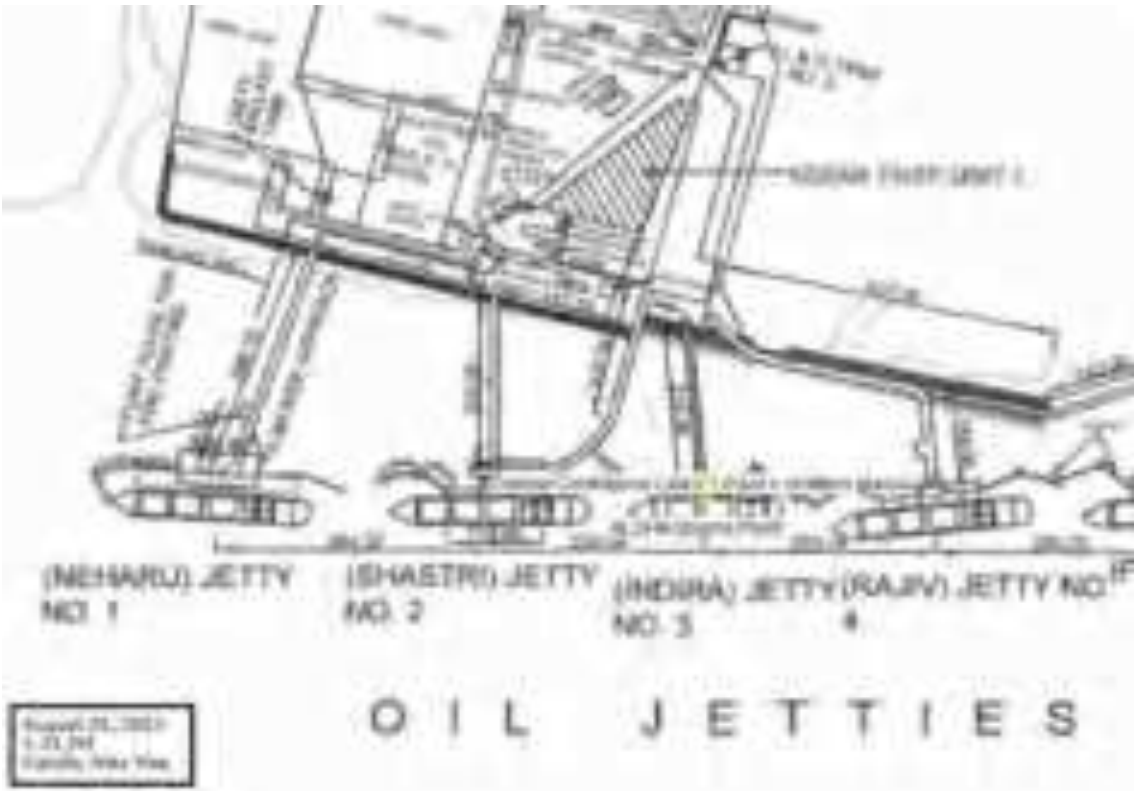
20.1.8.4 Instantaneous Release – Flammable Area of Vapor Cloud (Contour)



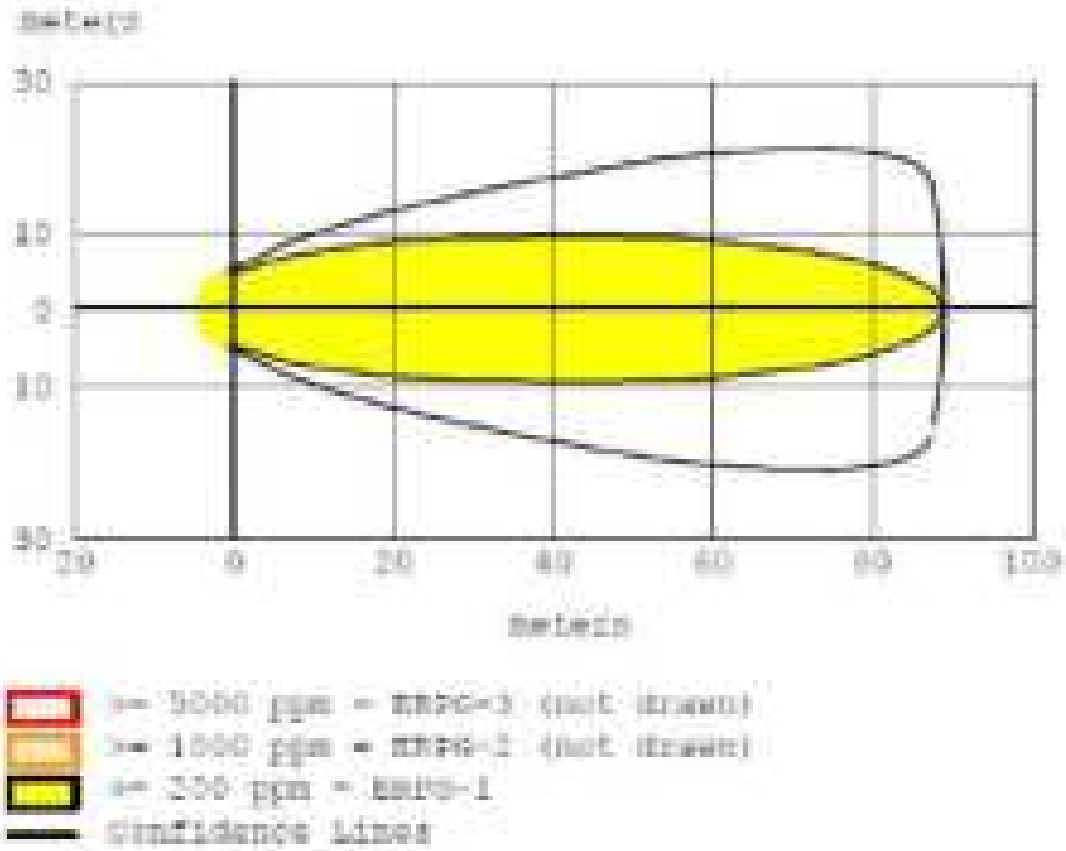
20.1.8.5 Instantaneous Release – Overpressure (Graph)



20.1.8.6 Instantaneous Release – Overpressure (Contour)

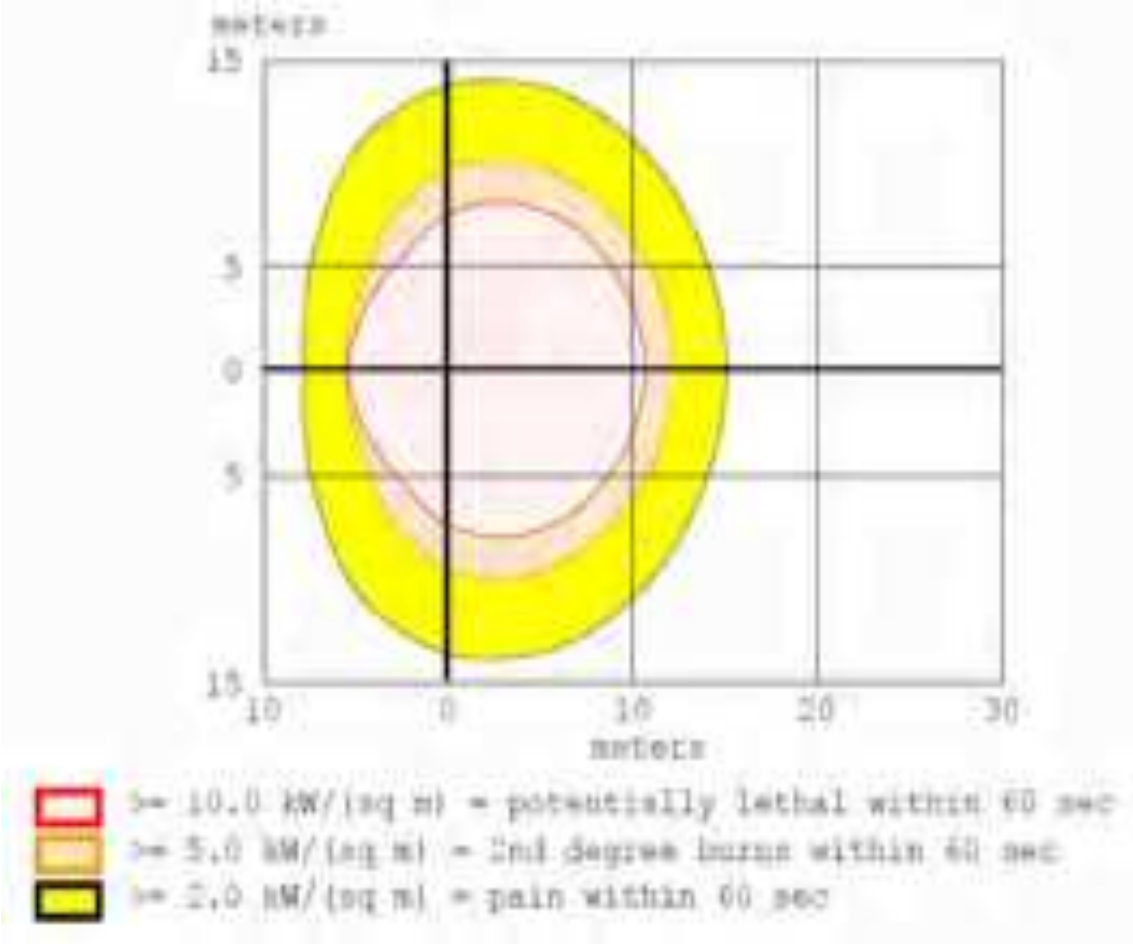


20.1.8.7 Evaporating Puddle – Toxic Threat Zone (Graph)

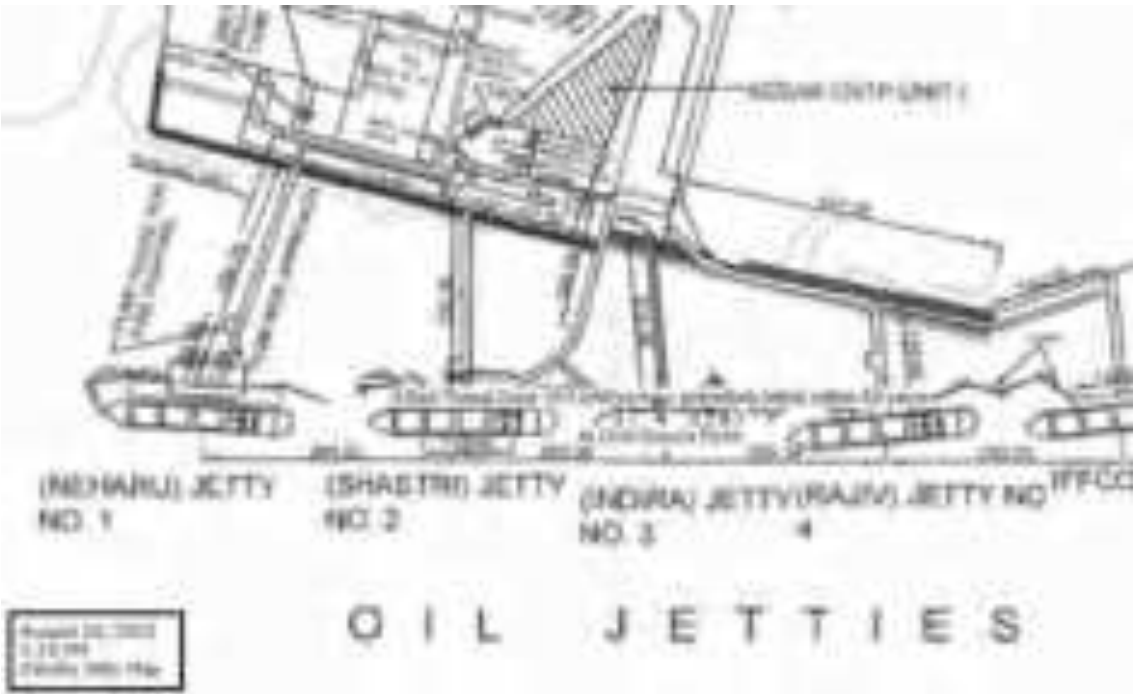


20.1.8.8 Evaporating Puddle – Toxic Threat Zone (Contour)

20.1.8.9 Burning Puddle – Thermal Radiation (Graph)

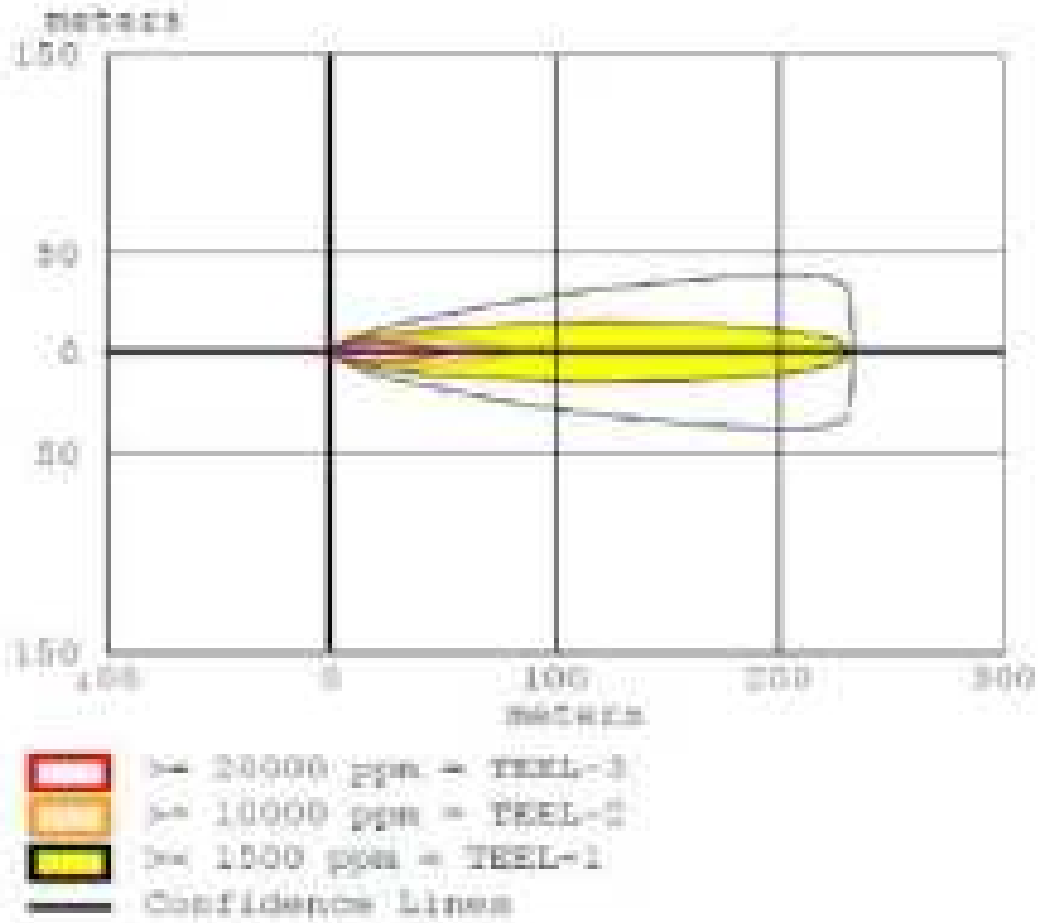


20.1.8.10 Burning Puddle – Thermal Radiation (Contour)

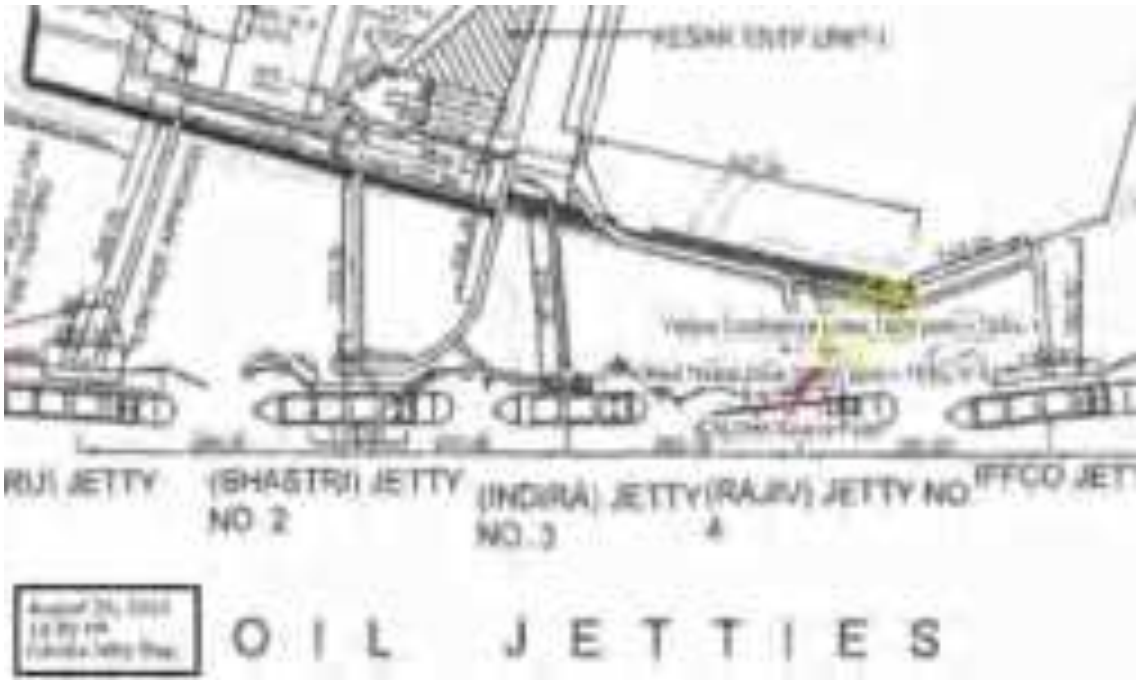


20.1.9 Jetty Four – Propylene

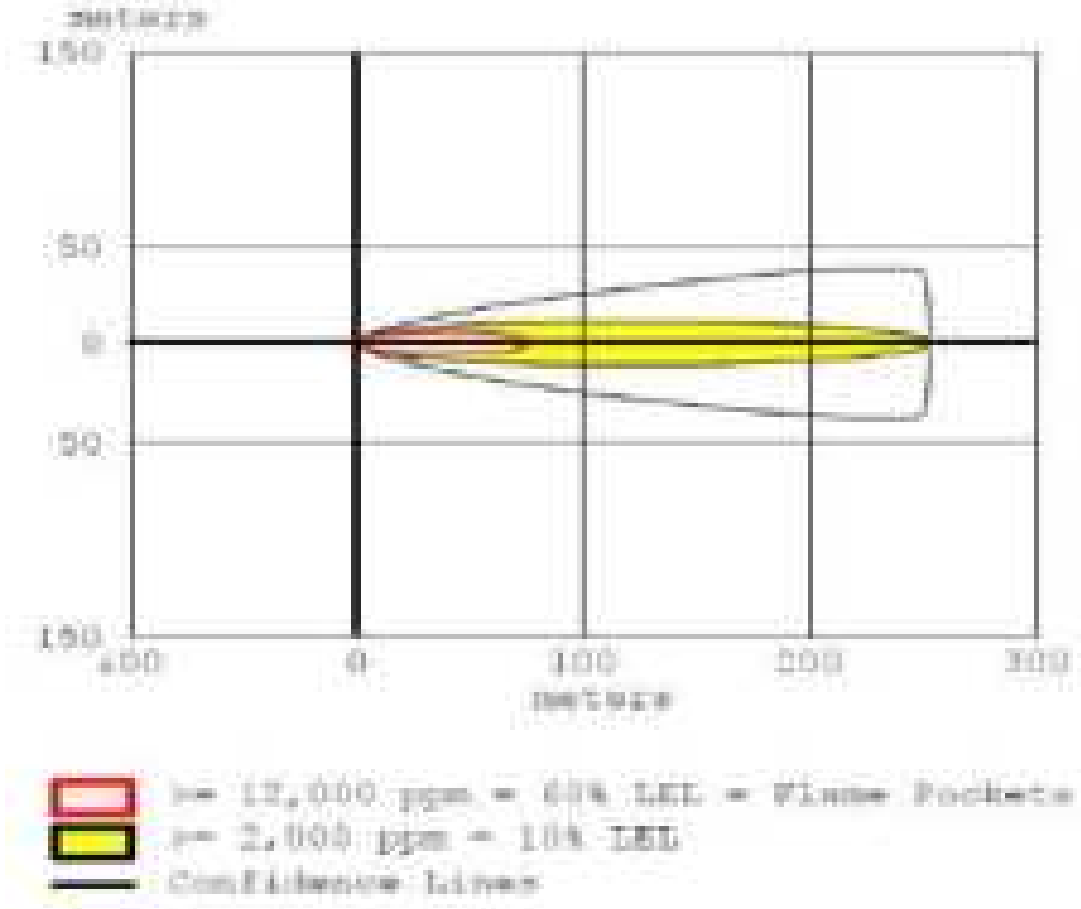
20.1.9.1 Instantaneous Release – Toxic Threat Zone (Graph)



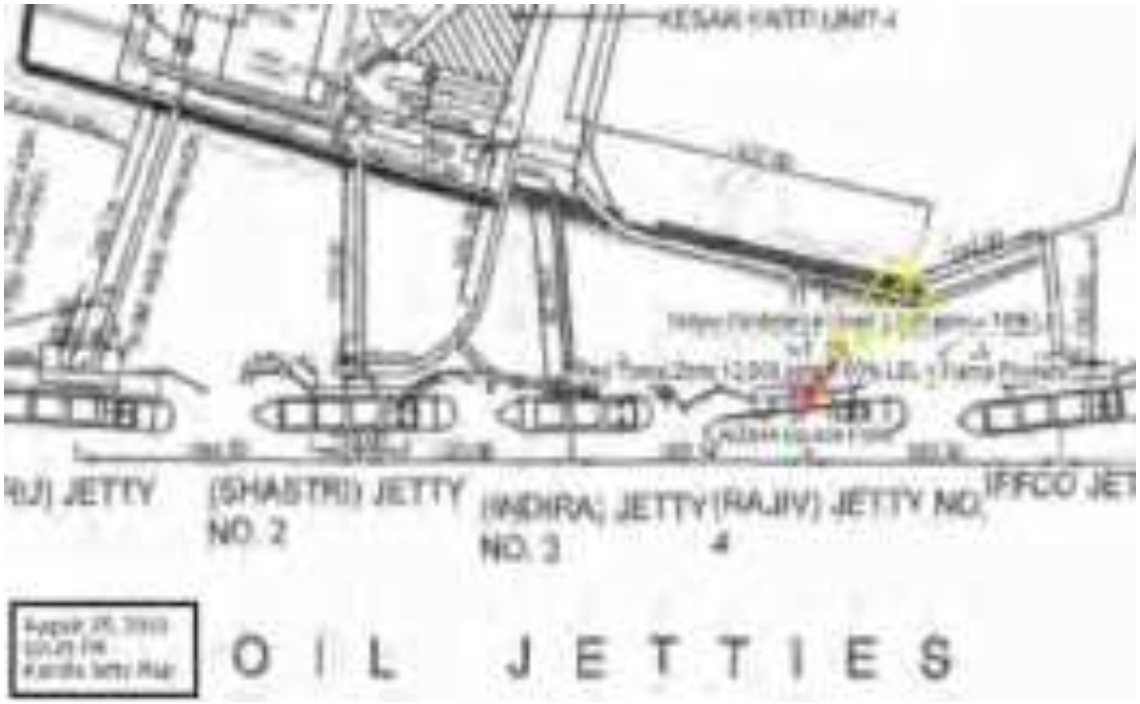
20.1.9.2 Instantaneous Release – Toxic Threat Zone (Contour)



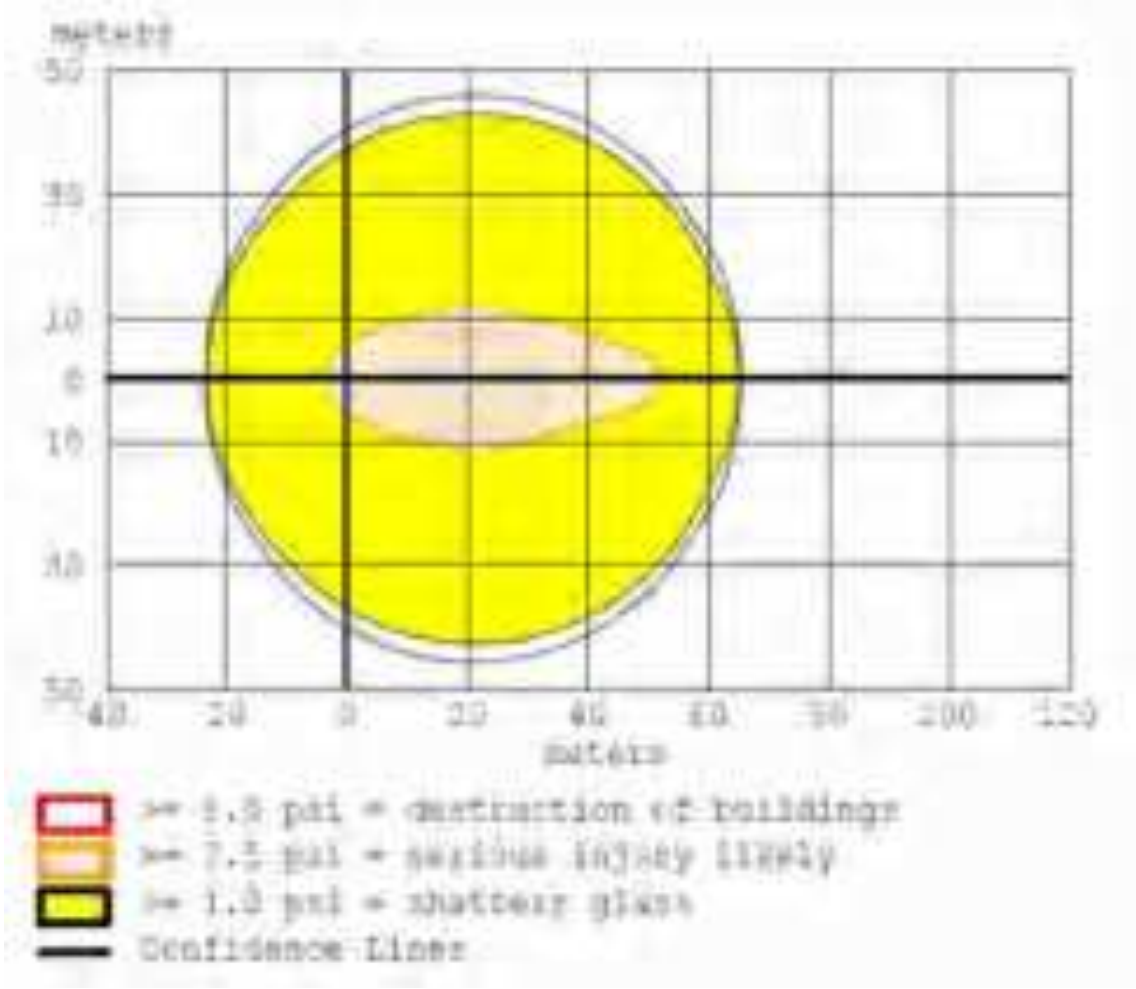
20.1.9.3 Instantaneous Release – Flammable Area of Vapor Cloud (Graph)



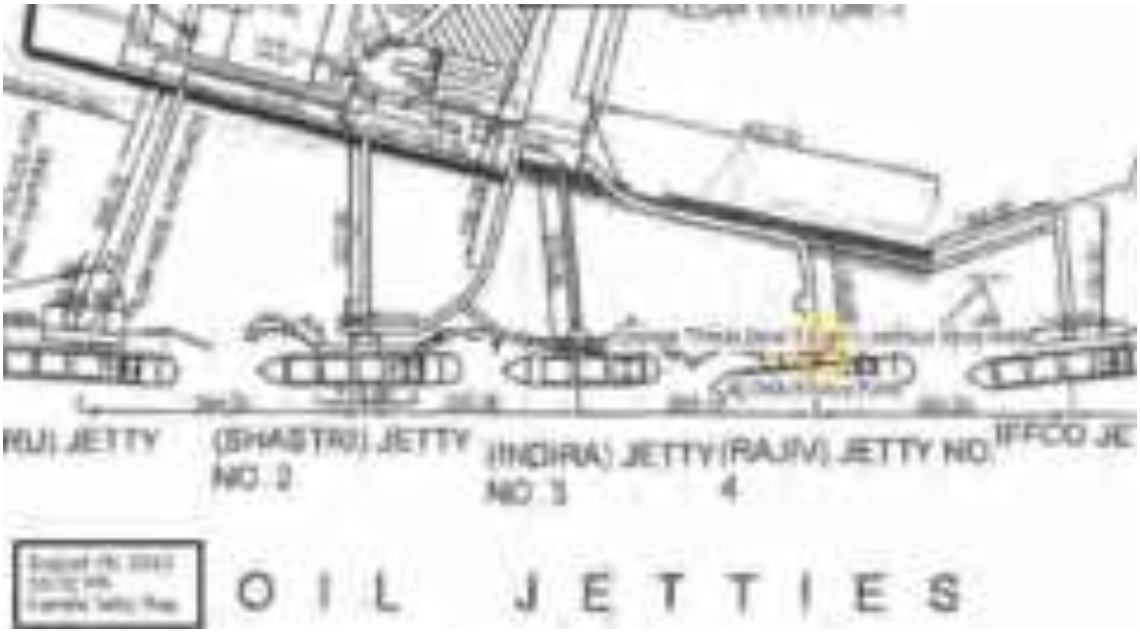
20.1.9.4 Instantaneous Release – Flammable Area of Vapor Cloud (Contour)



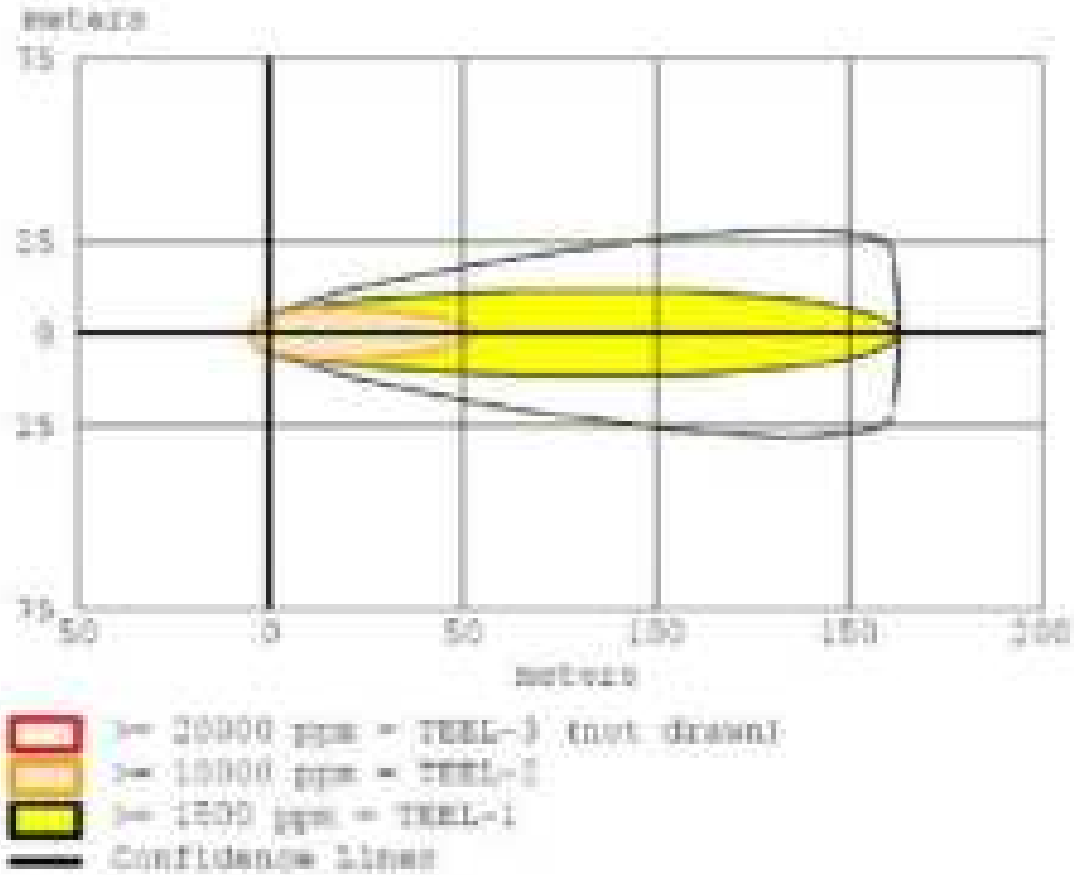
20.1.9.5 Instantaneous Release – Overpressure (Graph)



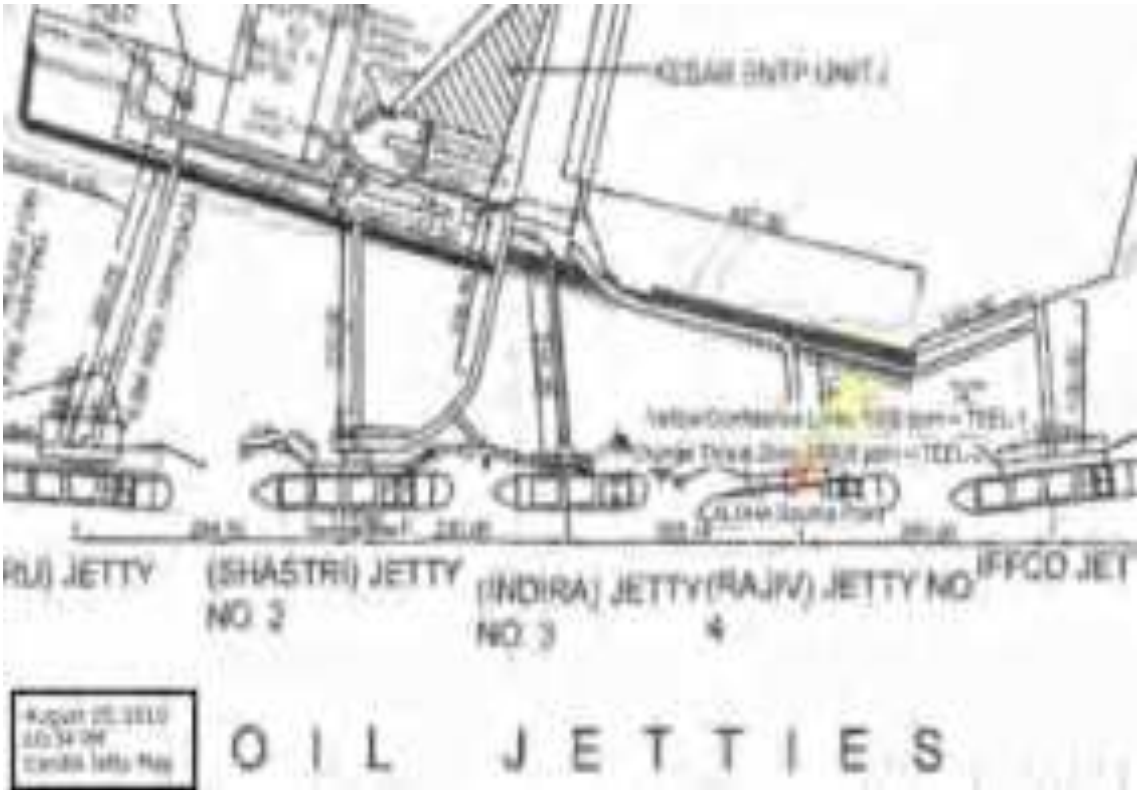
20.1.9.6 Instantaneous Release – Overpressure (Contour)



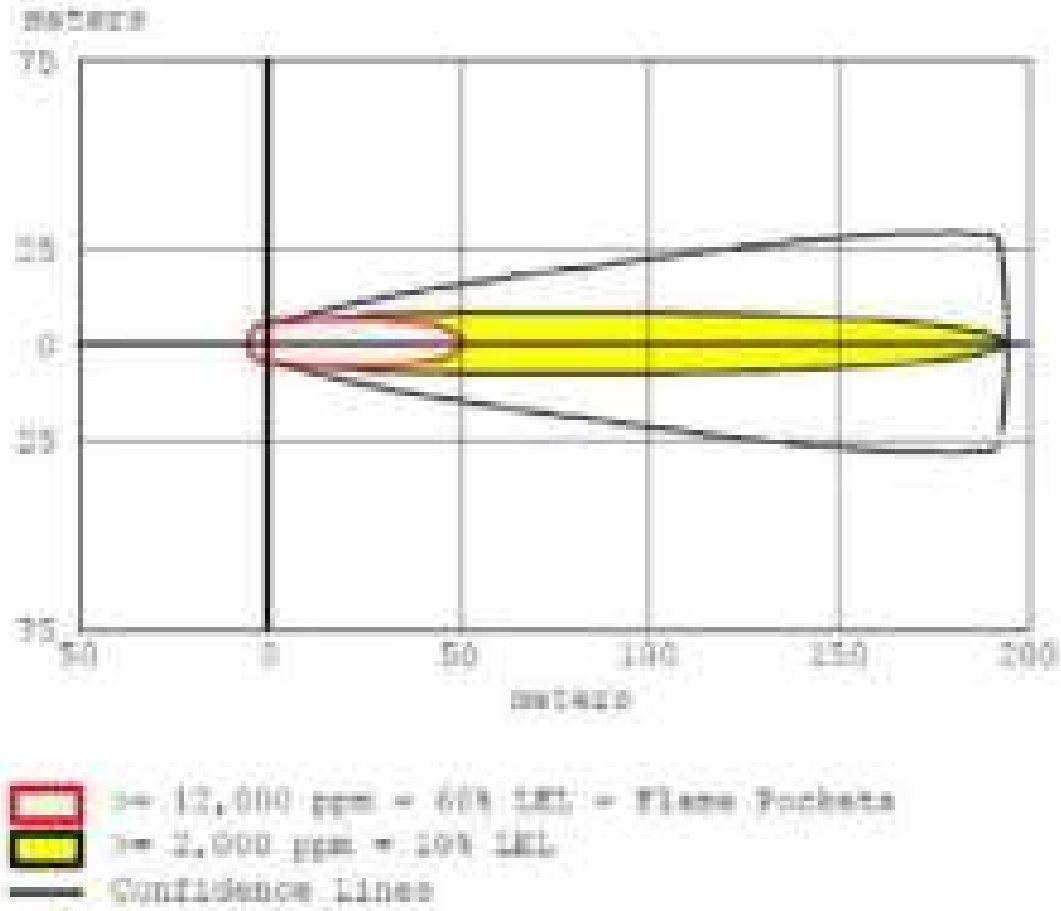
20.1.9.7 Evaporating Puddle – Toxic Threat Zone (Graph)



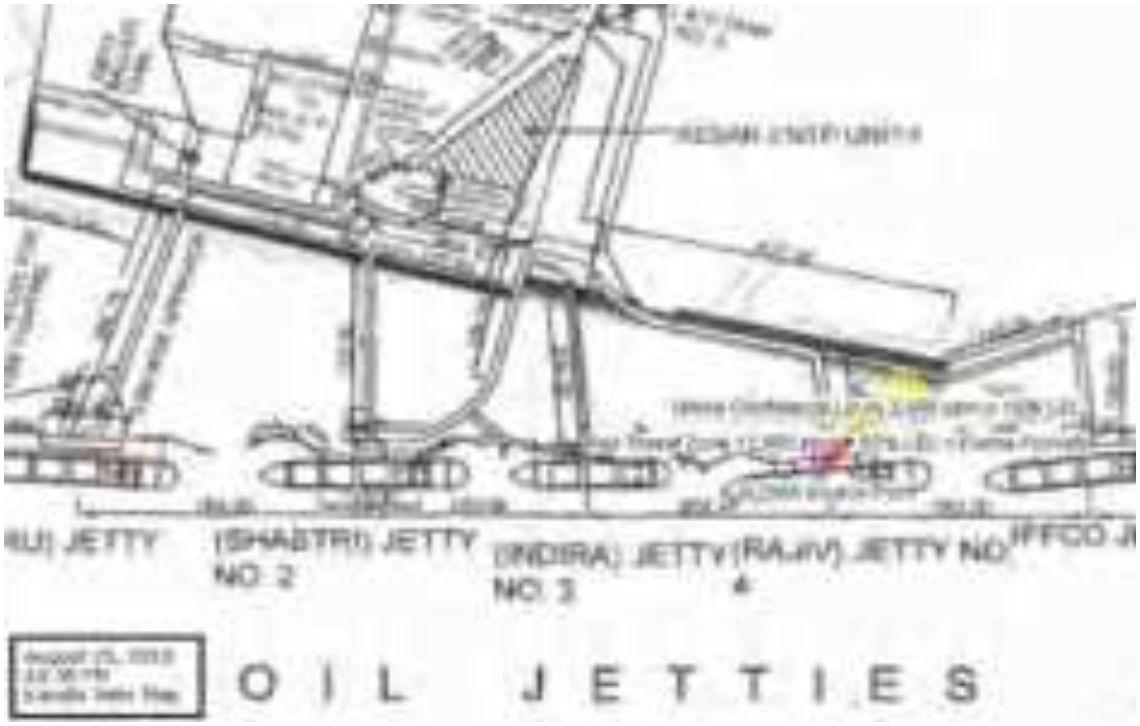
20.1.9.8 Evaporating Puddle – Toxic Threat Zone (Contour)



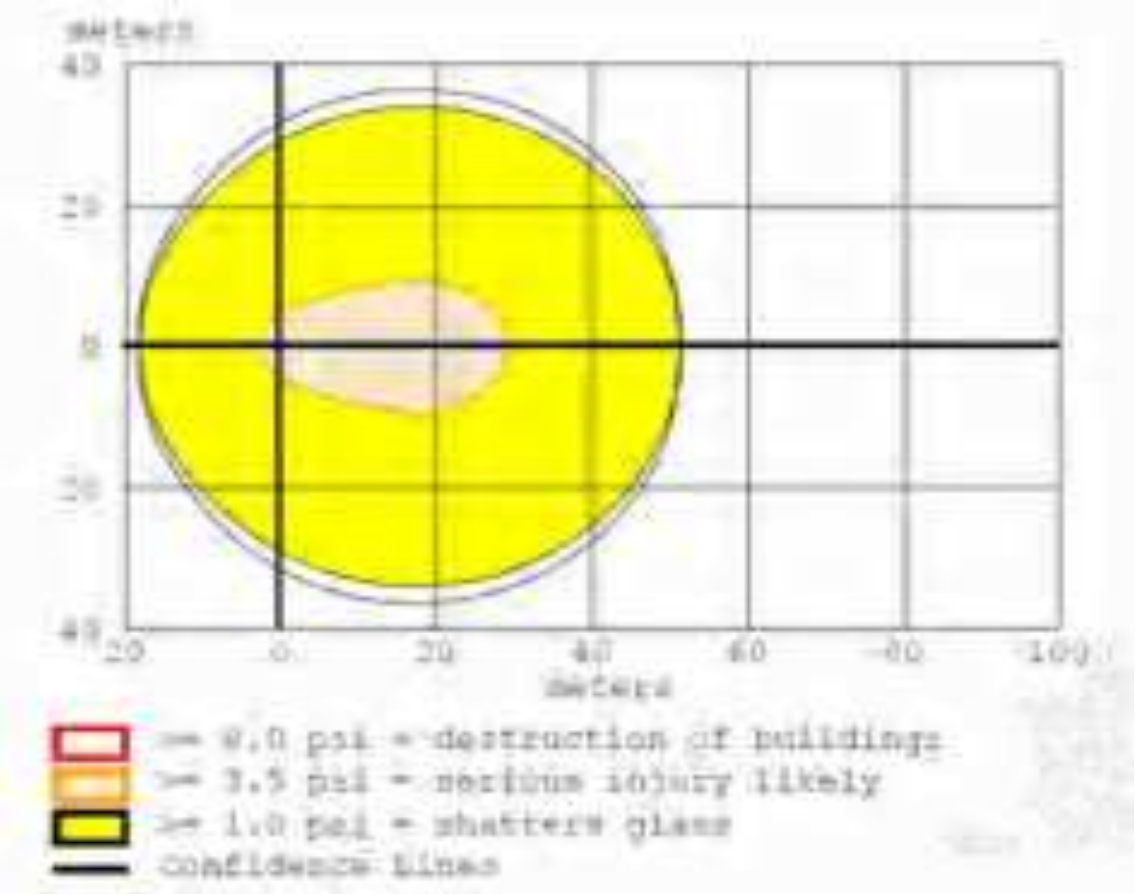
20.1.9.9 Evaporating Puddle – Flammable Area of Vapor Cloud (Graph)



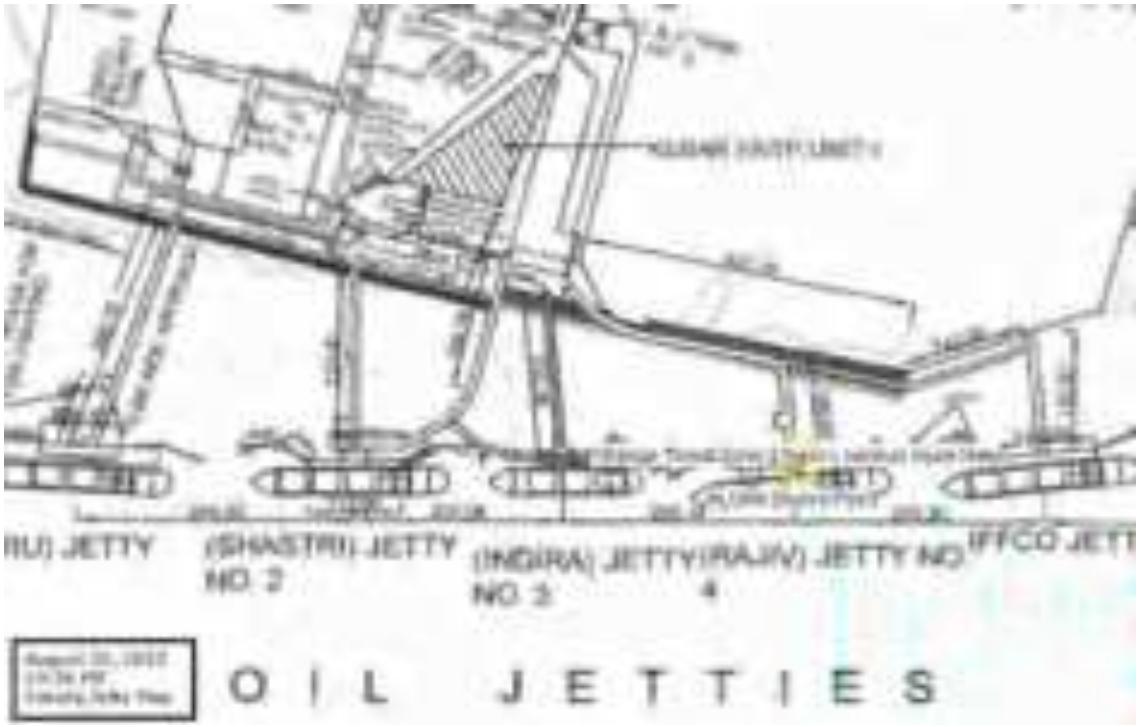
20.1.9.10 Evaporating Puddle – Flammable Area of Vapor Cloud (Contour)



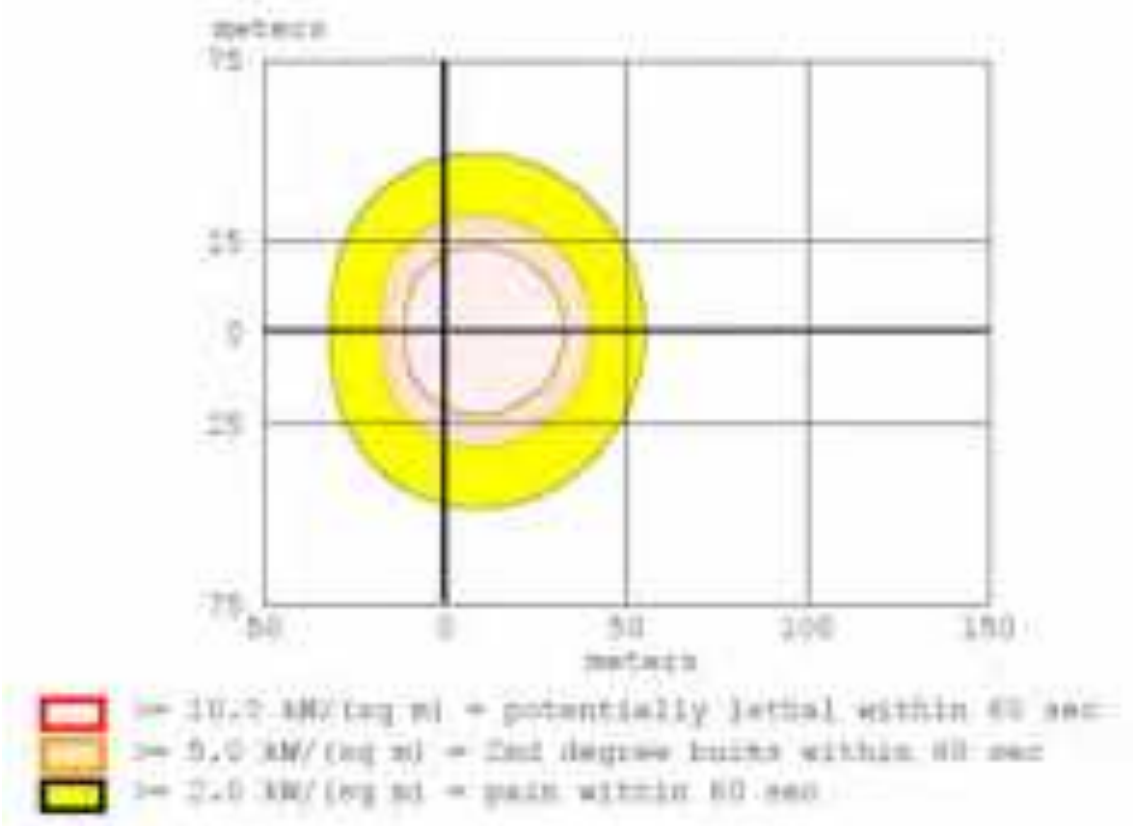
20.1.9.11 Evaporating Puddle – Overpressure (Graph)



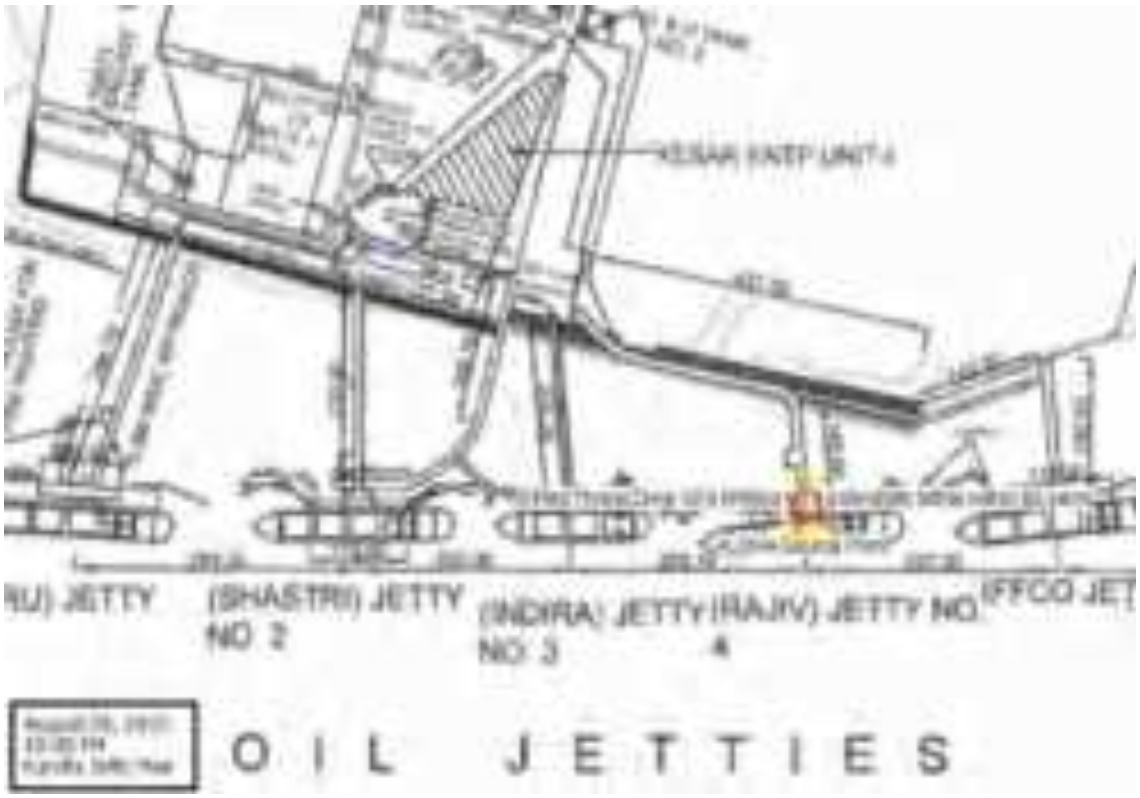
20.1.9.12 Evaporating Puddle – Overpressure (Contour)



20.1.9.13 Burning Puddle – Thermal Radiation (Graph)

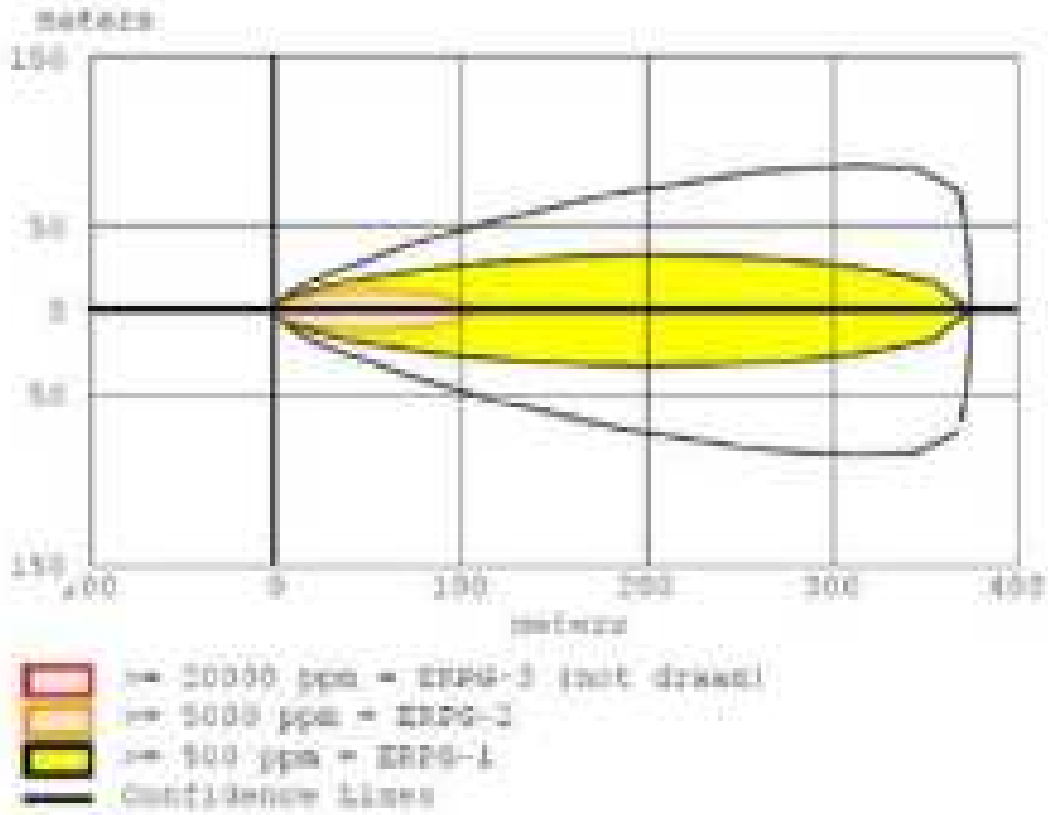


20.1.9.14 Burning Puddle – Thermal Radiation (Contour)

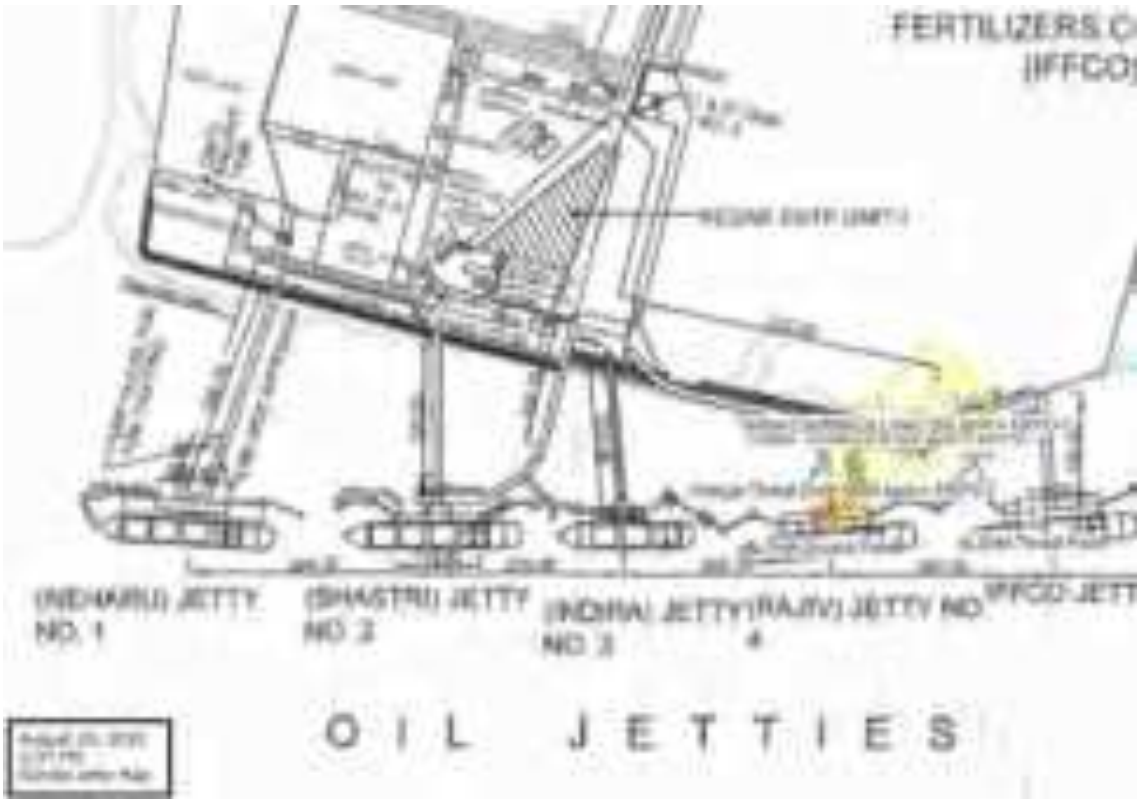


20.1.10 Jetty Four – Vinyl Chloride

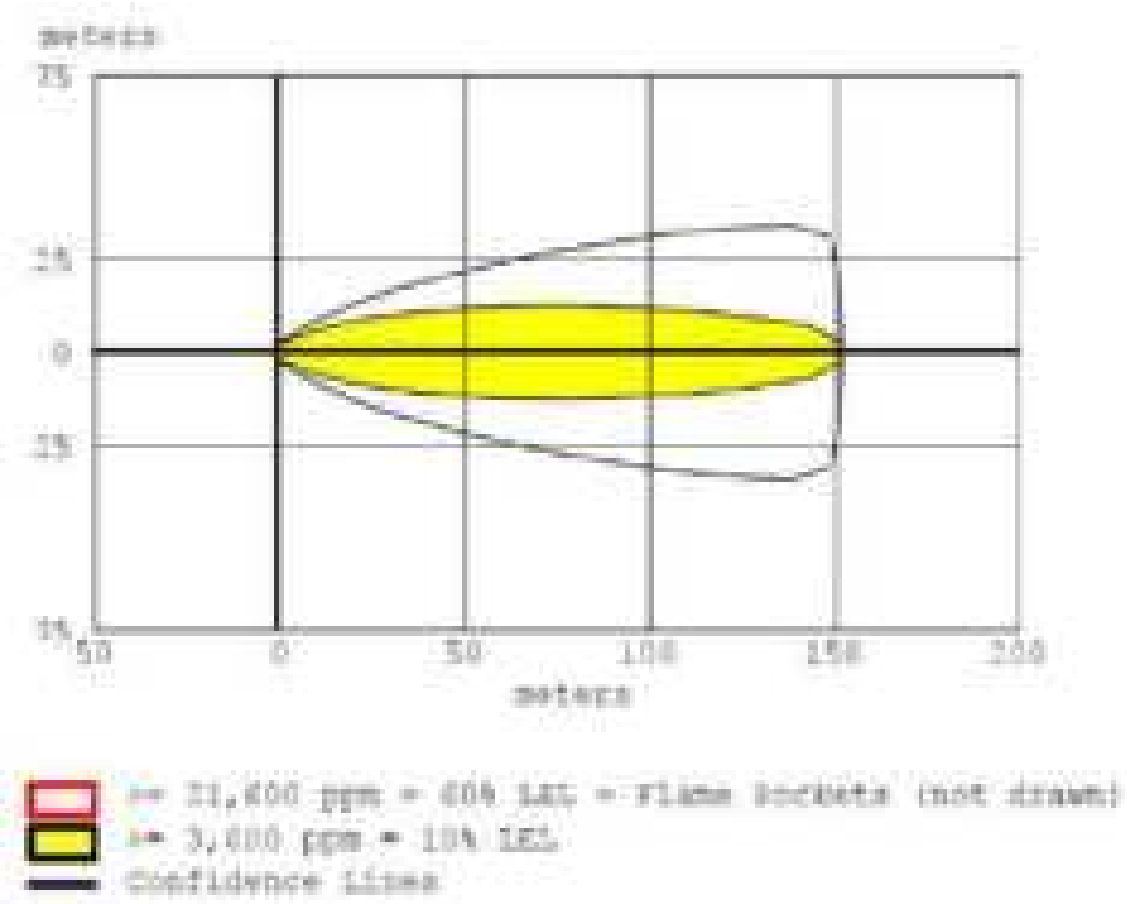
20.1.10.1 Instantaneous Release – Toxic Threat Zone (Graph)



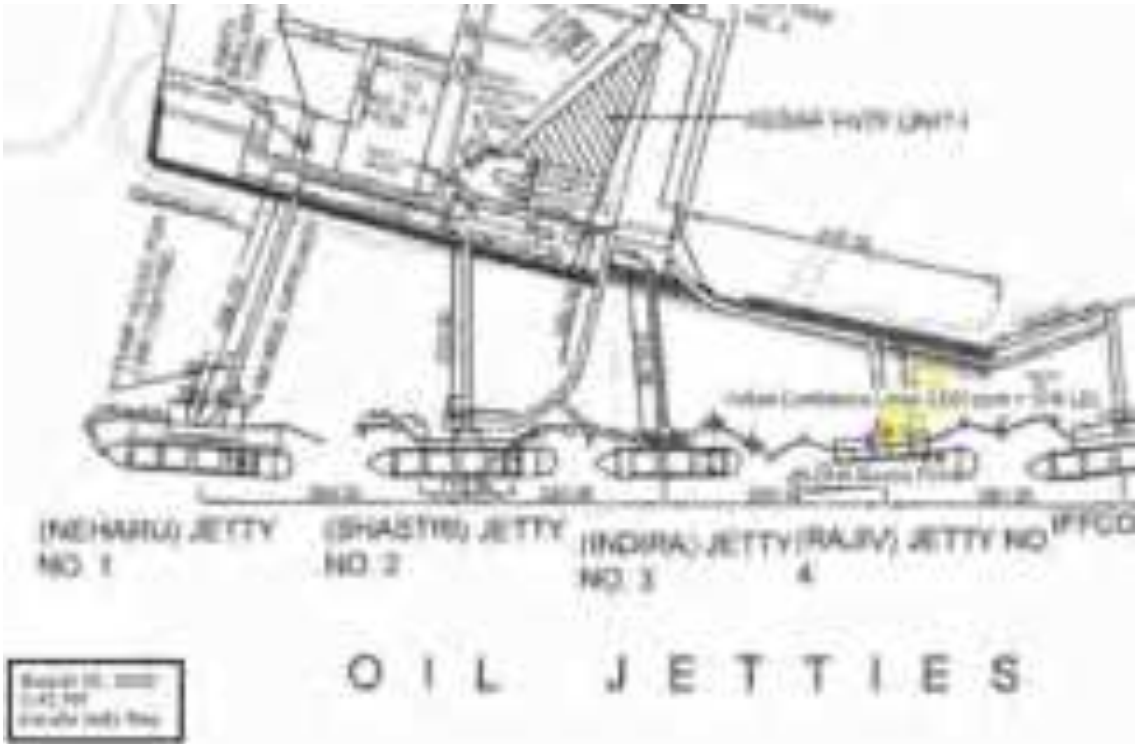
20.1.10.2 Instantaneous Release – Toxic Threat Zone (Contour)



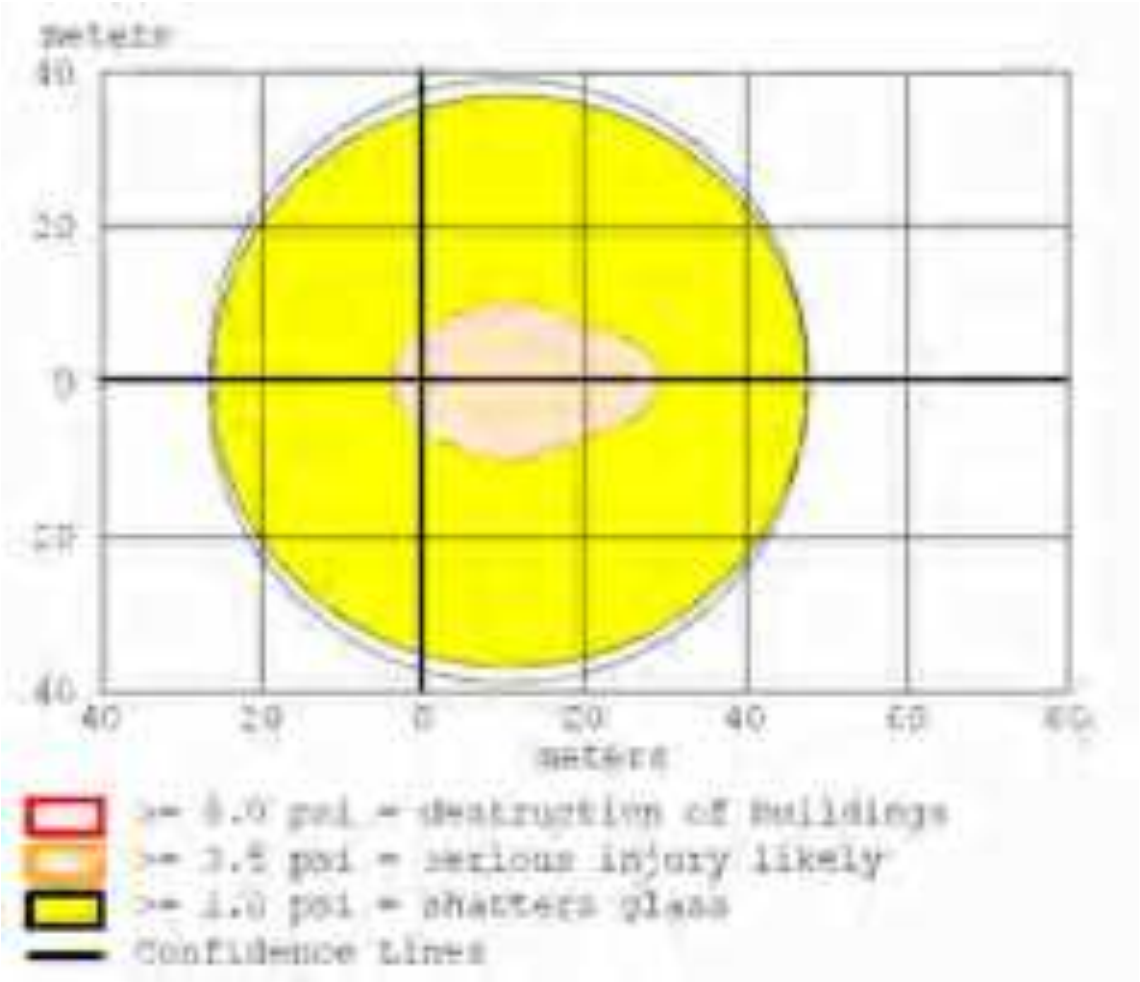
20.1.10.3 Instantaneous Release – Flammable Area of Vapor Cloud (Graph)



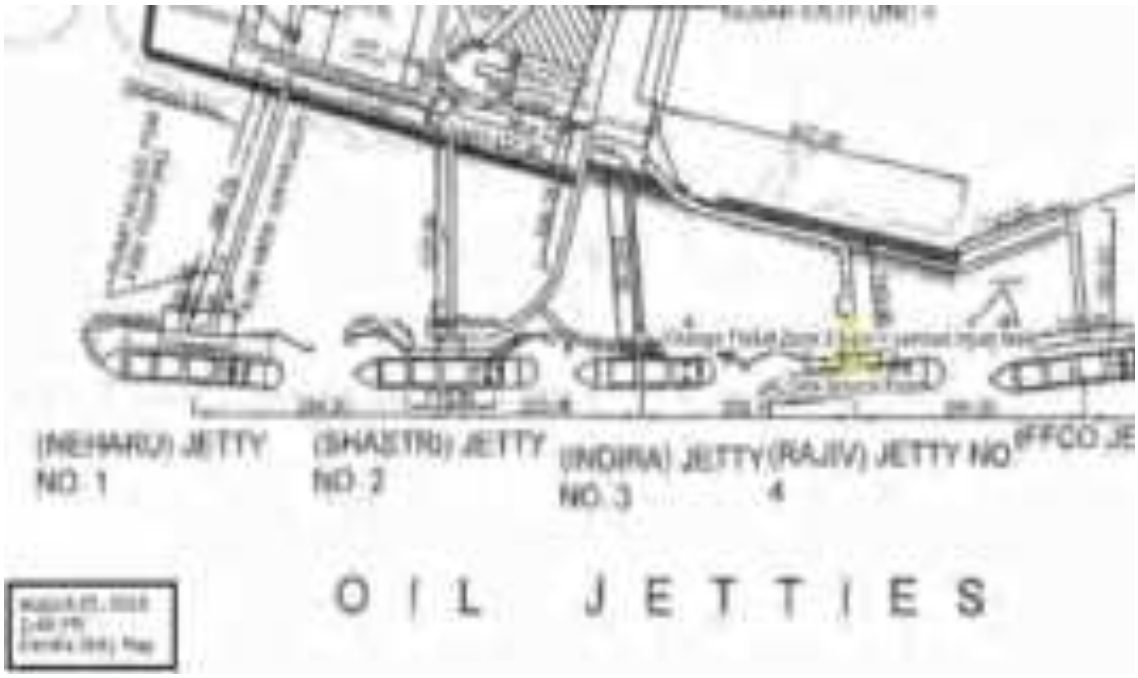
20.1.10.4 Instantaneous Release – Flammable Area of Vapor Cloud (Contour)



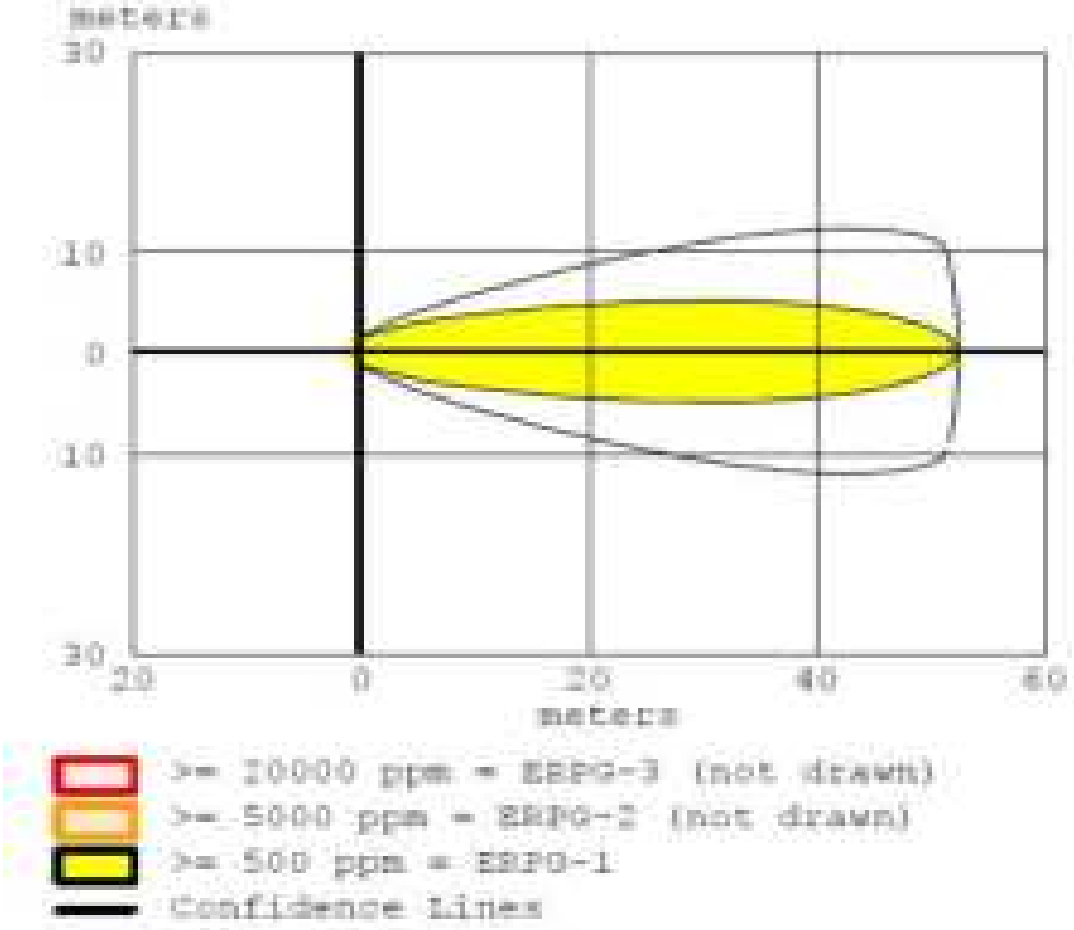
20.1.10.5 Instantaneous Release – Overpressure (Graph)



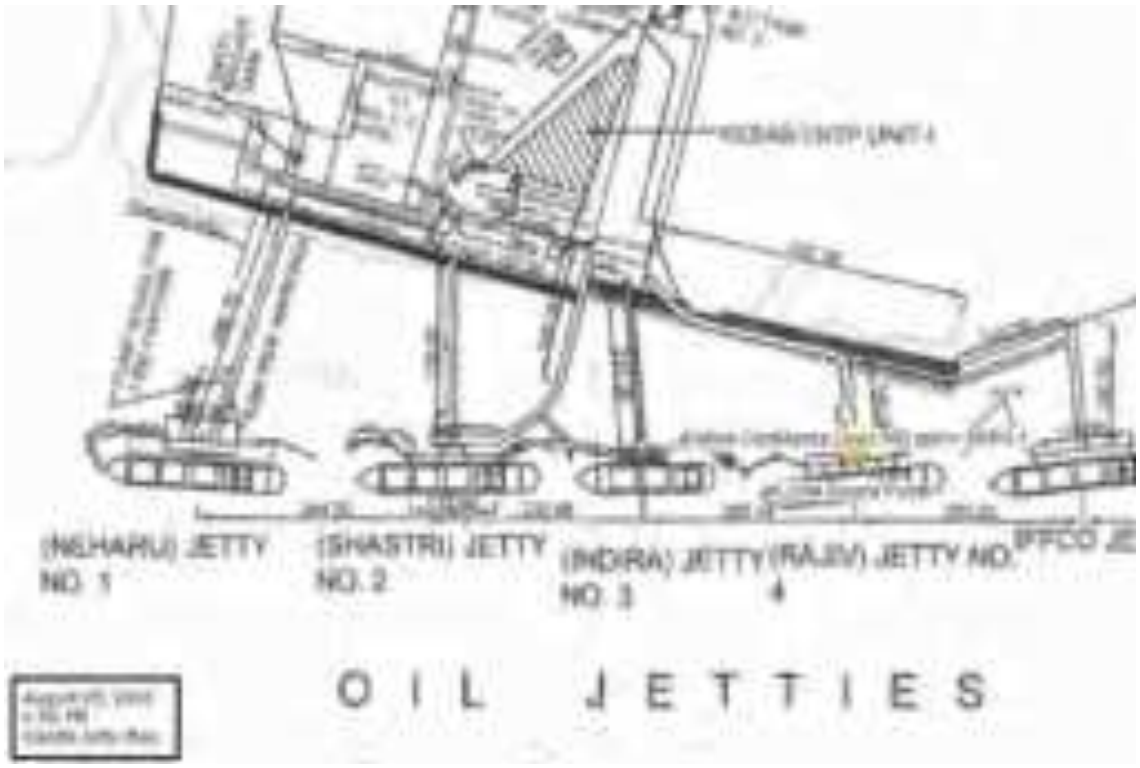
20.1.10.6 Instantaneous Release – Overpressure (Contour)



20.1.10.7 Evaporating Puddle – Toxic Threat Zone (Graph)

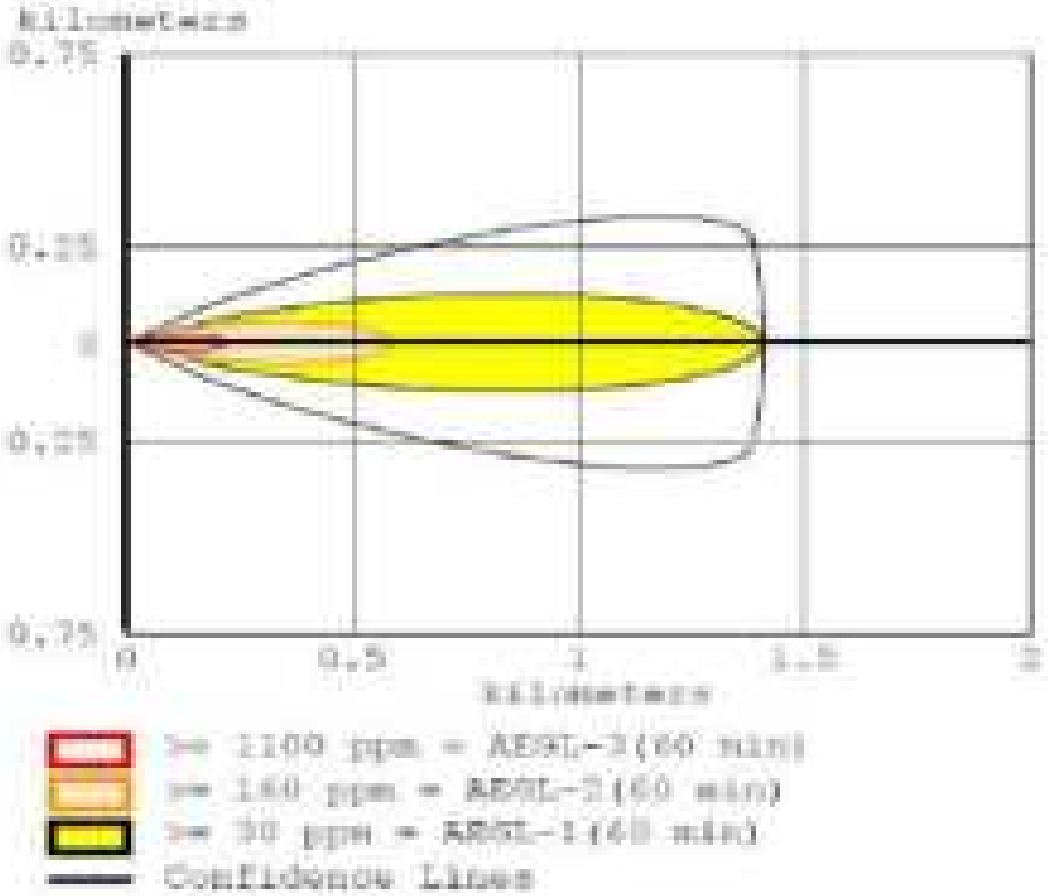


20.1.10.8 Evaporating Puddle – Toxic Threat Zone (Contour)

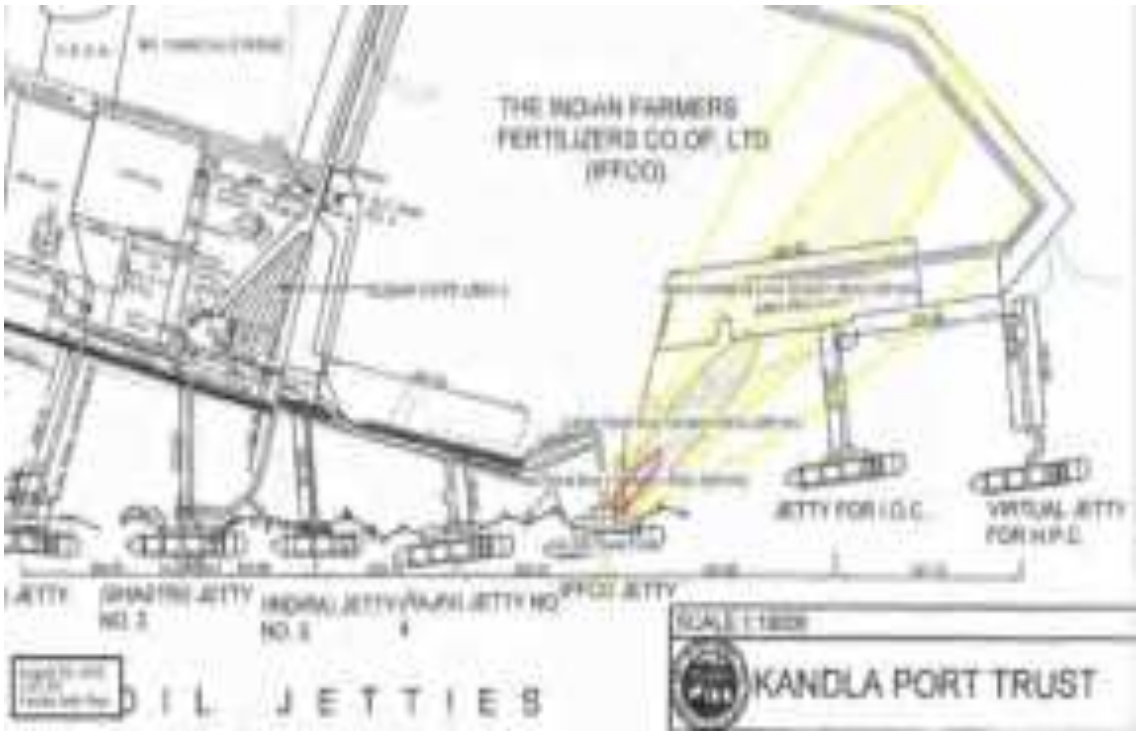


20.1.11 Jetty Five – Ammonia

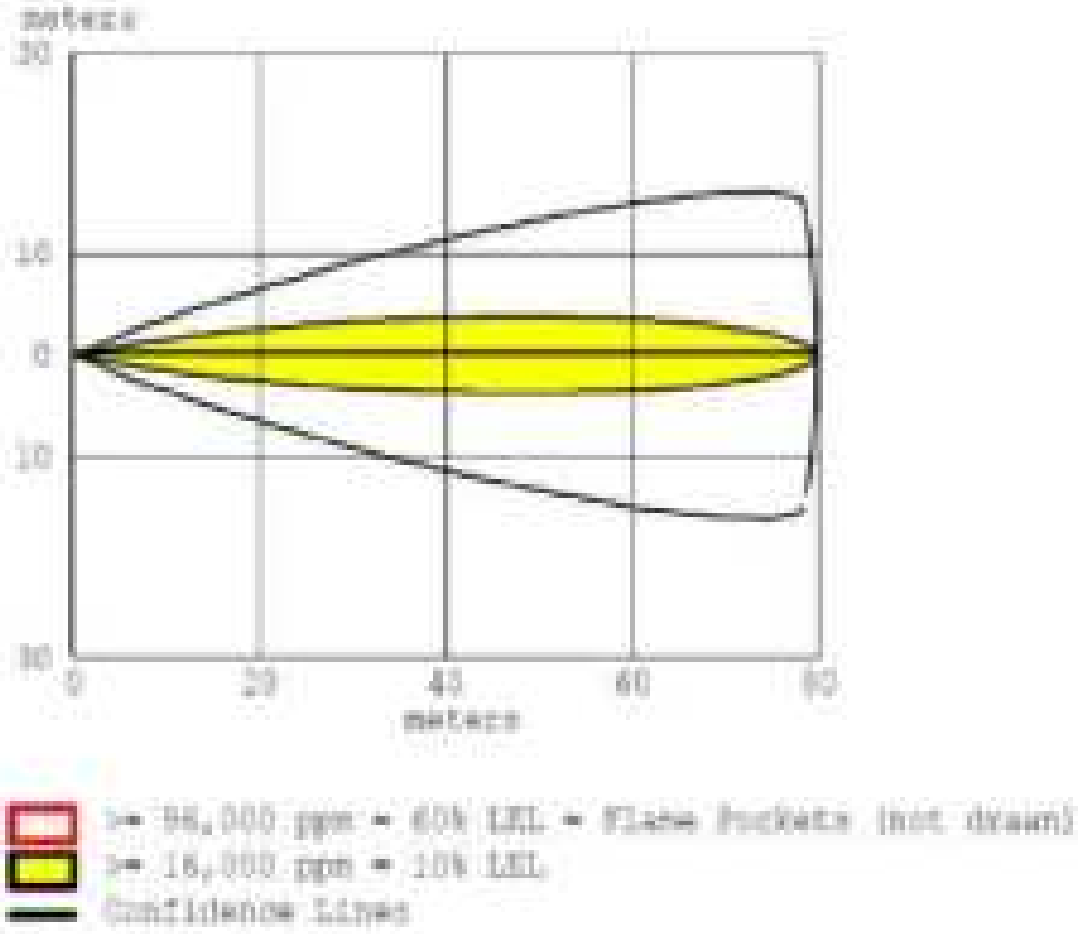
20.1.11.1 Instantaneous Release – Toxic Threat Zone (Graph)



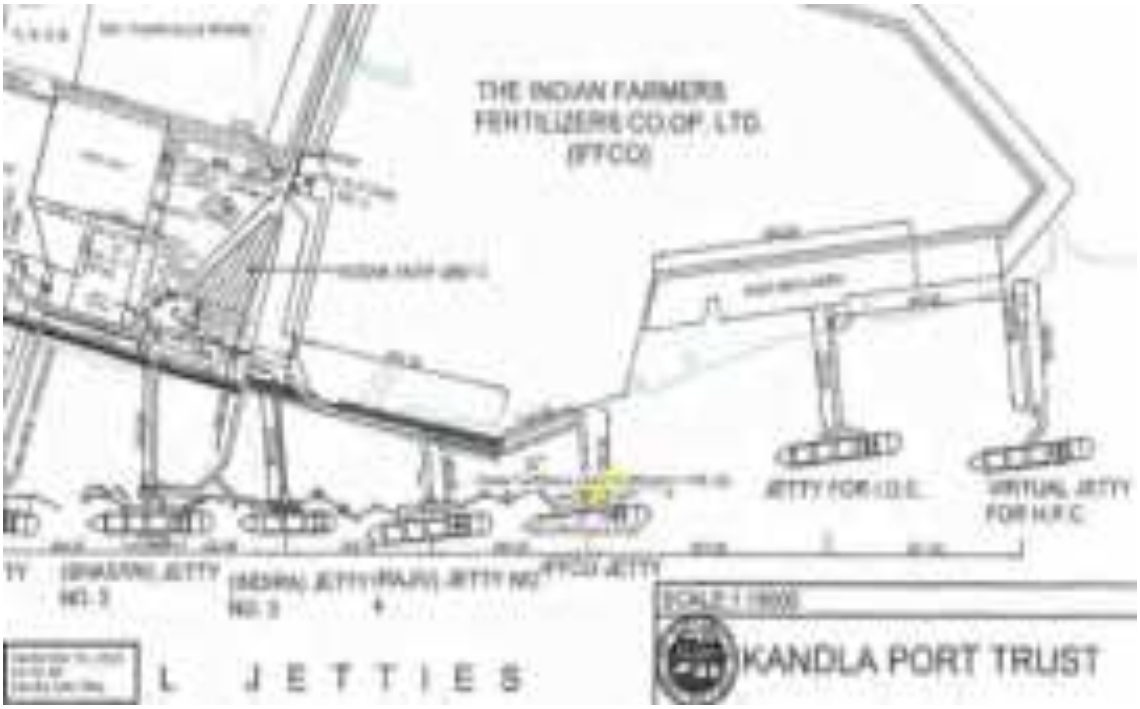
20.1.11.2 Instantaneous Release – Toxic Threat Zone (Contour)



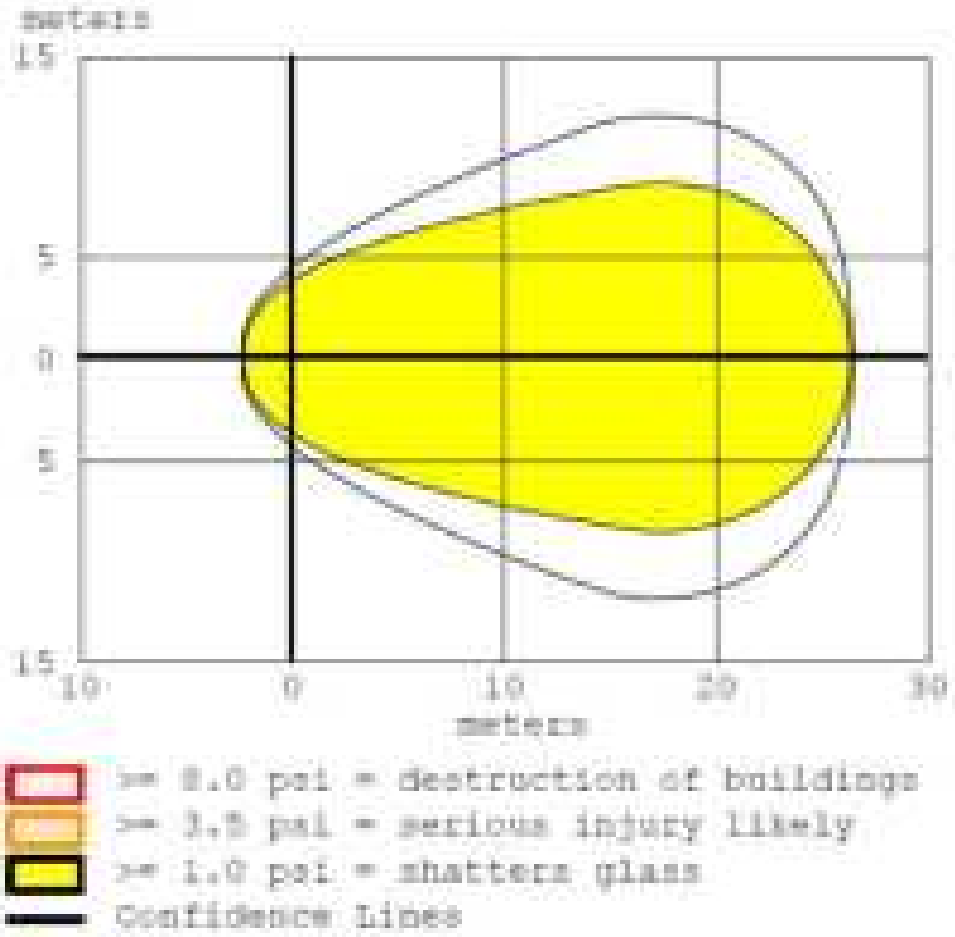
20.1.11.3 Instantaneous Release – Flammable Area of Vapor Cloud (Graph)



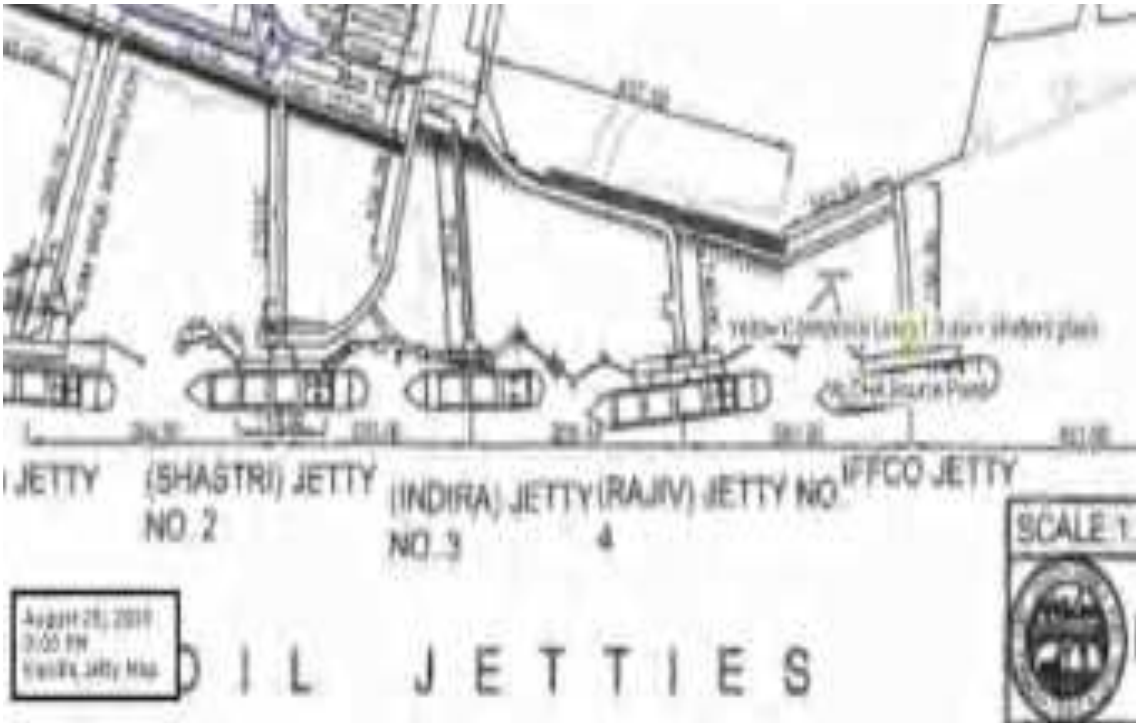
20.1.11.4 Instantaneous Release – Flammable Area of Vapor Cloud (Contour)



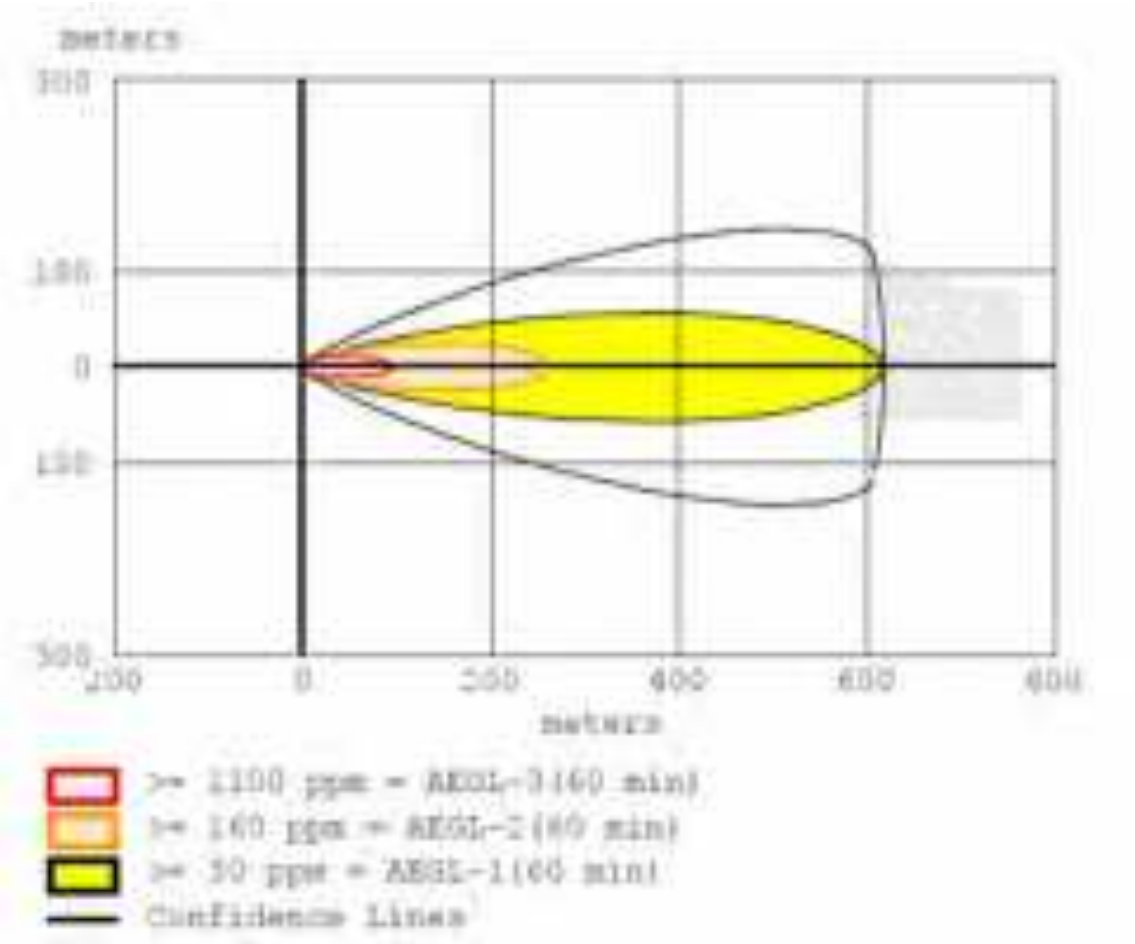
20.1.11.5 Instantaneous Release – Overpressure (Graph)



20.1.11.6 Instantaneous Release – Overpressure (Contour)

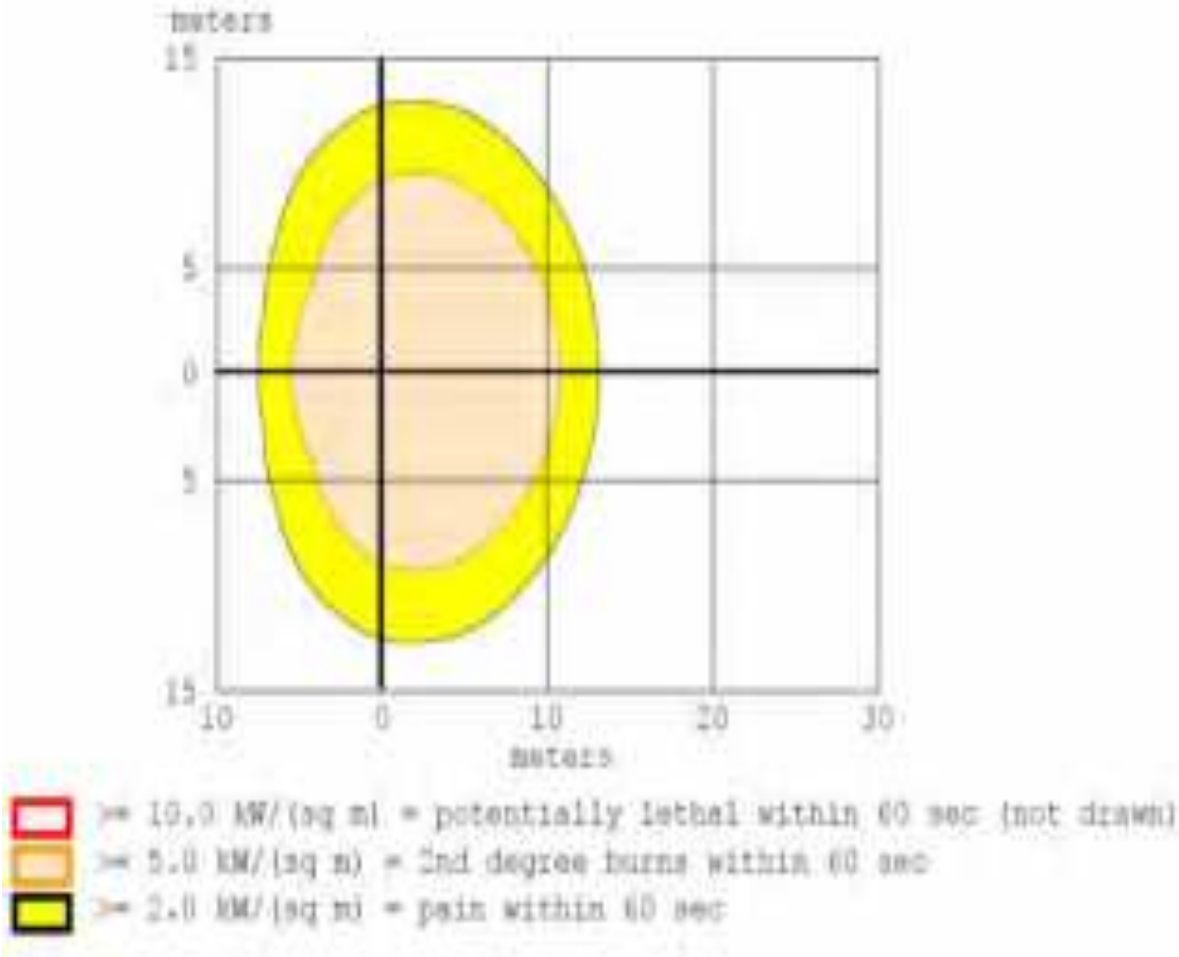


20.1.11.7 Evaporating Puddle – Toxic Threat Zone (Graph)



20.1.11.8 Evaporating Puddle – Toxic Threat Zone (Contour)

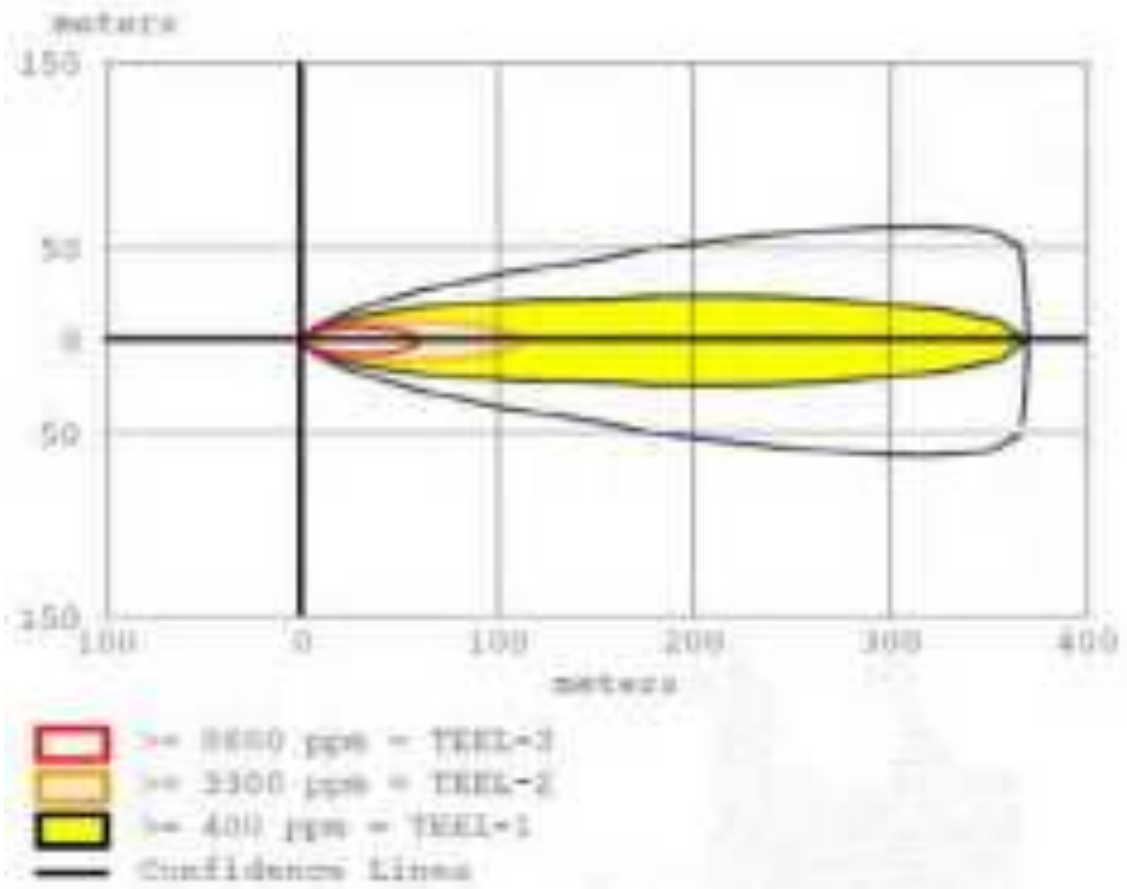
20.1.11.9 Burning Puddle – Thermal Radiation (Graph)



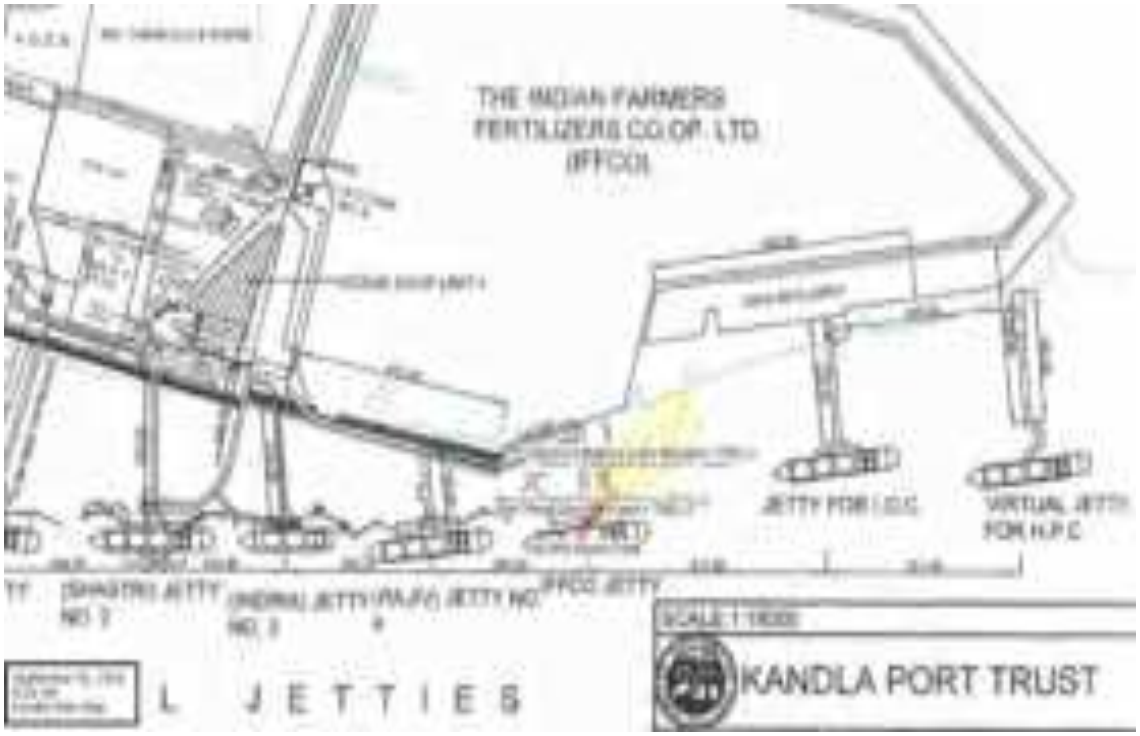
20.1.11.10 Burning Puddle – Thermal Radiation (Contour)

20.1.12 Jetty Five – HSD

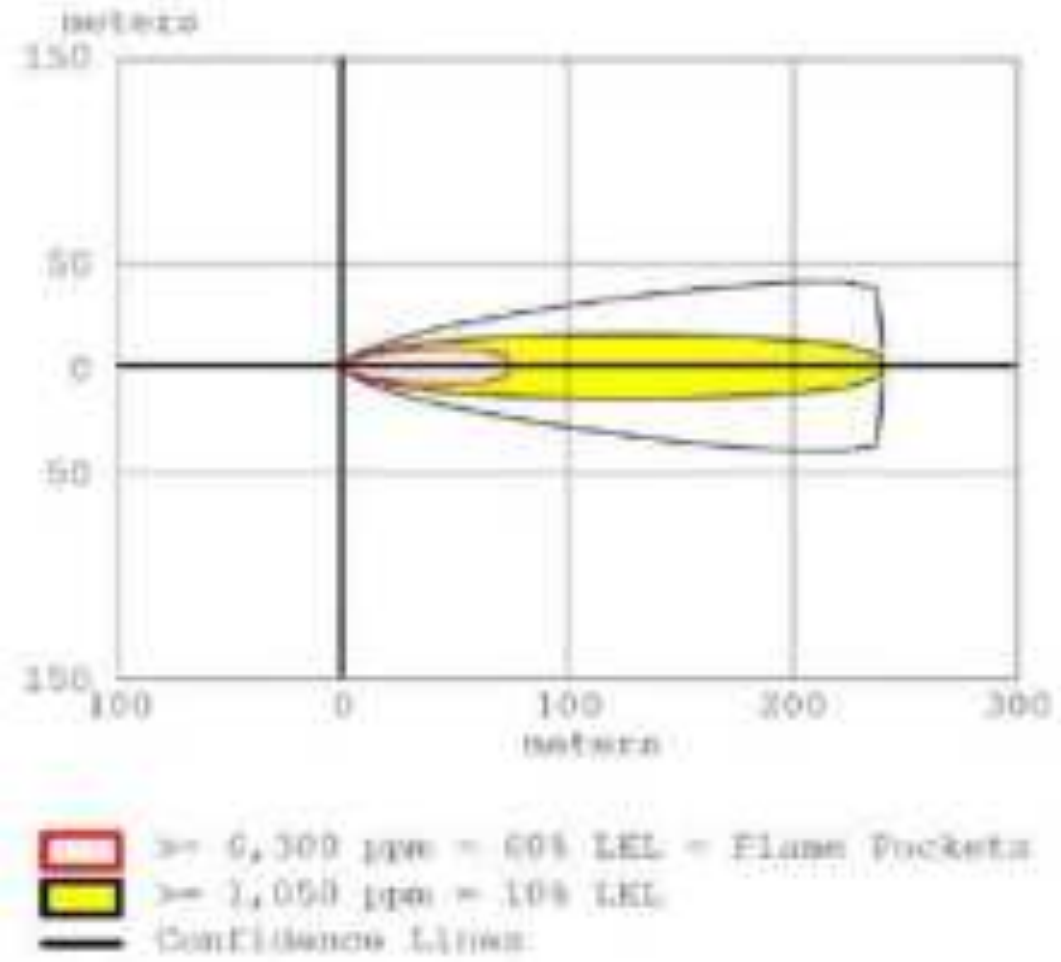
20.1.12.1 Instantaneous Release – Toxic Threat Zone (Graph)



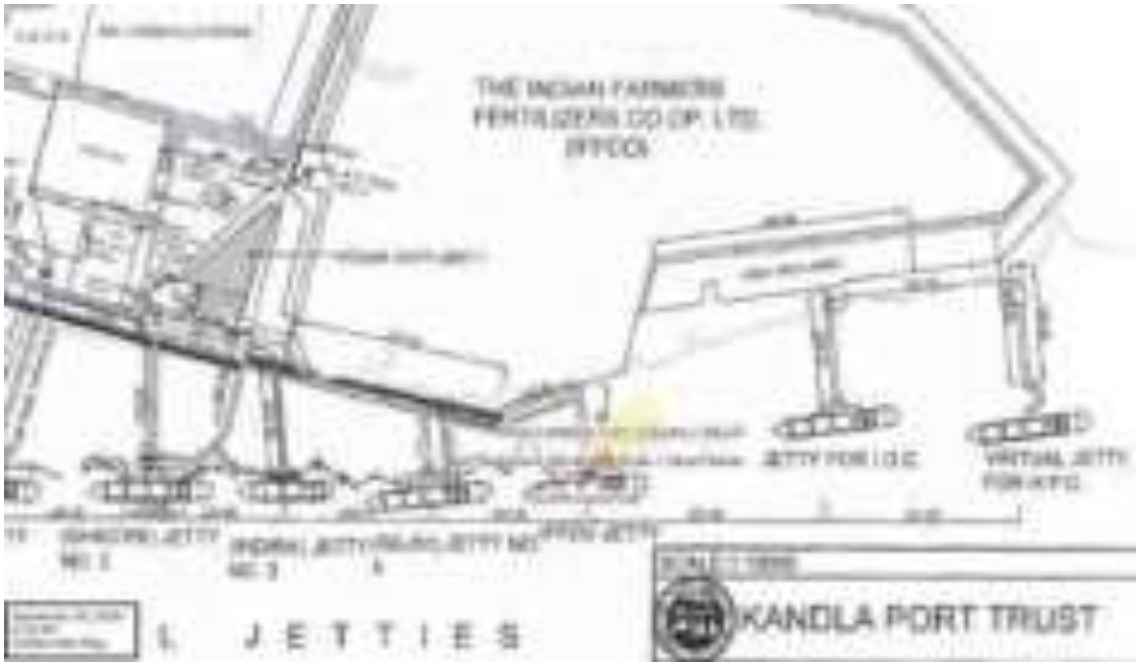
20.1.12.2 Instantaneous Release – Toxic Threat Zone (Contour)



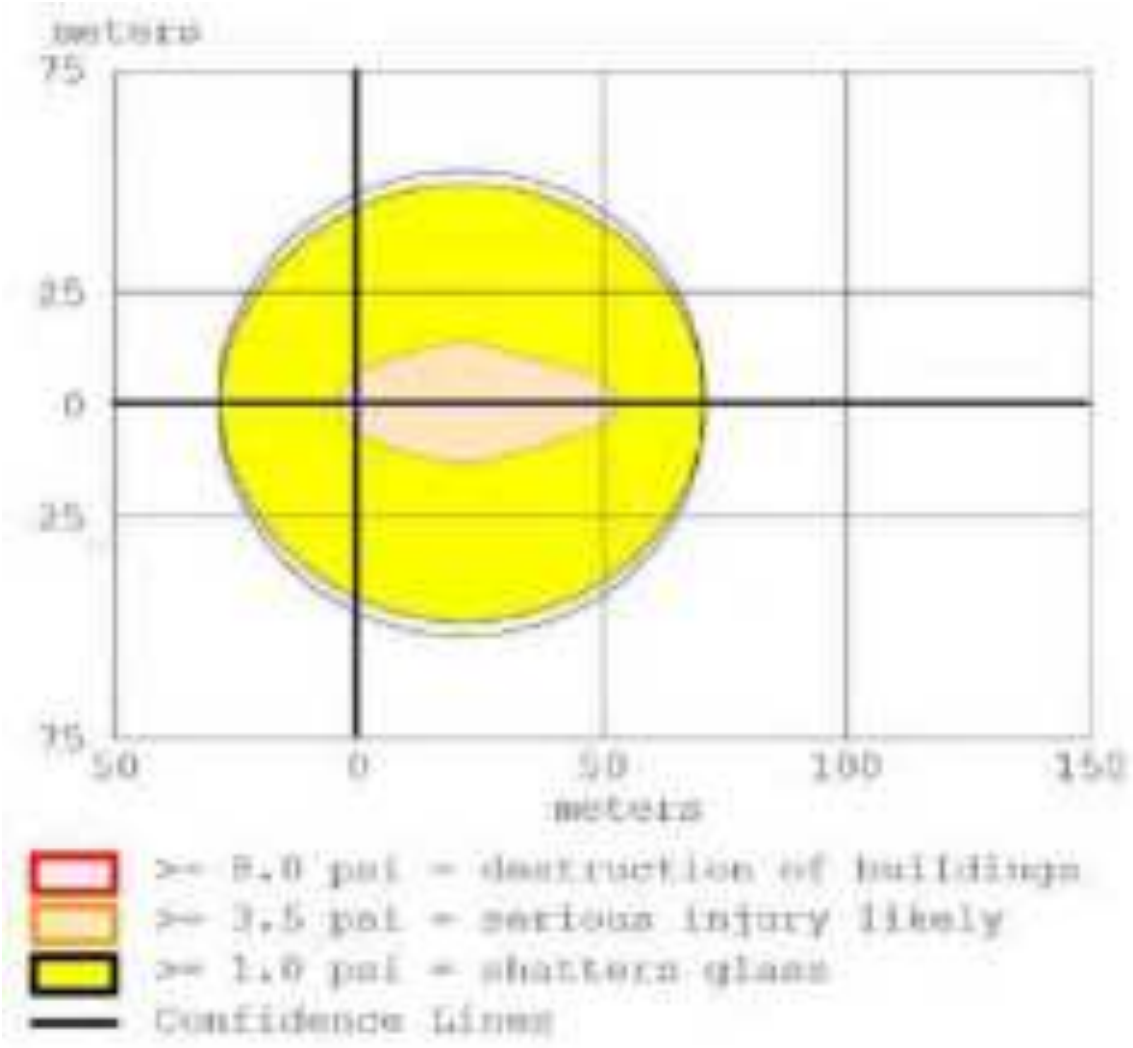
20.1.12.3 Instantaneous Release – Flammable Area of Vapor Cloud (Graph)



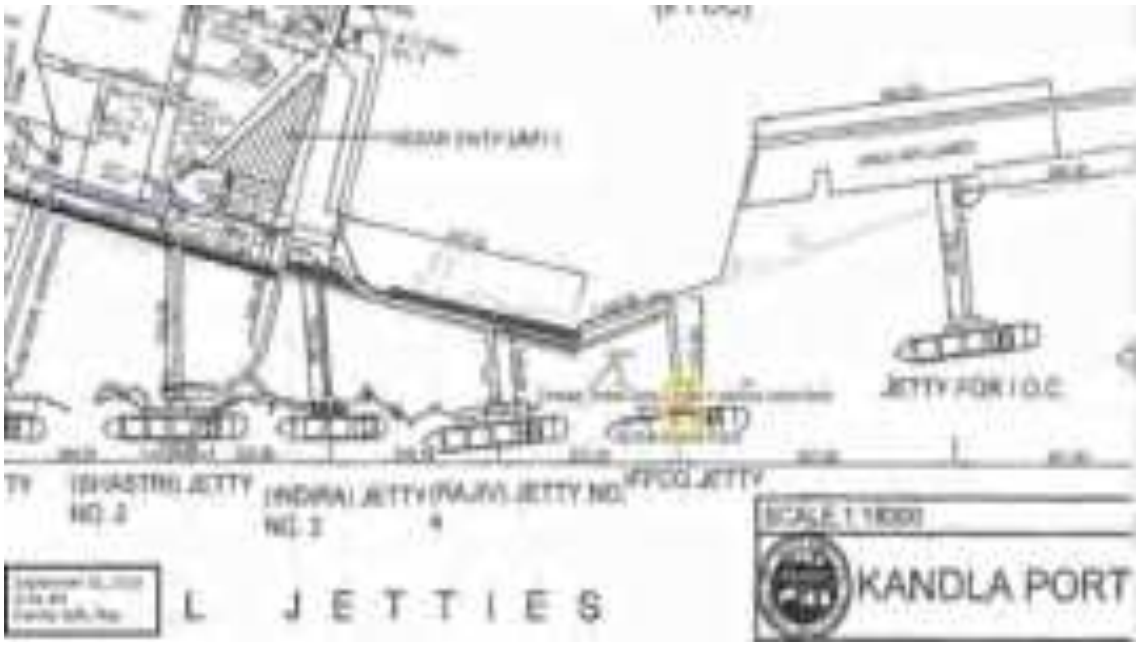
20.1.12.4 Instantaneous Release – Flammable Area of Vapor Cloud (Contour)



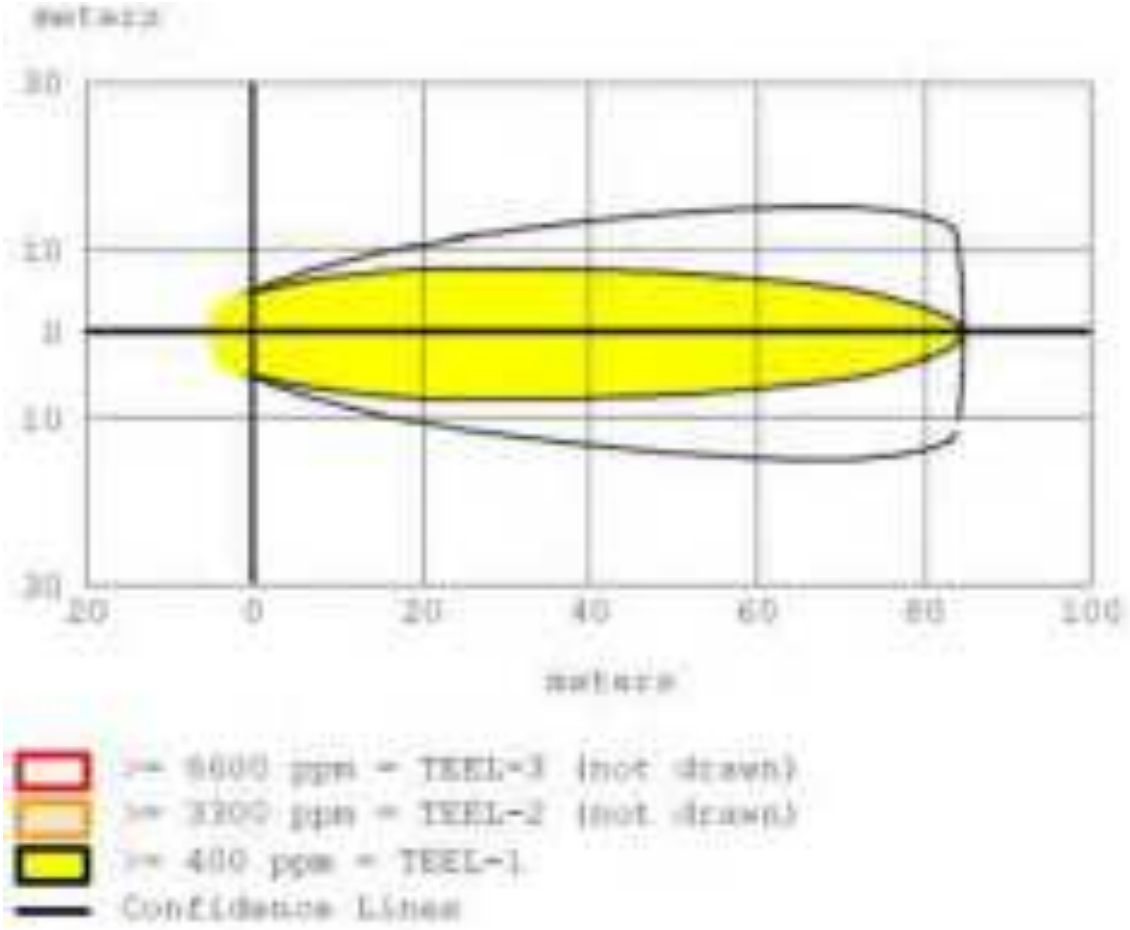
20.1.12.5 Instantaneous Release – Overpressure (Graph)



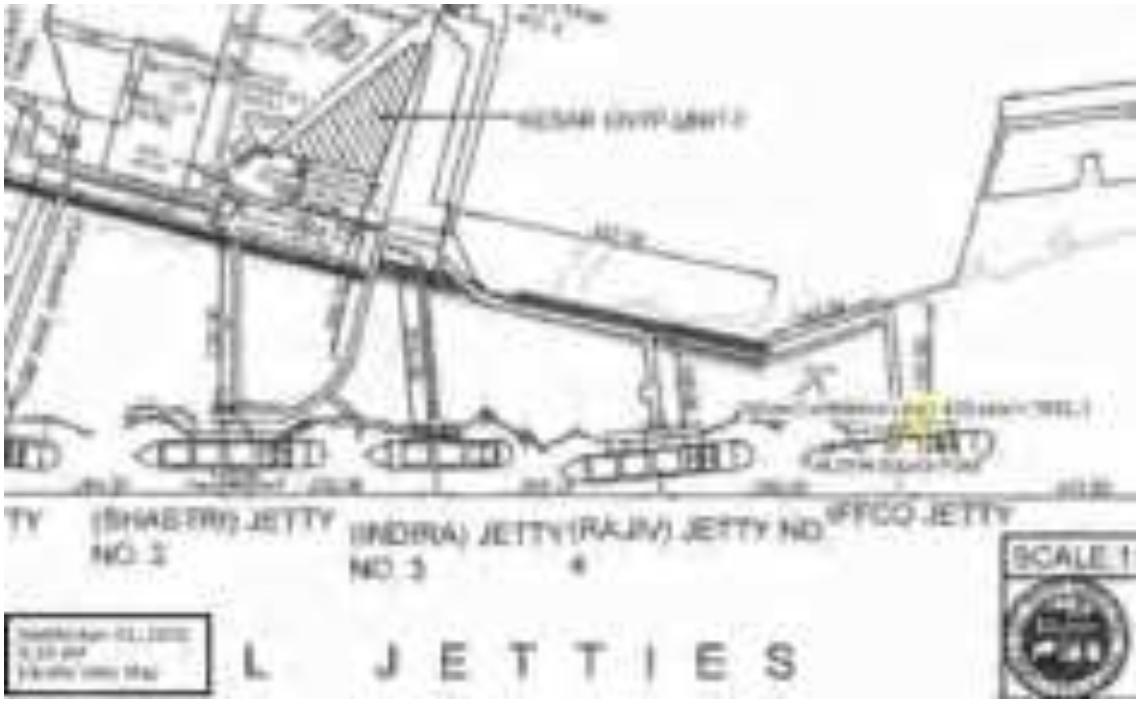
20.1.12.6 Instantaneous Release – Overpressure (Contour)



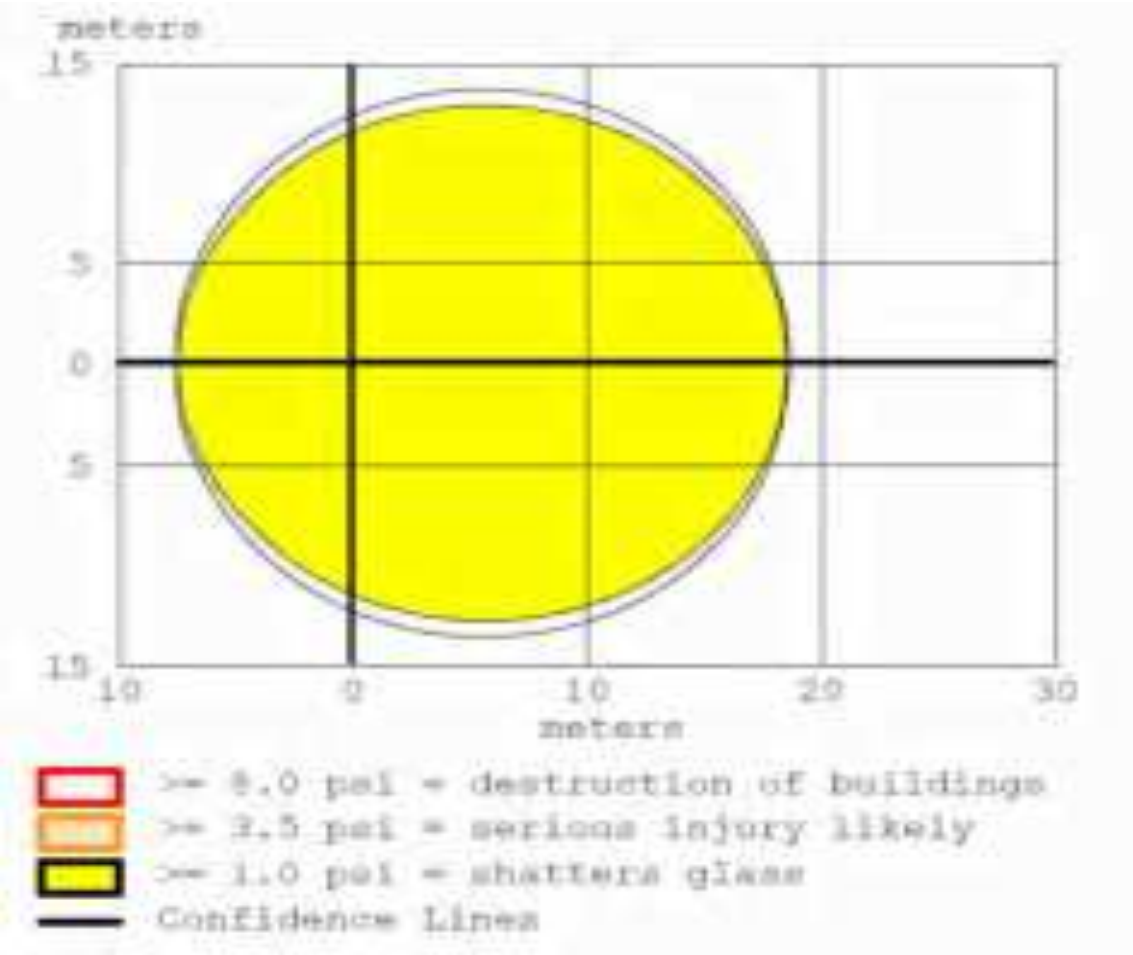
20.1.12.7 Evaporating Puddle – Toxic Threat Zone (Graph)



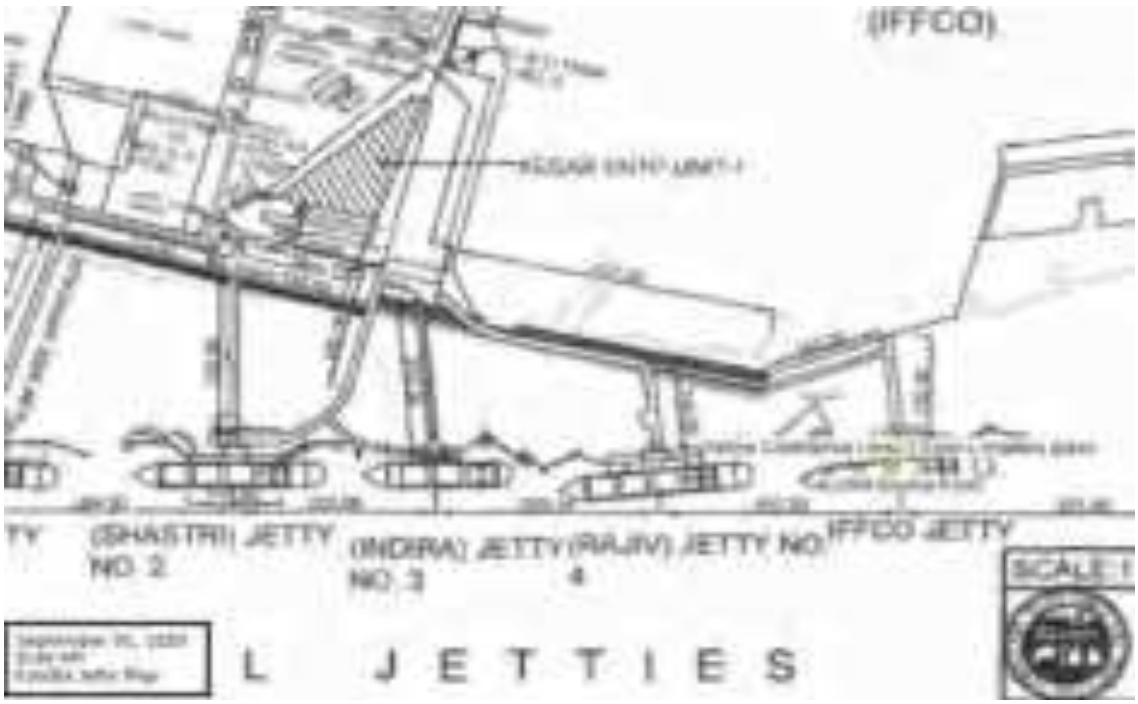
20.1.12.8 Evaporating Puddle – Toxic Threat Zone (Contour)



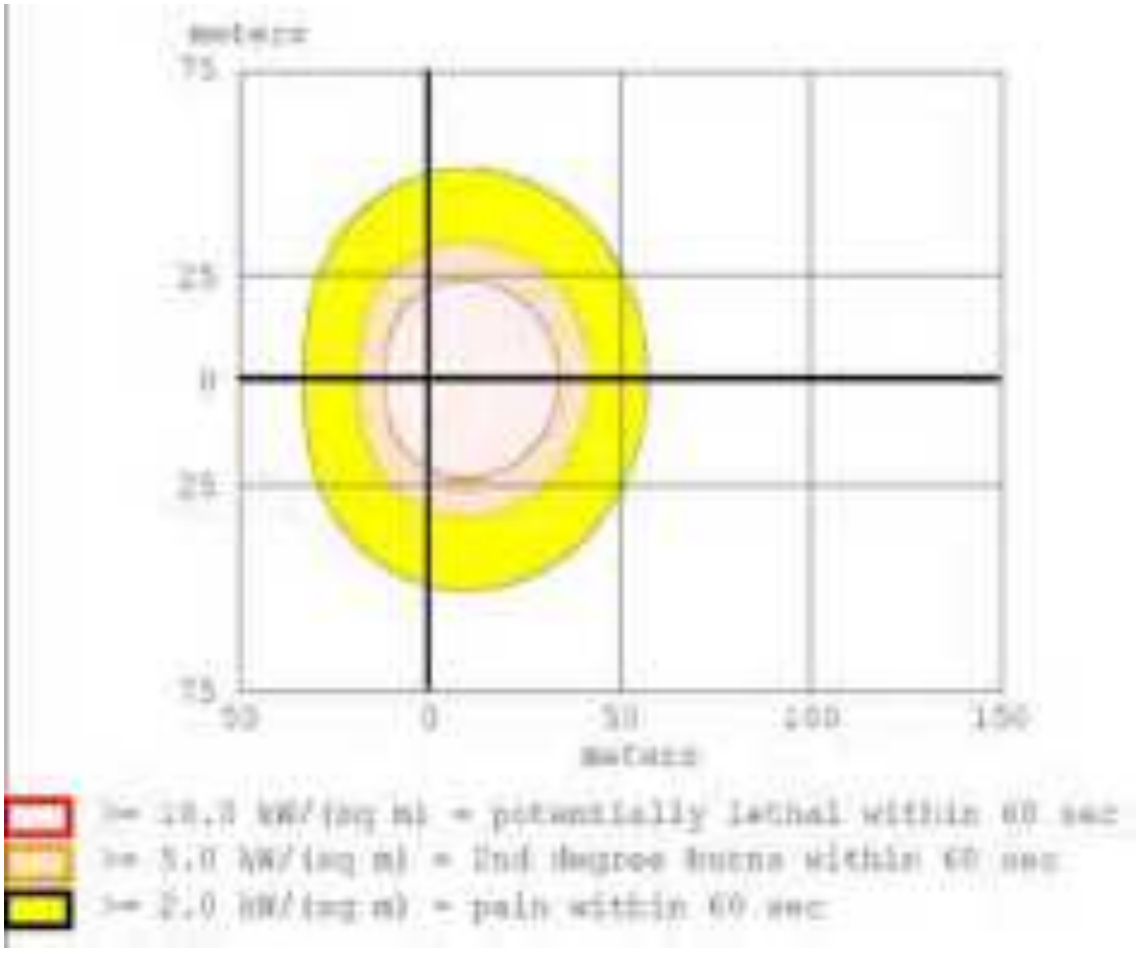
20.1.12.9 Evaporating Puddle – Overpressure (Graph)



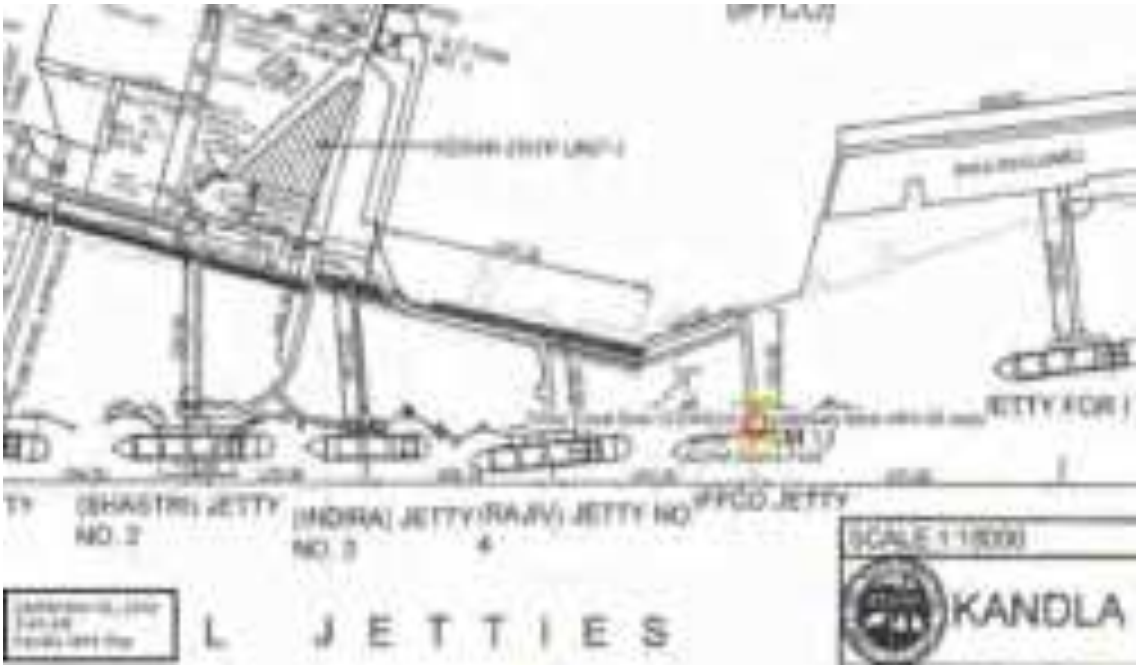
20.1.12.10 Evaporating Puddle – Overpressure (Contour)



20.1.12.11 Burning Puddle – Thermal Radiation (Graph)

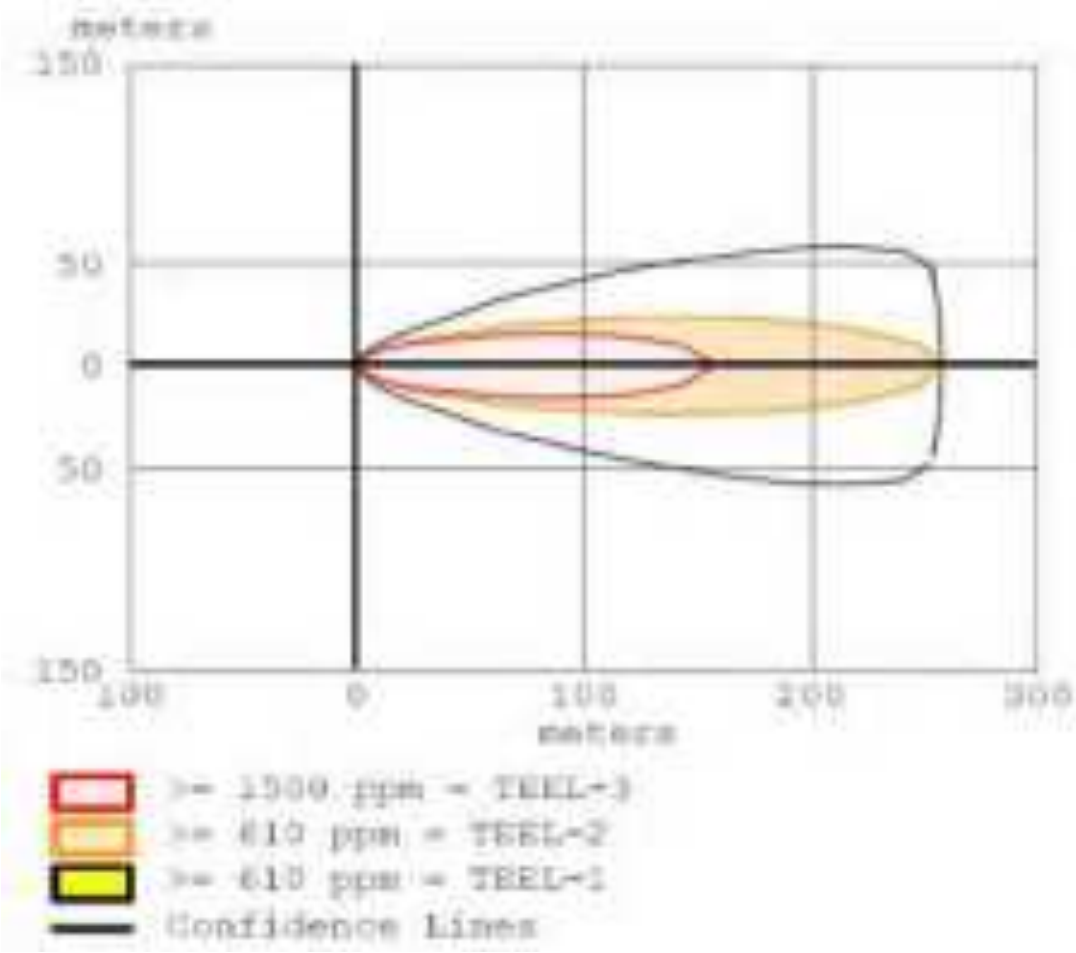


20.1.12.12 Burning Puddle – Thermal Radiation (Contour)

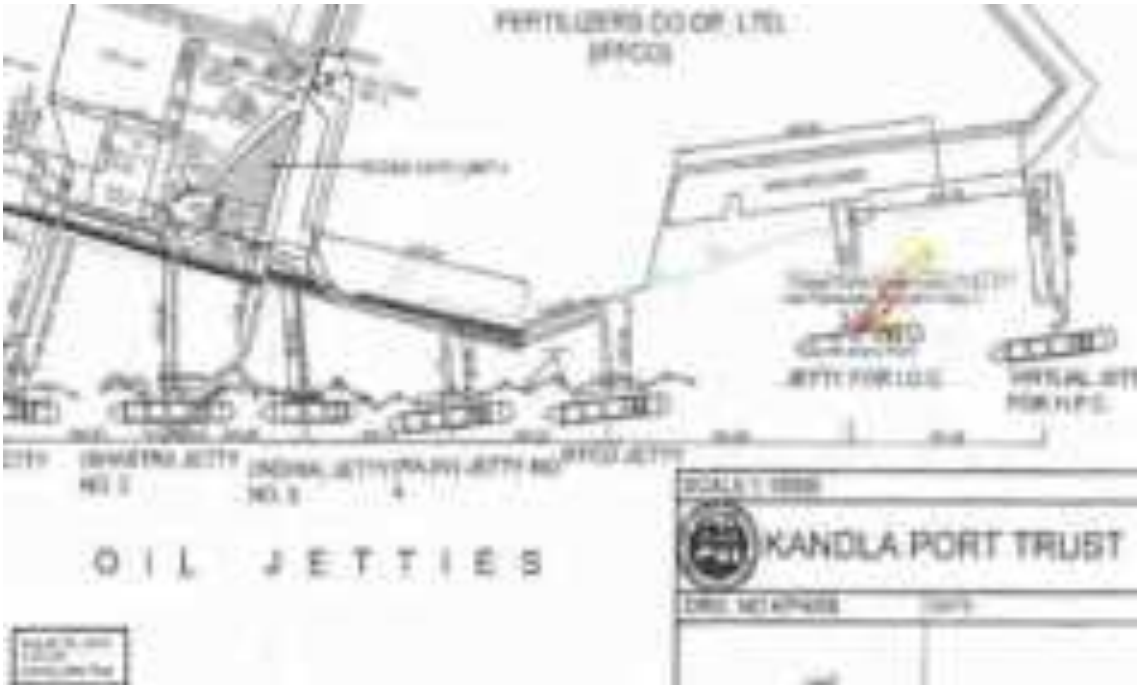


20.1.13 Jetty Six – Motor Spirit

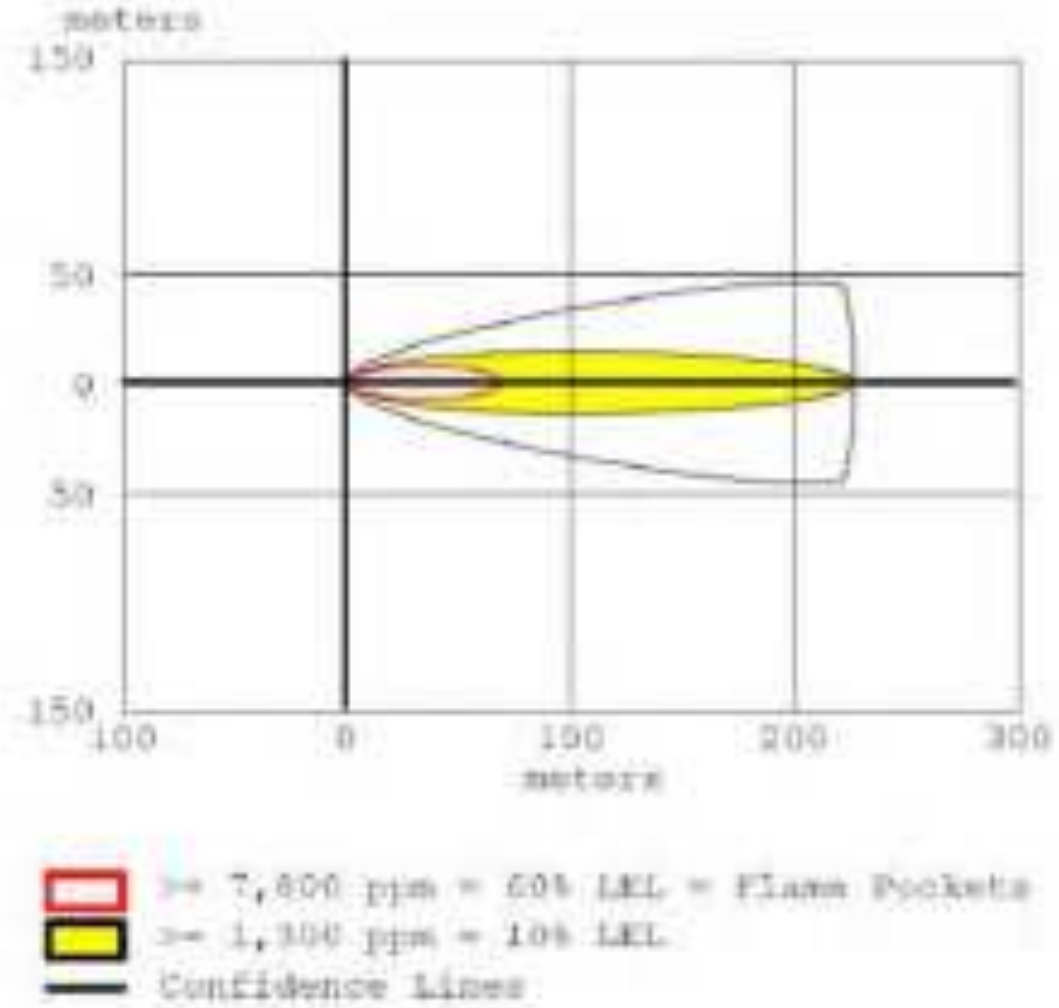
20.1.13.1 Instantaneous Release – Toxic Threat Zone (Graph)



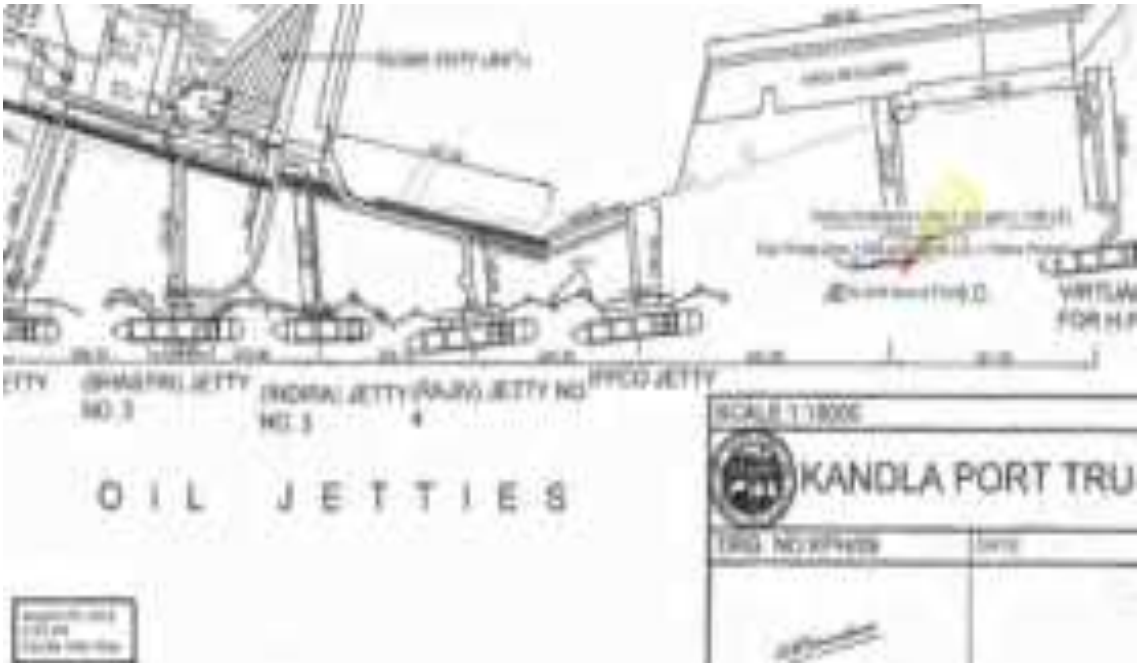
20.1.13.2 Instantaneous Release – Toxic Threat Zone (Contour)



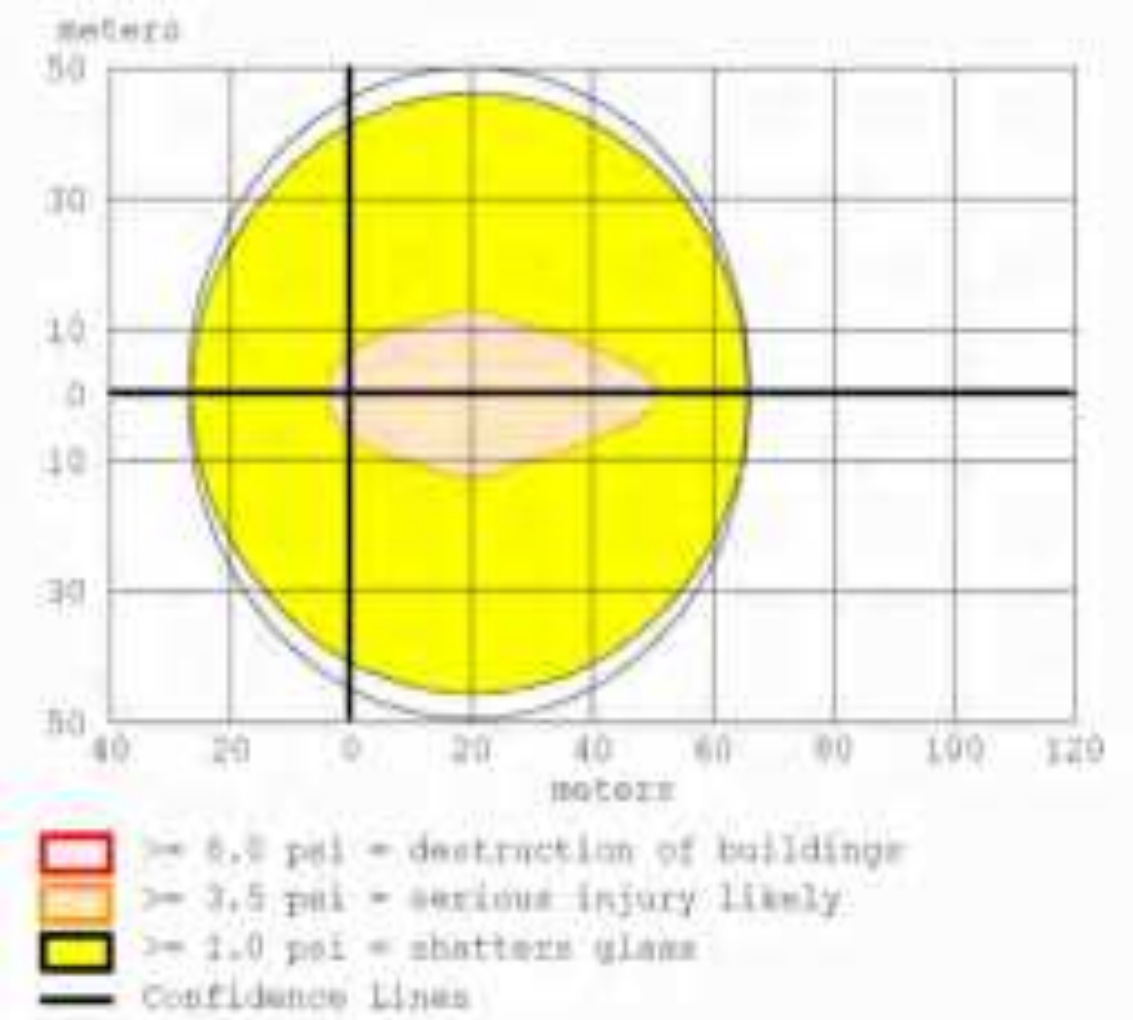
20.1.13.3 Instantaneous Release – Flammable Area of Vapor Cloud (Graph)



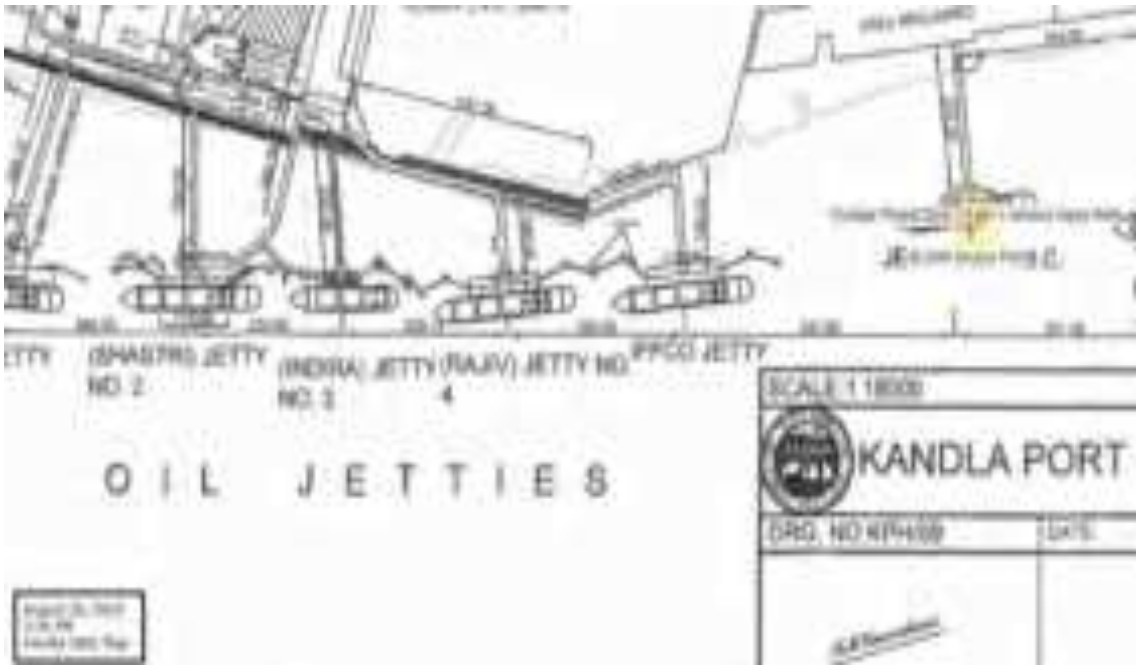
20.1.13.4 Instantaneous Release – Flammable Area of Vapor Cloud (Contour)



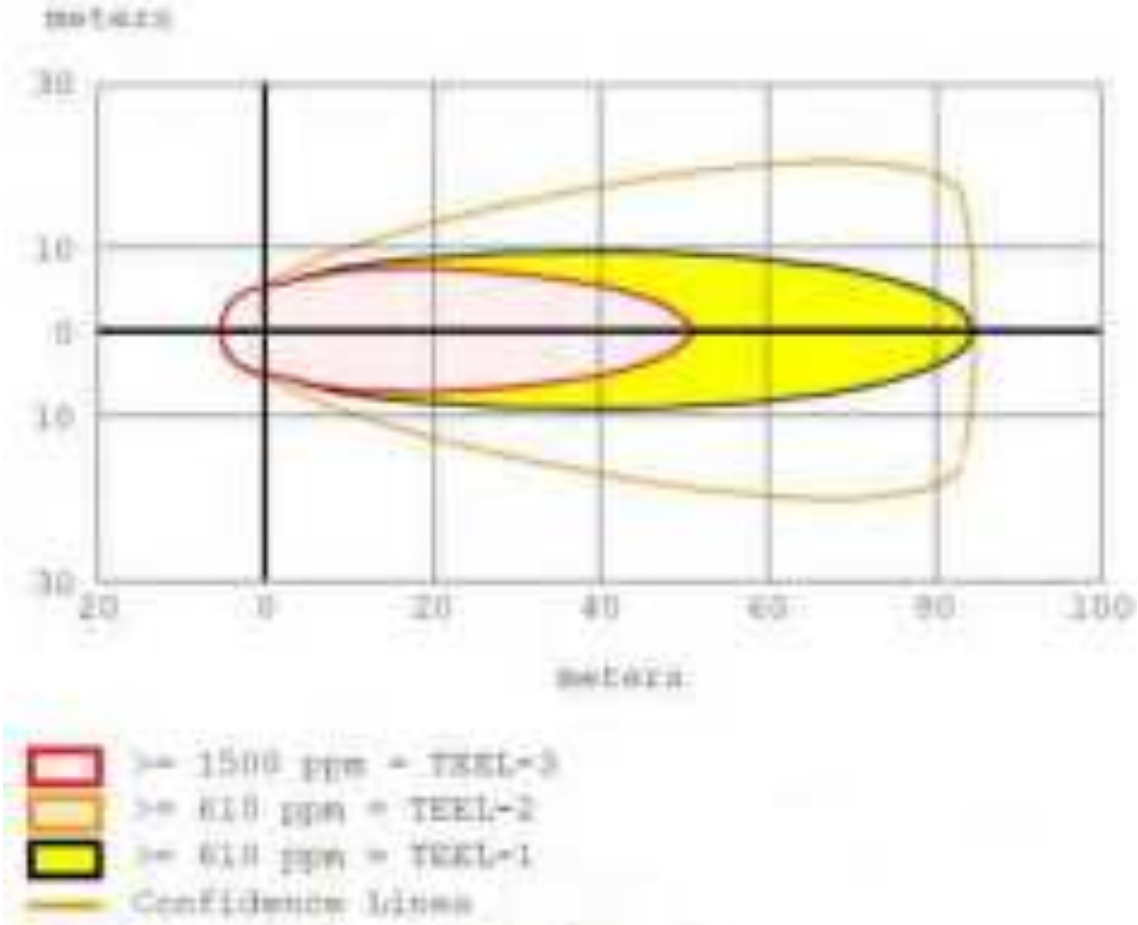
20.1.13.5 Instantaneous Release – Overpressure (Graph)



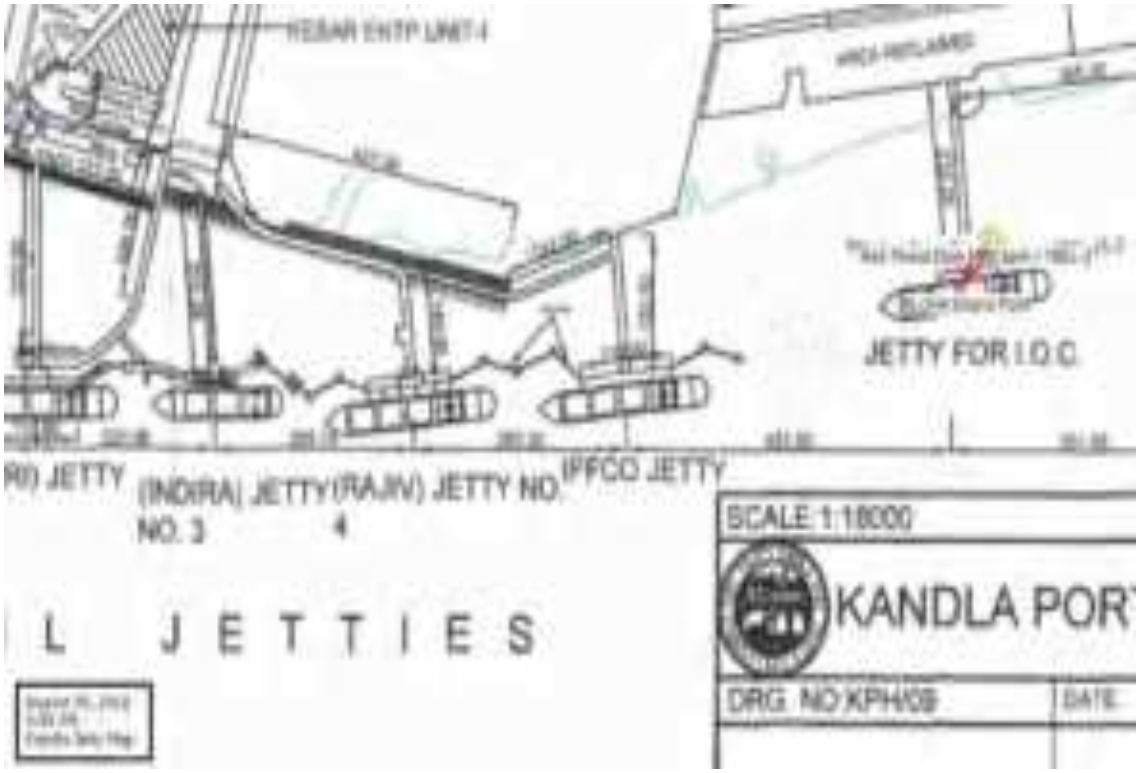
20.1.13.6 Instantaneous Release – Overpressure (Contour)



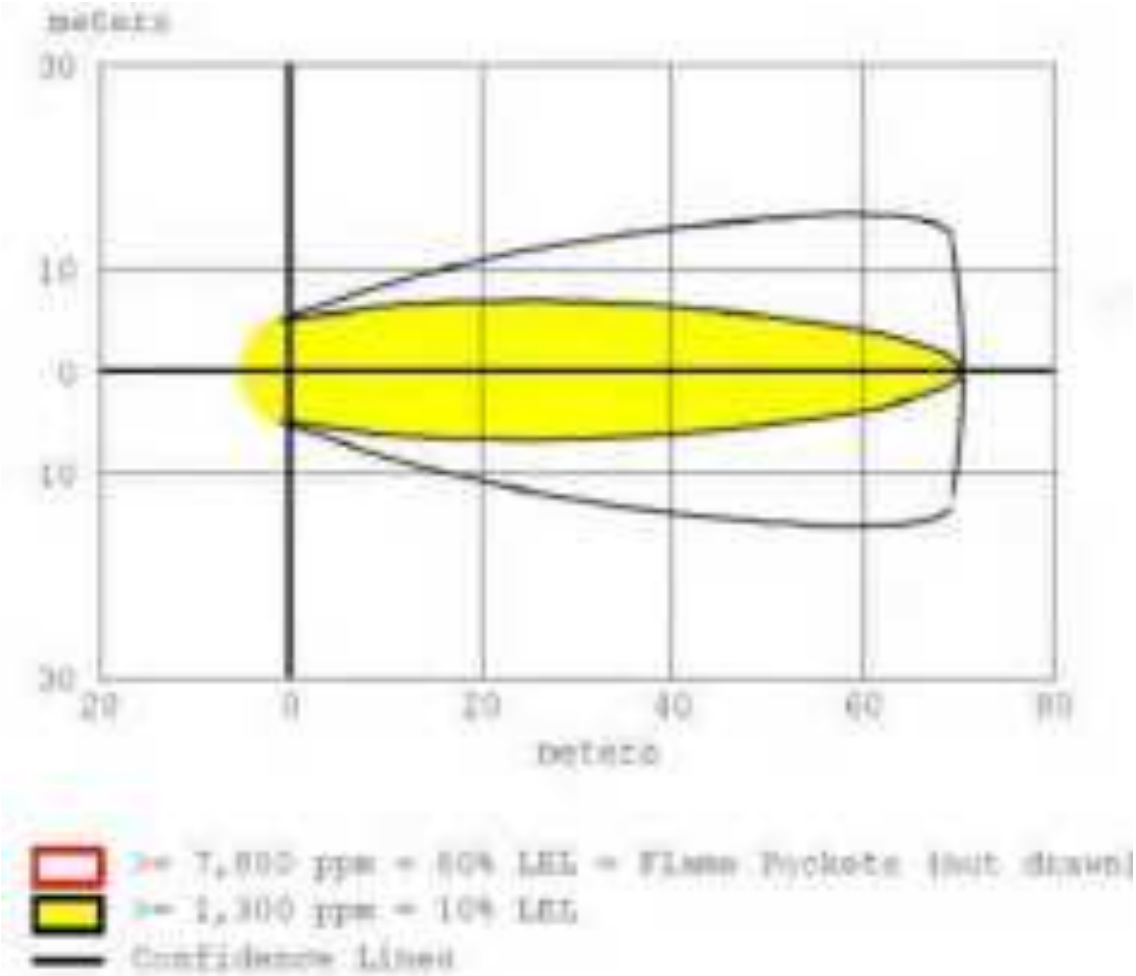
20.1.13.7 Evaporating Puddle – Toxic Threat Zone (Graph)



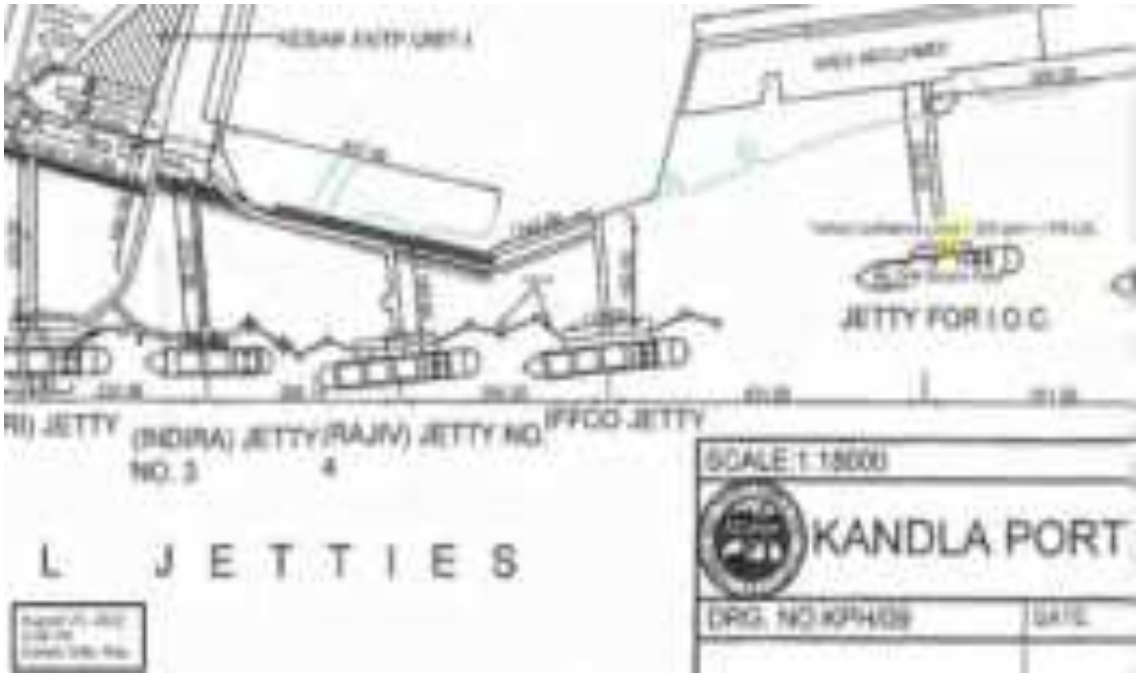
20.1.13.8 Evaporating Puddle – Toxic Threat Zone (Contour)



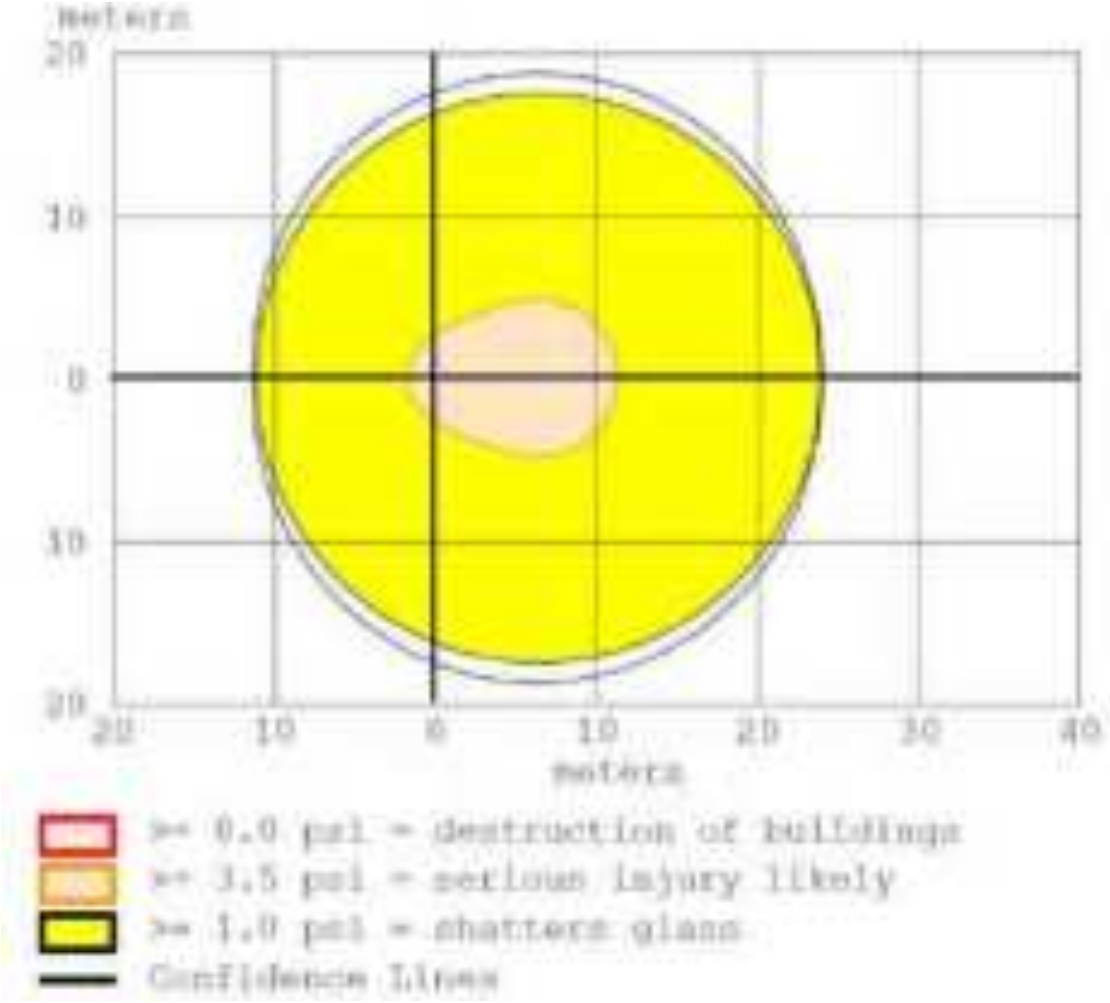
20.1.13.9 Evaporating Puddle – Flammable Area of Vapor Cloud (Graph)



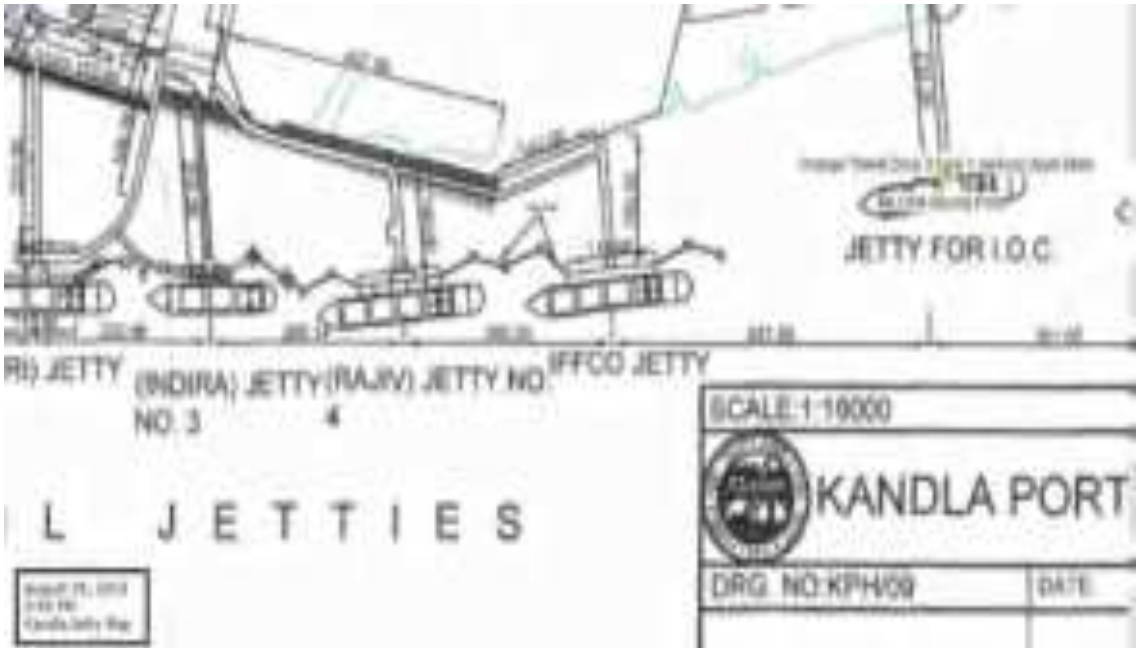
20.1.13.10 Evaporating Puddle – Flammable Area of Vapor Cloud (Contour)



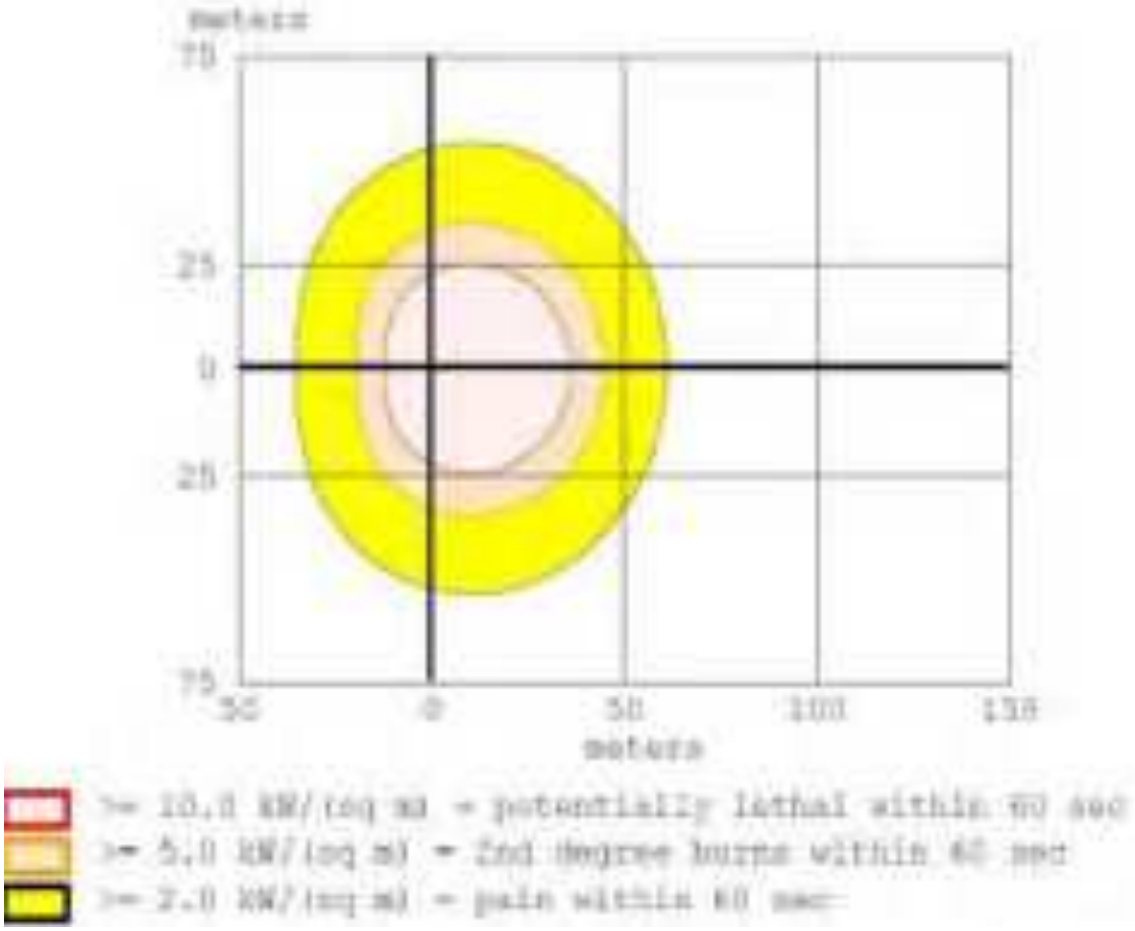
20.1.13.11 Evaporating Puddle – Overpressure (Graph)



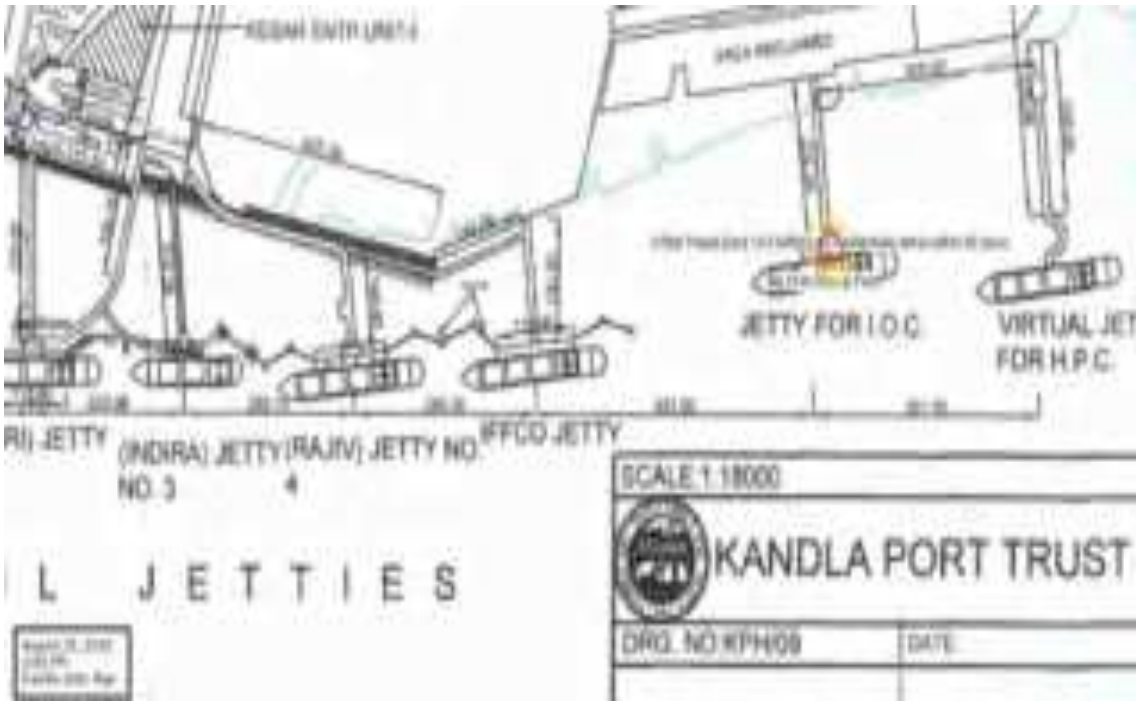
20.1.13.12 Evaporating Puddle – Overpressure (Contour)



20.1.13.13 Burning Puddle – Thermal Radiation (Graph)

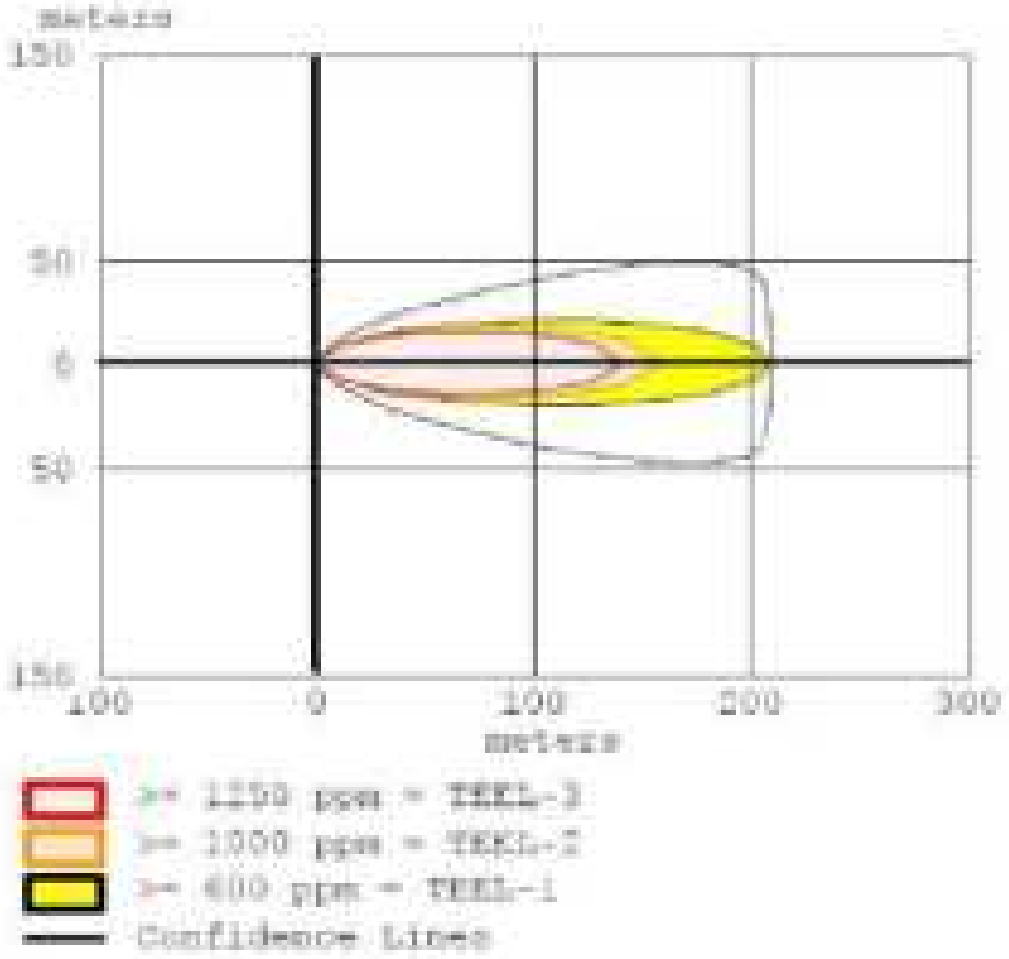


20.1.13.14 Burning Puddle – Thermal Radiation (Contour)

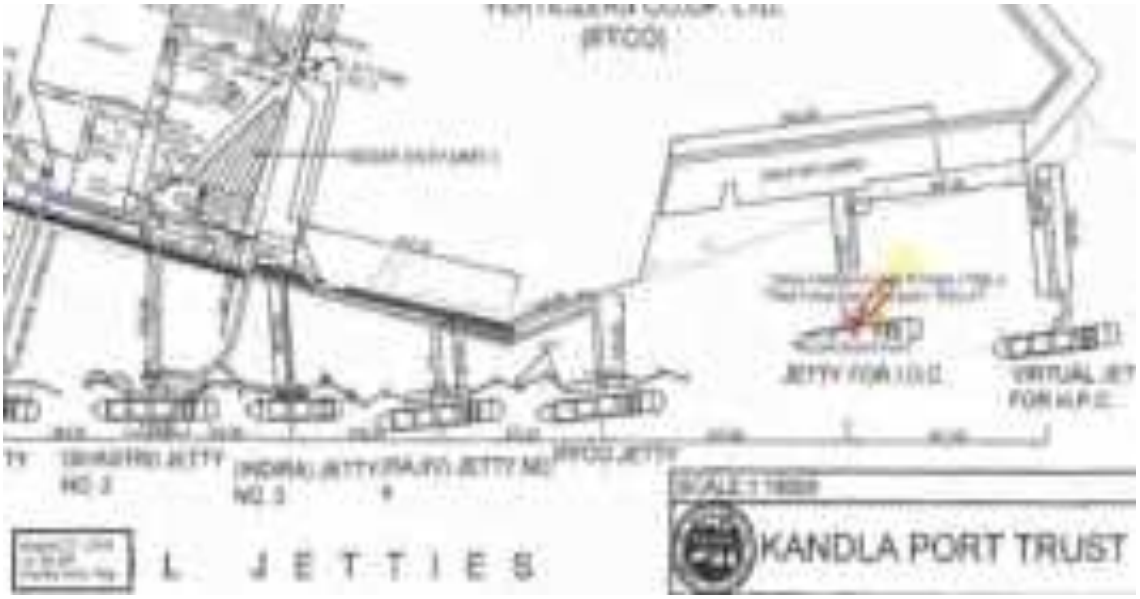


20.1.14 Jetty Six – Motor Spirit

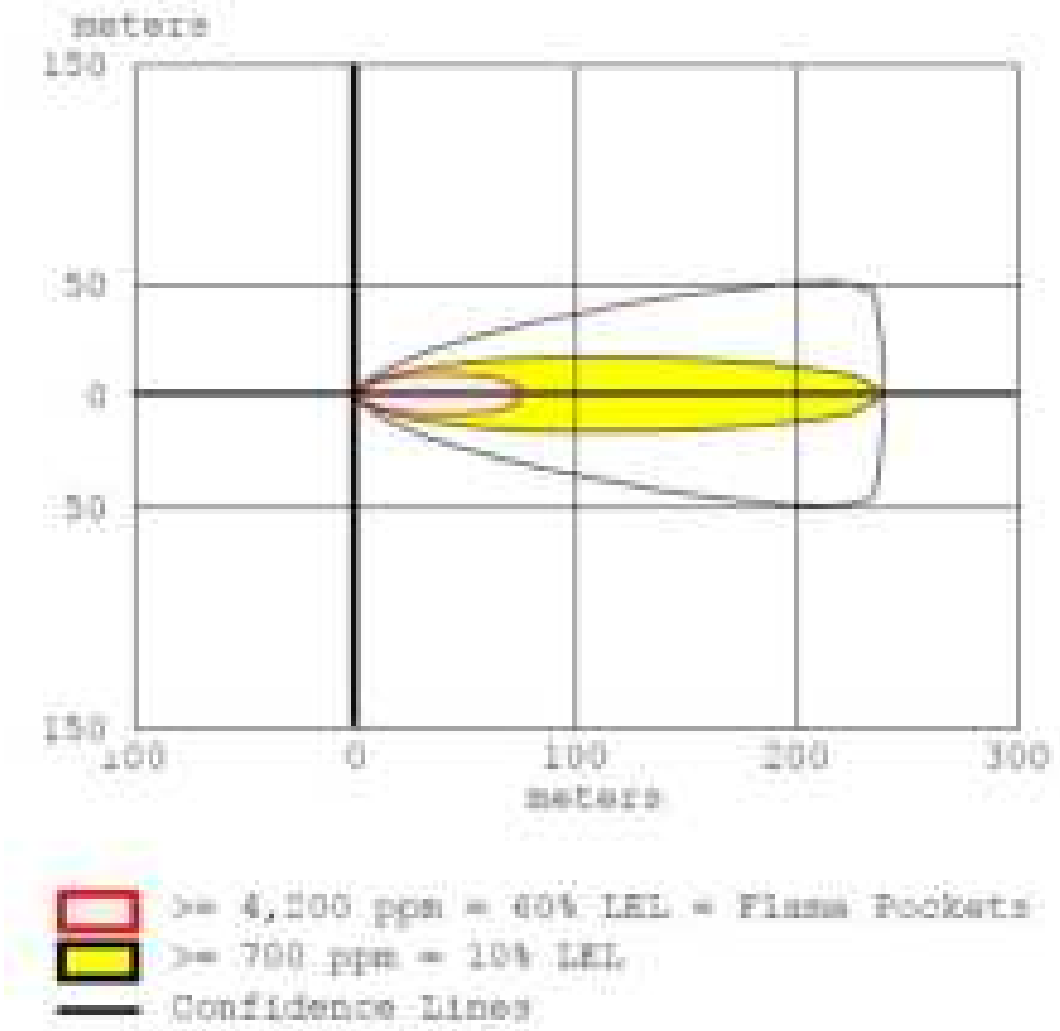
20.1.14.1 Instantaneous Release – Toxic Threat Zone (Graph)



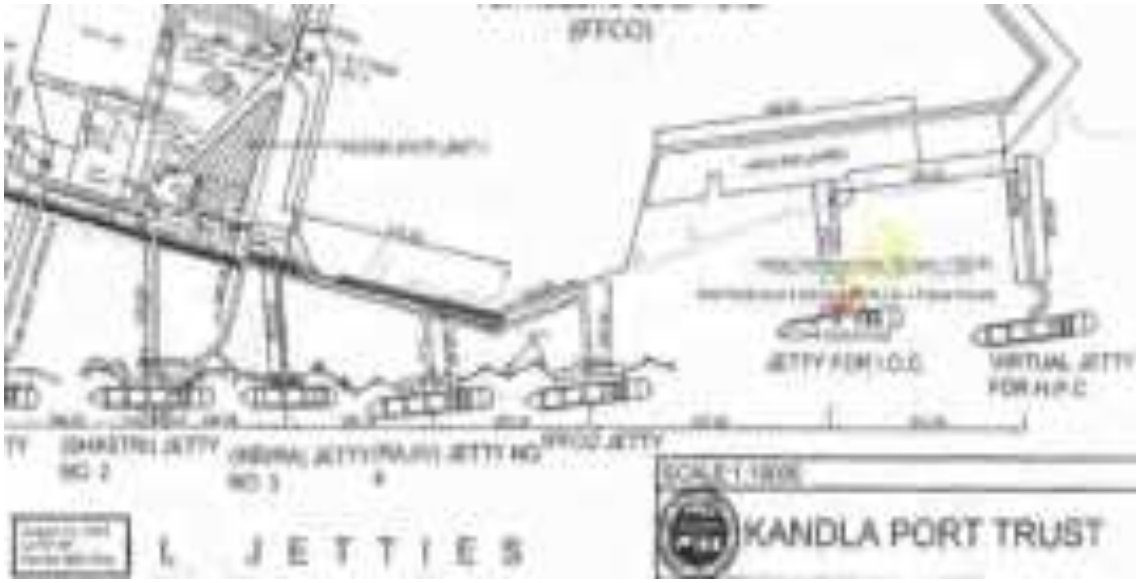
20.1.14.2 Instantaneous Release – Toxic Threat Zone (Contour)



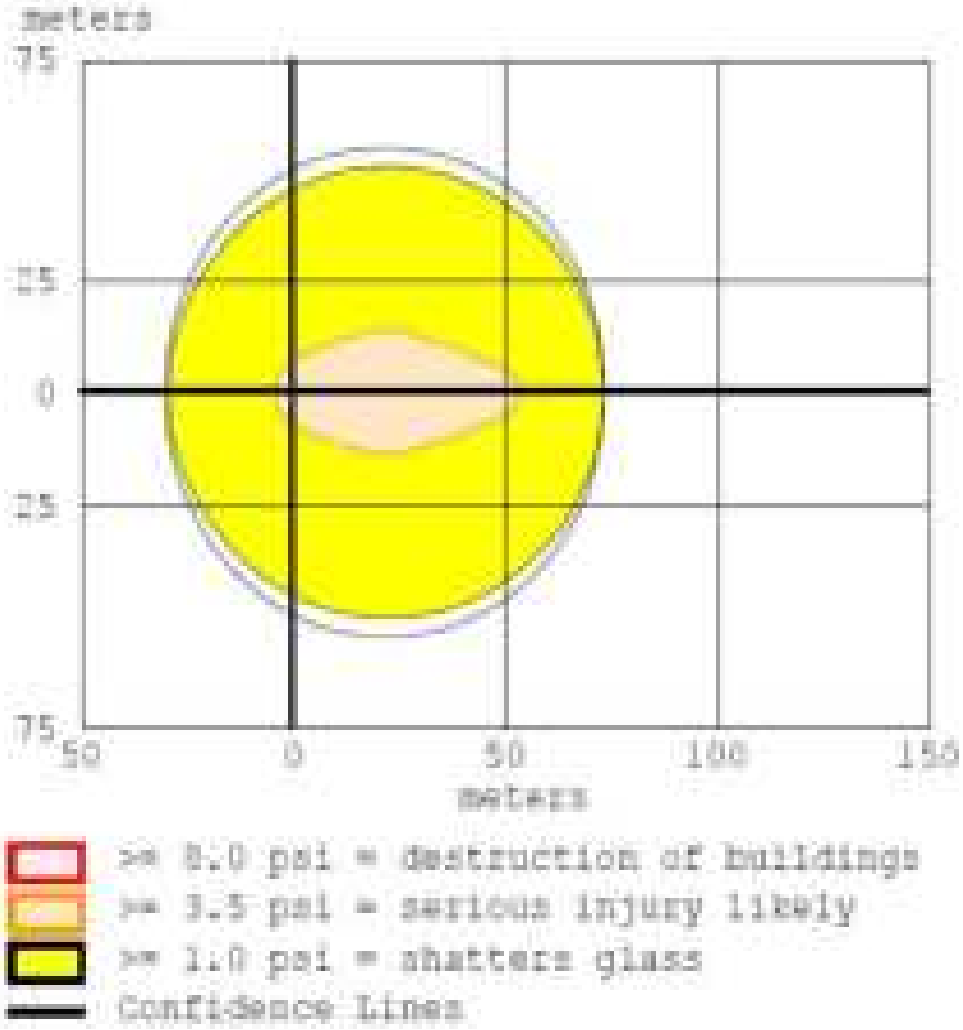
20.1.14.3 Instantaneous Release – Flammable Area of Vapor Cloud (Graph)



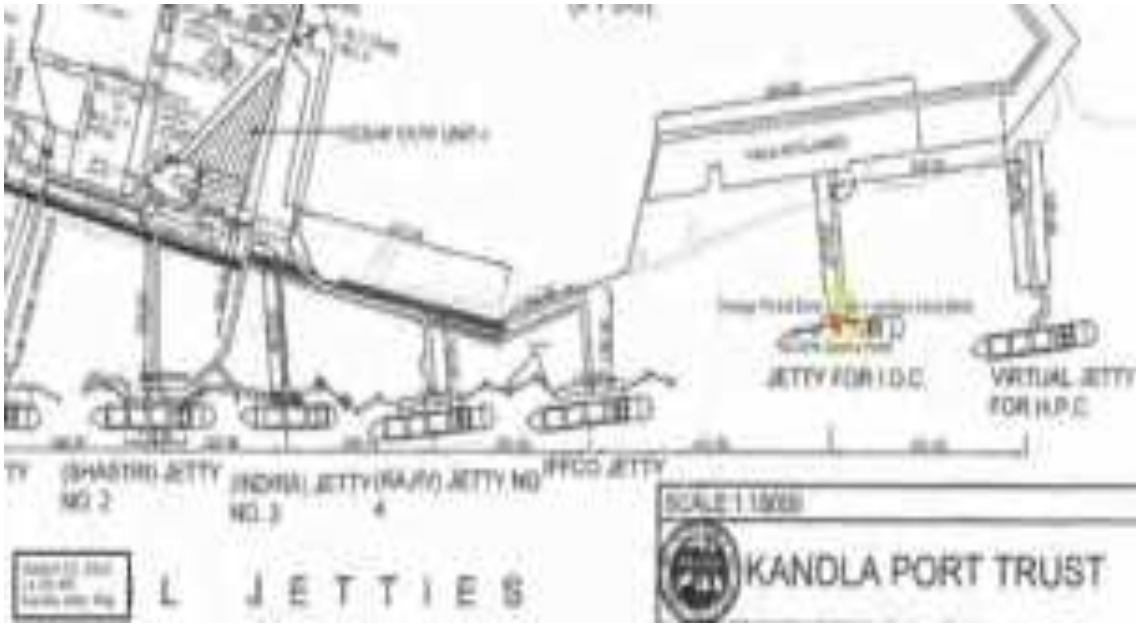
20.1.14.4 Instantaneous Release – Flammable Area of Vapor Cloud (Contour)



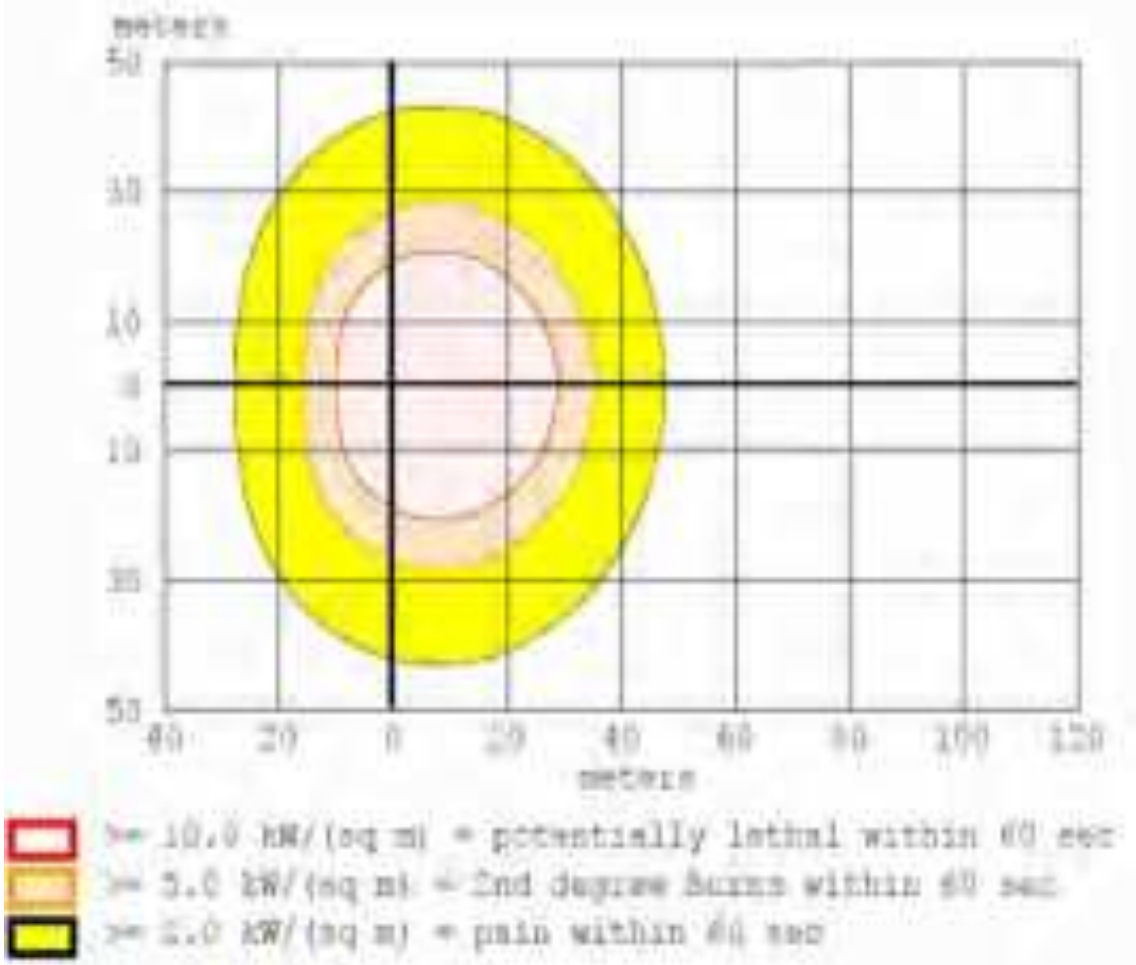
20.1.14.5 Instantaneous Release – Overpressure (Graph)



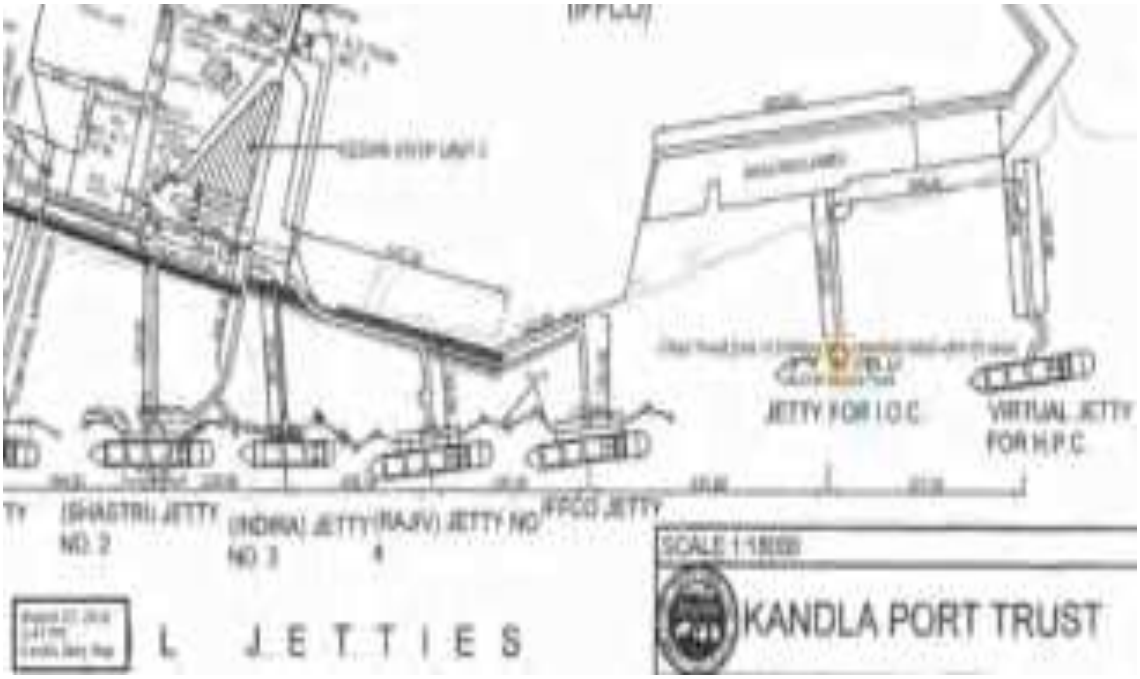
20.1.14.6 Instantaneous Release – Overpressure (Contour)



20.1.14.7 Burning Puddle – Thermal Radiation (Graph)



20.1.14.8 Burning Puddle – Thermal Radiation (Contour)



21 ANNEXURE

21.1 Telephone Nos of Gujarat State District Collectors

Sr. No.	Name and Designation	Office	Residence	Mobile
1	Dr. P. K. Mishra, Ph.D.IAS, Chief Executive Officer, GSDMA	3259392 Fax – 3259248	3261271	9825095142
2	Mr. M.Sahu, IAS, Addl. CEO, GSDMA	3259502 Fax-3259275	6309273	9825095148
3	Mr. C.L.Meena, IAS, Addl. CEO, GSDMA	3259293 Fax-3259289 / 48	3220488	9825244543
4	Mr. V.Thiruppugazh Joint CEO, GSDMA	3259451	3235404	9825084316
5	Mr. Arvind Joshi, IAS Director (Admn.)	3259500 Fax – 3259289	3235434	9825084317
6	Mr. P. C. Purabia Chief Engineer (Procurement)	3259219	2148066	9825084320
7	Mr. J.G.Pandya Director (Emer. Comm. & Housing)	3259501	3244022	9825084318
8	Mr. R.J.Makadia Director, (Disaster Management)	3259025		9825244540
9	Mr. H.K.Patel, Director (Finance)	3259279	6752930	9824033622
10	Mr. S. M. Shah Controller of Accounts	3259278	6302219	9825244541

21.2 District Level Authorities

Name and Designation of Officer	Fax	Telephone Nos. (Office)	Telephone Nos. (Residence)
District Collector, Bhuj.	250430	(02832) 250020	02832-250350
Resident Dy. Collector, Bhuj – Mob.9825300729	252704	250650	
Add. Collector, Bhuj Mob. 9825049360	252704	252704	251348

Mrs. Poonamben Jat, MP Bhuj		252595	251177
Dy. Collector, Anjar Mob. 9825228049		243345	243363
Mamlatdar, Anjar Mob. 9879278174		242588	243362
Mamlatdar, Gandhidham		250475 250270	222875 250475
Collector, Jamnagar		2555869	2554059
Collector's Control Room, Bhuj.		2252347 2231733	-
Doordarshan, Bhuj		2251107	
Dy. Mamlatdar, Gandhidham		250475 250270	
Civil Defense, Gandhidham		220221	
PGVCL, Gandhidham		221728 222809	
GW&SB, Gandhidham		220975	
GSRTC, Gandhidham		220198	
Duty Officer, All India Radio, Bhuj		222503	
State Information Dept. (Shri Antani)		224859 250954	253034 252855
Air Force Duty Officer, Bhuj		252501 252502	
Air Force, Bhuj		223450	
Air Port, Bhuj		254550	
Aerodrome Officer, Kandla		238370	223247
Indian Navy, Jamnagar		550263 to 5	550825
Air force, Jamnagar		550245 to 7	550247

21.3 List of Telephone Numbers of Gujarat Maritime Board

Sr. No.	Name, Designation and place of Office	Tele. No. (Office)	Tele. No. (Residence)	Fax No.
1	Mr. B.K.Sinha, Chairman, G'nagar	23250508 23250506		079-23250589
2	Mr. Pankaj Kumar, VC&CEO,Gandhinagar	23238363	23262280	23234703
3	Chief Nautical Officer, Gandhinagar	23238346-47		-do-
4	Chief Engineer(C), Gandhinagar	23238346		-do-
5	Officer on Special Duty, Gandhinagar	23238346	079-2323232	-do-
6	Exe. Asst. to VC&CEO,	3238363	7451465	-

	Gandhinagar			
7	Head Office, G'nagar	3238346 to 8	-	34703/04
8	Port Officer, Magdalla	0261-2470533	-	2475645
9	Port Officer, Bharuch	02642-241772	229082	220377
10	Port Officer, Bhavnagar	0278-2519221	2568580	2211026
11	Port Officer, Jafrabad	02794-245165		245152
12	Port Officer, Porbandar	0286-2242408	2242412	2244013
13	Port Officer, Veraval	02876-220001	242956	243138
14	Port Officer, Okha	02892-262001	262010	262002
15	Port Officer, Jamnagar	0288-2755106	2557163	2756909
16	Port Officer, Navlakhi Main Gate	02822-220435		232470
17	Port Officer, Mandvi	02834-220033	220040	230033
18	Traffic Inspector, Mundra	02838-222136	222136	-
19	Executive Engineer(C), Jakhau	02831-287261	222996	-
20	Gujarat Pipavav Port Ltd., Chief Operating Officer, Duty Office	02794-286314 86001/92	286070	-
21	Gujarat Adani Port Ltd., Mundra.	02838-288201 to 8	287241	-

21.4 For supply of Food Packets etc. following agencies to be contacted.

Sr. No.	Name of Agency	Contact Person	Telephone No.
1	Arya Samaj Mandal	Mr.Vachanidhi	231223 Mob. 9824221332
2	Agrawal Samaj	Mr.Dinanath	231638
3	RSS	Mr. Sunil Kothari	222560 / 232909
4	Lions Club, Gandhidham	Mr. Naresh Bulchandani	220212 Mb: 982428470

5	Rotary Club, Gandhidham	Mr. Rajabhai / P.K. Mukherjee	228213 / 232035
6	Red Cross Society	Dr. Bhavesh Acharya	234854, 232736
7	Lohana Mahajan, Gandhidham	Mr. Premji Bhai Thakker	220925
8	Rajasthan Yuva Mandal	Mr. Sunil Bajaj (President) Mr. Dilip Jain	221459 / 230902 234525 / 9825168170
9	Swaminarain Mandir	Mr.Lavjibhai Thackker	231555, 233666
10	Sindhi Youth Circle	Mr.Vijay Khubchandani & Mr.Kundabhai	220490
11	Satwara Samaj	Mr.Agavjibhai	235659
12	Sitaram Parivar	Mr.Mohanbhai Dharsi	222373, 234603
13	Gurudwara, Gandhidham		220643
14	Swaminarayan Gurukul	Swamimukta Prasadji	228098, 226555

21.5 Apart from the above, if required, the following hotels may be contacted for the supply of food packets:-

Sr. No.	Name of Hotel	Contact Person	Telephone No.
1	Shiv	Mr. Nagendra Singh / Mr. Bharat Singh	237712-13-14-15, 221297
2	Sharma Resorts	Mr. Madan Mohta / Mr. J. Gonasaives	31824/231823/231825/ 224885-86-87-88-89
3	Satkar	Mr. Babu Bhai Agrawal	234100/222597 234101 (R)
4	Natraj	Mr. Maulinbhai Acharya	221749/221956/221955 221954/238002
5	President	Mr. Rameshbhai	220053/229364/238002
6	K.K.Caterers	Kaniyalal Rajwani	(O) 227419, (R) 224995, (Mob) 9825226998
7	Bhawani Caterers	Mr. Hukamsinh Purohit	230366(PP)
8	Hotel Mid-Town, Adipur	Mr. Nagendra Singh	9825226568 260237/260080
9	Hotel Sea-Rock, New Kandla	Mr. Vithal Shetty	270490

21.6 List of Labour contractors operating at Kandla Port

Sr. No.	Name of the Company	Contact person	Address	Contact Nos
1	Neelkant Handling A/c Shree Radhey Shipping	Haresh Bupendra	Tenament B Plot 290,Ward 10/A, G'dham	237040 9825001743
2	Ratnakar Handling A/c Aditya Marine	Radhakishan Parida	83-84, GIDC G'dham	9879123371
3	Tirupati Handling Co.	Dayalal B. Rabari	6-8, Goyal Chamber, GIM	235504 9825056599
4	Al Pirani Al Sailani	Akbar Yakub	CS-10, Port Colony, Kandla	22053,232174 9979331100 9825787808
5	Shree Ravechi Handling A/c Trinity Shipping	Mahadeva Agaria	11,2nd Floor, Plot.343, Ward 12- B, GIM	250286 9825361347
6	Shree Ramdev Handling	Nimbaram Gulabji	377, Sector-7 GIM	9825348935 9979898564
7	AVB & Co	Mukesh Gujjar	15, GF, Gokul Park, GIM	232967
8	Ashapura Labour Supply	Khimji Jallabhai Rathod	48, GIDC, Near Ambika Weigh Bridge, GIM	9979053378 9898128069
9	Shree Krishna Handling	Harinder Yadav	E – 108, GHB ,Sec-5,GIM	9879549803
10	Naasmin & Co	Umar Osman Chamadia	Plot – 14, Sector- 7, GIM	9898333397
11	M.S. Logistics	Asgar Haji Mungrani	Shop No. 5, Opp.CISF Gate,Kandla	9825241065 9913620407
12	Shree Majeesa Handling	Jugal Kishor Joshi	Block 24, MIG, Kidana, GIM	9879373992 9979898564
13	Shree Kailash Handling Co.	Mohanbhai Heera	Plot No. 7, Sector- 8, GIM	9825228555 9879288875
14	Javed Abu Saicha	Javed Abu Saicha Gani Patel	Shop – 13, Port Colony,	9825092748 9825563094

			Kandla	
15	Shree Ganesh Handling	Dayabhai Rabari	6-8, Goyal Chamber, GIM	9825056599
16	Bhupendra & Co	Mayur M Ahir	Plot 253, Ward 12/C, GIM	9727762191 9825225239

21.7 List of Doctors in Gandhidham Complex

Sr No	Name of Doctor	Telephone	Telephone	Mobile No
Consulting Physician (MD Medcine				
1	Dr. Babita	261802	322111	
2	Dr. Gandhi C. K.	234561	230111	
3	Dr. Gonsair R. M.	230333	239944	
4	Dr. Johnson Samuel	222344	232244	
5	Dr. Morkahia V. L.	222008	232161	
6	Dr. Raiyani V. R.	230022	234214	9824241220
7	Dr. Sakaria S. B.	230114	230947	
8	Dr. Siju	230160	223852	
Dentist				
1	Dr. Asha Y. Parekh	234295	234451	
2	Dr. Ajay Bhimjiani	233347	260256	982544118
3	Dr. Chadotra M.	220142	237909	
4	Dr. Hitesh Sheth	226763	220965	
5	Dr. Kela B.V.	222094	231181	
6	Dr. Sanghvi V.K.	234979	223343	
7	Dr. Sharma R.	229211	227627	
8	Dr. Singh N.	230769	261343	
9	Dr. Soneta S.	236319	229172	
Dermatologist				
1	Dr.Jhala J.J.	223568	235567	
2	Dr. Deepak Sorathia	242882		9426909822
E.N.T. Surgeon				
1	Dr. Dave A.B.	221931 260394	260461	
2	Dr. Harani D.D.	222096	239121	9825227322
3	Dr. Khatri R.S.	222701	235959	9879195798
4	Dr. Maheswari S.K.	231874	250940	
M.B.B.S				
1	Dr.Acharya B.F.	220715	232736	9825210157
2	Dr. Acharya C.M.	220263		
3	Dr. (Mrs.) Acharya S.C	232606		
4	Dr. Agarwal B.B.	227767	570212	9825225599

5	Dr.Asher G.K.	239139	233765	
6	Dr. Bhadra D.M.		230259	
7	Dr. (Mrs.) Bhatia K.	260255		
8	Dr. C. Jonwal	220263	263987	
9	Dr. (Mrs.) Chellani	220099	270441	
10	Dr. Chudasama V.K.		240952	
11	Dr.Dasani M.G.	260001	261495	
12	Dr. Goswami S.K.	261399		
13	Dr. Guptabhaya D.N.	221305	231777	
14	Dr. Gurdasani V.S.	260674		
15	Dr. Harani H.C.	235369	239327	
16	Dr. (Mrs.) HitemathU.S.	261844	260097	
17	Dr.Joshi N.L.	260666	261661	
18	Dr. Kela H.V.	232069	232071	
19	Dr. Khushlani A.	260562	260738	
20	Dr. Leon A.	261802	262188	
21	Dr. Makwana	220263	263406	
22	Dr. Minocha Ravi	236306	232127	
23	Dr.Mehta H.K.	231590	235021	
24	Dr. Mehta J.R.	220164	220834	
25	Dr. Morbia V.M.	230011		
26	Dr. Parekh S.K.	260608	261123	
27	Dr. Puri R.P.	223355		
28	Dr.Rawal S.	235119		
29	Dr. Singh D.P.	221990		9825359928
30	Dr. Thakkar A. D.	220582	222829	
31	Dr. Thakkar H. M.	223506	222350	
32	Dr. Thakkar M. C.	260577		
33	Dr. Thakkar S. B.	221046 228267 221177	238467	
34	Dr. Vaccharajani N. D.	220088		
35	Dr. Vasudev Jethani	260577	261650	
36	Dr. Vora C. B.	223084		
37	Dr. Vadhwani Vjay	262076	262843	
38	Dr. Zola Mithubhai	260608		
39	Dr. (Mrs.) Raiyani P.V.	230022	234214	
40	Dr. (Mrs.) Singh R. D.	221990		
General Surgeon				
1	Dr. Ahir J. K.	237744		
2	Dr. Dasani D. G.	229231 227505	223346	
3	Dr. Gandhi R. G.	236700	229156	

4	Dr. Girdhani R. C.	233300	231219	
5	Dr. Jiladiya A.	220263	244844	
6	Dr. Joshi Y. V.	221557 230013	233324	
7	Dr. Naik S. K.	234333	231332	
8	Dr. Patel J .K.	230007		
9	Dr. Vora Chetan	224787	229369	9825225942
Obstetrician & Gynecologist				
1	Dr. (Mrs.) Acharya N.B.	220715	232736	9825226700
2	Dr. Alpa D. Mehta	262599	265266	
3	Dr. Chandrakant Thacker	224488	225588	
4	Dr. Darshak Mehta	220263	265266	9824211534
5	Dr. (Mrs.) Gor A. A.	235135	239635	
6	Dr. Khanchandani	260833	260839	
7	Dr. (Mrs.) Kaur J. P.	229655	220673	
8	Dr. (Mrs.) Naik P. S.	234333	231332	
9	Dr. (Mrs.) Patel M. H.	230202	230353	
Ophthalmic Surgeon				
1	Dr. Gor A.	235135	239635	
2	Dr. Masand S. N.	220139	234187	9825196989
3	Dr. Parikh Y. B.	234295	234451	
Orthopedic Surgeon				
1	Dr. Hotchandani	220039	261530	
2	Dr. Patel H. A.	230202	230353	
3	Dr. Sailesh Ramawat	230160		
4	Dr. Vachhani P. S.	230400	222400	
Pediatrician				
1	Dr. Dubal J. A.	232591	233777	
2	Dr. Jeswani R. M.	255689		9825229249
3	Dr. Majithiya M. S.	222413 222406	227134	
4	Dr. Rupesh Seth	260836	222397	
5	Dr. Naveen Thacker	230195	230894	
6	Dr. Nitin Thacker	221046	220615	
Pathologist				
1	Dr. Sukla K. L.	221611	234062	
2	Dr. (Mrs.) Pawde S. V.	230370	231352	
3	Dr. (Mrs.) Verma G. H.	229168	238386	
		Psychiatrist		
1	Dr. Barot S.	221041	234885	
		Radiologist		
1	Dr. Shah R. M.	222878 234215	222868 235868	

2	Dr. Bhupendra Shah	572824	227724	

21.8 List of Essential Services

HOSPITALS		OFFICE	RESIDENT
1	General Hospital, Bhuj Civil Surgeon, Bhuj	222850	250554
2	Referal Hospital, Anjar	232455	
3	Rambaugh Hospital, Gandhidham	220263	
4	Divine Life, Adipur	261802	
5	Railway Hospital, Gandhidham	231874	
6	Government Dispensary, dipur	260608	
TELECOMMUNICATION			
1	General Manager, BSNL, Bhuj	253000	252322
2	Dy. Manager, Bhuj	252505	251505
3	Area Manager, Gandhidham	238000	235000
4	SDO, Gandhidham	236250	236251
ELECTRICITY			
1	S.E., PGVCL, Bhuj	222550	250189
2	Jr. S.E., Anjar	243008	242656
3	XEN, Anjar	242845	242446
4	Dy. Engineer, Gandhidham	222809	--
5	Line Office, Gandhidham	221728	
WATER SUPPLY			
1	S.E., GWS&SB, Bhuj	221806	250601
2	XEN, Bhuj	250685	253016
3	SE, Anjar	242416	242421
4	XEN, Gandhidham	220717	223273
5	Control Room, Gandhidham	221252	
6	Water Tank, Sunderpuri	231313	
7	Water Tank, NU-4	654564	
8	Gandhidham Municipality	231610	
9	Chief Officer, Gandhidham Municipality	234967	

21.9 List of Vehicle Suppliers

Sl. No	Name of Institution	Contact Person	Parking Place	Name and Phone No.	Availability of

			Phone No.	of Driver	Vehicle.
(A) Vehicle Hire Contractors					
2	M/s Rohit Enterprise	Mr. Rohit Shah 228550/237538 237547 (O) 234140 (R) Mob.9825225121			
3	M/s Jai Somnath Travels (GIM)	Mr. Mishra Mob.9825386739			
(B) Ambulance Pool					
01	St. Joseph Hospital, Gandhidham	Administrator 230160/229336	Hospital Premises	Driver available round the clock	First come first serve
02	IFFCO-Kandla on contract, Dispensary No. 20164 Dr. Mehta (R) 220832 Plant. Dispt. 270832	Mr. Mukesh Agrawal Hotel Gokul 221311			First come first serve
03	Kandla Salt Mfg. Ass. Neelkanth Bldg.	Mr. Shamji Ahir 231485 (R) 222765/220421 (O)	Zanda Chowk	Driver available round the clock	First come first serve
04	Zhulelal Mandir Trust	Mr. Kundan Guwalani 221760 (R) 229800 (O) Kundan Stores 221533/227800 229580	Mandir Premises	255580	
05	Red Cross Society	Dr. B F Acharya 225636/230345	Red Cross	Driver available round the clock	
06	Western Railway, Gandhidham	Medical Supdt. 231874 (R)	Hospital		
07	Rambaugh Government Hospital	220263	Hospital Premises	Driver available round the	

				clock	
08	Gautam Freight Pvt Ltd.	Mr. Ramesh, Proprietor 232605/220163, 230345 (O)	GIDC Work shop Sector-10C, Plot No. 24.		First Come First Serve
09	Sindhu Sewa Samiti Trust, Adipur	Mr. Jotwani (R) 260836, 260698 TBX-45, Adipur	Hospital Premises	Driver round the clock residence in hospital (Break duty at present)	
10	Tolani Eye Hospital	1. Supdt. (O) 260497 (R) 260773 2. Vice Chairman (O) 260373 Mr. N K Chandnani (R) 260456, Prabhu Chaya, Behind Prabhu Darshan	Hospital Premises	One driver in absence of compounder residing in hospital	First Come first Serve
11	Divine Life Society, Adipur	261802	Hospital Premises	Round the clock	
12	Atmaram Severam Charitable Trust	237759 Mob. 9825225294	Gandhidham	Round the clock	
13	Dev Smruti Trust	222096/231073			
14	Mobile Morgue	229430/239965	Lions Club		
15	Shav Vahini/Mobile Mrogue	239965			

21.10 List of Clearing & Forwarding Agents at Kandla

A V Joshi & Co Tel. 232605, 232227, 230345	C. Jivram Joshi & Sons (Gujarat) Tel. 220621 Fax. 231141

Fax. 233924 Mr. Harshandu Mr. Vaidya (Mob.) 9825226013	Mr. Sunil Chowdhari (Mob) 9825225400
ACT Shipping Ltd Tel. 270111/12/13, 270530, 220407 Fax. 270579, 232175	Cargo Movers Tel. 220453, 230883, 270563 Fax.231687
A. Jaswantrai & Co. Tel. 222630, 222717, 222145, 221943 Fax. 232308, 270385	Cargo Clearing Agency (Gujarat) Tel. 221721, 221674, 220655, 270542 Fax. 233034
Asia Shipping Services Tel. 230954. Fax. 231285	Chinubhai Kalidas & Brothers Tel. 232284 Fax. 231881
Airol Shipping Services Tel. 230080, 220180. Fax. 236131	CAP Shipping Pvt Ltd Tel. 221460, 232081 Fax. 233734
Aarpee Clearing Agency Tel. 222614. Fax. 255252	Centrans Shipping Agency (I) Pvt Ltd Tel. 256854 Fax. 234074
Ashirwad Clearing Agencies Tel. 232426, 233245 Fax. 234107	Cargo Shipping Tel. 270802, 270803 Fax. 270802
Ambalika Enterprises Tel. 255382. Fax. 255577	C. Joshi & Sons Tel. 221094
Ashmka Shipping (Tel. 222481)	Dilip A Goplani Tel. 224082, 255423 Fax. 224082
Ashis Enterprise (Tel. 234722)	D.B.C. & sons Gujarat Pvt Ltd Tel. 270263, 270348, 270503 Fax. 270631
Anchor Shipping Tel. 235781 Fax. 235781	Damjidhiroo & Sons Tel. 222329, 221328 Fax. 230139
B N Thakkar & Co., Tel. 222293, 222285, 270239 Fax. 230556	Dvji Premji Punara & Sons Tel. 222057, 221338 Fax. 230139
B. Devchand & Sons Pvt Ltd Tel. 232220 Fax. 234014	Express Transport Pvt Ltd Tel. 220193, 220179, 270591, 222565 Fax: 220193
Benits Forwarders Pvt Ltd Tel. 221707, 222086 Fax. 223151	Friends & Friends Shipping Pvt Ltd Tel. 232227, 231588 Fax. 233924
Blue Sea Shipping Agencies Tel. 235317 Fax. 255221	Fast & Fair Company Tel. 255254, 238175 Fax. 255254
Bhanu Clearing Agency Tel. 256861 Fax. 256861	Flamingo Shipping & Forwarding Pvt Ltd Tel. 256755, 257756 Fax. 256755
Global Marine Agencies Tel. 222928, 223196, 223252 Fax.255418	Liladhar Passoo Forwarders Pvt Ltd Tel. 252288, 252297, 252402, 252617 Fax. 252383
Gayatri Shippers Tel. 230692, 223292 Fax. 230818	Lalbahi Trading Company Tel. 222139

Hiral Enterprise Te. 255644	Leap Forwarders Pvt Ltd Tel. 255530, 255509 Fax. 252383
Hindustan Shipping services Tel. 255644, 222821 Fax. 256618	Link International Tel. 255206/07 Fax. 255530
Hardip Shipping Logistics Pvt Ltd Tel. 232909, 222560 Fax. 232909	Lexicon Shipping Agencies Pvt Ltd Tel. 229951-53 Fax. 229949/50
Hansraj Pragji & Sons Tel. 221650, 255228 Fax. 255228	Logistics Enterprise Pvt Ltd Tel. 255157, 255458 Fax. 255520
H K Dave Pvt Ltd Tel. 221504, 2333632 Fax. 230411	Mathuradas Narndas & Sons Forwards Pvt Ltd, Tel. 252224, 252350, 252115 Fax.252221
Intralink Clearing & Forwarding Tel. 255188 Fax. 23148	Magal Singh & Company Tel. 224030, 255253, 234688
J M Baxi & Co. Tel. 270630/35, 270148/50, 270525 Fax. 270616	Meridian Shipping Services Tel. 233981, 255362 Fax. 230701
Jesia Mistry Agencies Pvt Ltd Tel. 222317, 223317	Megha Shipping Agency Tel. 222671, 255304 Fax. 230937
Jaisu Shipping Company Pvt Ltd Tel. 270428, 270128/538 Fax.270556	Mayur Forwarders Pvt Ltd Tel. 222671, 255304 Fax. 230937
Jivanlal Laloobhai Tel. 220308, 230530 Fax. 231640, 233803	Maritime service Pvt Ltd Tel. 222671, 255304 Fax. 255304
Krishna Clearing Agency Tel. 223813, 230501 Fax. 233135	Marathon Shipping Combine Tel. 222202, 230106 Fax. 255220
Kiran Roadlines Tel. 232297, 231984, 234108 Fax.231422	Shiv Shipping Service Tel. 255568 Fax. 22256
Kandla Clearing Agency Pvt Ltd Tel. 232337, 223211, 223210 Fax.230402	Narendra Forwarders Pvt Ltd Tel. 232504, 231795 Fax. 256678
Kamat & Co. Tel. 223471, 232730, 232729 Fax. 255243, 270779	Natwar Parikh Industries Ltd Tel. 232628 Fax. 232628
K S Chaya & Co Tel. 256604 Fax. 230693	New Dholera Shipping & Trading Company Limited. Tel. 222637 Fax. 255329
Kashyap Shipping Ltd Tel. 220816 Fax. 230030	National Shipping Tel. 232319 Fax. 232319
Kanak Shipping & Transport Tel. 231314, 230543, 222059 Fax.221702	Navjeevan Enterprise Tel. 252611, 252360 Fax. 252515
IEE & Muirhead Pvt Ltd Tel. 231535/36 Fax. 231018.	N. G. Bhanushali & Company Tel. 233648, 256791 Fax. 256879
OTA Kandla Pvt Limited	Shivji Kanji & Company

Tel. 220145, 223241, 270450 Fax.223241	Tel. 230127, 223728, 223729 Fax.220308
Pravin Bhatt & Sons Tel. 224032, 230079 Fax. 230079	South India Corp. (Agencies) Limited Tel. 234646, 231494, 221276, 255209 Fax.234416
Prime Forwarders Tel. 234047, 232505 Fax. 231345	S J Thacker & Company Tel.255678,221745 Fax.230659
Purshotam Ramjee & Company Tel. 220354, 222287 Fax. 231754	Star Shipping Services Tel.255424,255425,235326(F)255426
Patel Handling Agency Tel. 221718, 224024, 231004, 270017 Fax. 231143	Shivani Shipping, Tel. & Fax.256836
P S Bedi & Company Tel. 223201, 222841 Fax. 255494	Sea Trans Shipping Agency Tel. 255564 Fax. 233228, 233517
Purshotam Chtrabhuj Thacker Tel. 222720	Seaster Shipping Services Tel. 255349 Fax. 232719
Prashant Shipping Tel. 255306, 223927 Fax. 223927	Seaway Shipping Services Tel. 234272 Fax. 232719
Pramukh Forwarders Tel. 255400 Fax. 232602	Star Clearing Agencies Tel. 230273, 255529, 222983 Fax.232719
P M Agency Pvt Ltd Tel. 232553, 233973, 236414 Fax.255413	S S Shipping Agencies Tel. 236605, 238283 Fax. 236605
Raj Shipping Service Tel. 233948, 232402 Fax. 231395	SPN Shipping Services Tel. 222453, 270733 Fax. 236605
Rajesh Shipping Service Tel. 255444, 255450/52, Fax.255151	Sierra Shipping Pvt Limited Tel. 255395 Fax. 232771
Rudra Shipping Service Tel. 220429, 255317 Fax.255317	Sonal Enterprises Tel. 252666, 252053
Rishi Shipping Tel. 220813, 229830, 2555661/2/3 Fax. 238943, 255522 Mr. B K Mansukhani (M)9825225170	S R Clearing Agency Tel. 232974, 255494 Fax. 255494
Rudraksh Shipping Service Tel. 235937 Fax. 255582	St. John Freight System Limited Tel. 235414, 236444 Fax.235414
Sanghvi Freight Forwarders Pvt Ltd Tel. 234993, 234995, 222401 Fax.230508	Siddi Shipping Services Tel. 232356, 230268 Fax.256712
Sri R K Shipping Pvt Ltd Tel. 232028, 231940, 231936 Fax. 232740	Spalsh Shipping Pvt Limited Tel. 255562, Fax. 220710
Shakti Enterprises Tel. 223531, 221591 Fax. 233898	Thakarshi Madhavji & Sons Tel. 255457, 255458 Fax. 221770
Shree Ambica Commercial Company	Trinity Shipping & Allied Services Pvt

Tel. 220213, 221253	Ltd Tel. 223703, 230911 Fax. 232060
Shri Maruti Shipping Services. Tel. 270760, 256853, 233245 Fax.220308	Tokto Shipping Services Tel. 234040
Unity Shipping Tel. 255271	Vinson Tel. 220466 Fax. 231948
Umiya Shipping Agency Tel. 255640 Fax. 233625	Vaz Forwarders Ltd Tel. 235317 Fax. 255221
Unique Forwarders Tel. 230080, 255417 Fax. 236131	Varsh Shipping & Travels Tel. 222386, 255300 Fax. 255300
V. Arjoon Tel. 221049, 221335, 222058, 223307 Fax. 234167	Venus Clearing Agency Tel. 233960 Fax. 233362
Velji Dosabhai & Sons Tel. 270220, 270025, 221818, 231423 Fax. 270164, 232363	Vishal Shipping & Handling Tel. 223960 Fax. 233362
Vishvajyoti Enterprises Tel. 252381, 252318 Fax. 253091	Worldwide Cargo Care Pvt Ltd Tel. 221290, 221479, 220307, 230217 Fax. 231913
Velji P & Sons Tel. 255327, 231545, 231546, 270976 Fax. 255328	Zenith Trade Link Tel. 223193 Fax. 255522
Vailash Transport Co. Tel. 233579, 223580	

21.11 Surveyors at Kandla

Adnuralty Marine Services Tel. 235412, 256813 Fax. 256813	Marine Consultants & Surveyors Pvt Ltd Tel. 255293 Fax. 234416
Capt. S. Kochar & co. Tel. 222247, 221084 Fax. 231357	Murray Fenton (India) Surveyors Limited Tel. 235960, 236238 Fax. 233335
Dr. Amin Superintendents & Surveyors Pvt Limited, Tel. 221520, 235636 Fax. 226527	M. M. Cargo Gear & Marine Surveyors Tel. 231385 Fax. 235255
Det Norske Veritas (DNV) Tel. 232712	M.BS. Surveyors Tel. 256782
Geo-Chem Laboratories Pvt Limited Tel. 221841, 222179 Fax. 233743	Navark & Mareng Surveyors & Consultants Tel. 232123, 233270
G. P. Dave & Sons Tel. 234288 Fax. 234382	S.G.S. India Limited Tel. 221857, 238047, 231869 Fax.232883
Gupta & Associates Tel. 222542 Fax. 222542	S. K. S. Surveyors Assessors Tel. 220555
Inspectorate (India) Consulting	Seascan Surveyors Pvt Limited

Engineering Pvt Limited Tel. 221520, 235636 Fax. 255217	Tel. 221833, 233639, 221627 Fax. 233639
Indian Register of Shipping & Indian Register Quality System Tel. 238623, 233695 Fax. 233695	Sterling Surveyors Tel. 230216 Fax. 230216
Iteng Engineering Tel. 221520, 255429 Fax. 255247	Technomar Surveyors Pvt Limited Tel. 221966
J B Boda Surveyors Pvt Limited Tel. 231801, 231946 Fax. 231693	TCRC Surveyors Tel. 220862, 230050 Fax. 230050
Lloyds Register of Shipping Tel. 234068	Uni Lab (India) Surveyors and Superintendents Tel. 255503
Mitra S K Pvt Limited Tel. 222648	Universal Cargo Inspection Agencies Tel. 222542
Metcalfe Hodgkinsons Pvt Limited Tel. 220940, 221740, 233707, 221845 Fax. 231629	U Marine (India) surveyors Tel. 220070 Fax. 233228

ANNEXURE – Q

M/s Precitech Laboratories, Vapi Work order dated 05/02/2021

DEENDAYAL PORT TRUST

Administrative Office Building
Post Box NO. 50
GANDHIDHAM (Kutch).
Gujarat: 370 201.
Fax: (02836) 220050
Ph.: (02836) 220038

www.deendayalport.gov.in

NO.EG/WK/4783/V/131 Dated : 05/02/2021

To,
M/s Precitech Laboratories Pvt Ltd,
1st Floor, Bhanujyot Complex,
Plot No C5/27, B/h Panchratna Complex,
Nr. GIDC Char Rasta,
VAPI-396195.

Sub: **Work order** for "STRENGTHENING OF EXISTING ENVIRONMENTAL MANAGEMENT CELL AT DEENDAYAL PORT TRUST: Appointment of environment experts for two years further extendable for one year"-**reg**.

Ref: 1) Tender dated 21.06.2019 submitted by M/s Precitech Laboratories Pvt.Ltd, Vapi.
2) Letter of Acceptance vide no-EG/WK/4783/V/100 dtd 01(04).01.2021
3) Letter from DPT no E/WK/4783/V/103 dtd 06.01.2021
4) Performance Guarantee submitted by M/s Precitech Laboratories Pvt Ltd in the form of Bank Guarantee of Rs. 3,60,000.00 vide Bank Guarantee no. 1102921BG0000016 dated 19.01.2021 issued by State Bank of India, Vapi.

Sir,

Kindly refer above cited Letter of Acceptance dtd 01(04).01.2021.

2) You shall have to provide Key Experts as per tender requirement during the entire contract period. Accordingly, you shall have to submit the qualification and experience certificates of the Key experts to be appointed at DPT, as per tender conditions for verification & approval.

3) Please submit the Agreement of contract as per tender conditions no 1.29.

4) Kindly commence the work on or before 15.02.2021.

……Cont……..

Please note that the time period for providing Consultancy services for the subject work will be initially for two years and further extendable for one year on mutual consent as per tender conditions.

Thanking you.

Yours faithfully,

Superintending Engineer (Design & EMC (i/c))
Deendayal Port Trust

ANNEXURE – R

Office order of Environment Manager

दीनदयाल पोर्ट ट्रस्ट
अभियांत्रिकी विभाग
(स्थापना अनुभाग)

Sub: Duty Report of Shri Mukkannawar Utkarsh Suresh appointed as Manager (Env.) - reg.

With reference to above cited subject, as Shri Mukkannawar Utkarsh Suresh has been appointed as Manager (Environment) on contract basis, accordingly Duty Report already forwarded to SE (EMC) under Pipeline Division. The establishment/salary may please be process in the Pipeline Division.

संलग्न्क : यथोक्त।

मुख्य अभियंता के निजि सहायक
दीनदयाल पोर्ट ट्रस्ट

S E (PL)
No. EG/PS/4729/ 539 Date : 11 /02/2022

DA(PL)/Shri Pandhir

दीनदयाल पोर्ट ट्रस्ट

अभियांत्रिकी विभाग

(स्थापना अनुभाग)

Sub: Duty Report of Shri Mukkannawar Utkarsh Suresh appointed as Manager (Env.) - reg.

With reference to above cited subject, as Shri Mukkannawar Utkarsh Suresh has been appointed as Manager (Environment) on contract basis, accordingly Duty Report dated 07/02/2022 received from Shri Mukkannawar, is forwarded in original alongwith Fitness certificate vide No. MH/GNU/1112 dated 04/02/2022 issued by the CMO and Offer letter for engagement issued by the Secretary vide No. GA/PS/4292/HE(PF)/2017/304 dated 17/01/20222, read with remarks of Chief Engineer below the Duty report, posting of Shri Mukkannawar in EMC Cell, for information and further necessary action in accordance with the relevant rules please.

संलग्नक : यथोक्त।

मुख्य अभियंता के निजि सहायक
दीनदयाल पोर्ट ट्रस्ट

SE(EMC)
EMC CELL
No. EG/PS/4729/526

Date : 9 /02/2022

Copy to:

192
09/02/2022 Sr. AS (P) w.r. to his note no. GA/PS/4292(HE)PF/2017/496 dtd. 07/02/2022, for further necessary action, please.

Shri Anwar Dave
Shri Padalia
9/2/22

Date : 07.02.2022

To
The Secretary,
Deendayal Port Trust,
Gandhidham

Sub : Duty Report.

Sir,

I have been offered the appointment to the post of Manager(Environment) vide your offer letter No. GA/PS/4292/HE(PF)/2017/304 dated 17.01.2022.

Therefore, I hereby submit my duty report today i.e. 07.02.2022(FN).

Thanking you,

Yours faithfully,

(Dr.Mukkannawar Utkarsh Suresh)

EMC-Cell

07/02/2022
CE

DS(E)
7/2/22

DEENDAYAL PORT TRUST

Medical Department

Sub: Certificate of Fitness – Shri Mukkanwar Utkarsh Suresh Manager-Environment

Ref: GA/PS/4292/HE/PF/2017/304 dated 17.01.2022

With reference to the above, Shri Mukkanwar Utkarsh Suresh has been examined on 07.02.2022 and he is found medically fit.

7/2/22

Chief Medical Officer

Secretary

No: MH/GN/1112/

Date: 07.02.2022

GENERAL ADMINISTRATION DEPARTMENT

ESTABLISHMENT SECTION

Sub : Duty Report of Shri Mukkannawar Utkarsh Suresh as Manager (Environment)

Shri Mukkannawar Utkarsh Suresh was offered the post of Manager(Environment) vide this office's offer letter No.GA/PS/4292/HE(PF)/ 2017/304 dated 17.01.2022 with last date of joining as 27.01.2022. On his request vide email dated 19.01.2022, he was granted extension of 11 days for joining, after approval of the Competent Authority.

A copy of the duty report and extension letter for joining is enclosed herewith for further necessary action please.

Encl : As above. (plus medically fitness certificate)

Sr.Asstt. Secretary
Deendayal Port Trust

PA to Chief Engineer

No.GA/PS/4292/HE(PF)2017/ 496 Date : 07 /02/2022

318
08/02/22

DEENDAYAL PORT TRUST

ISO 9001 : 2008 : ISO 14001 : 2004

Ph. : 02836-220167
Fax: 02836-233172
website: deendayalport.gov.in
e-mail : secretary@deendayalportgov.in

General Administration Deptt.
Administrative Office Building,
Post Box No. 50,
Gandhidham (Kutch) 370 201

By Speed Post / E-mail

No. GA/PS/4292/HE(PF)/2017/ 304 Dated, 17 January, 2022

OFFER OF CONTRACTUAL ENGAGEMENT AS MANAGER(ENVIRONMENT), IN DEENDAYAL PORT TRUST.

With Reference to your application for contractual engagement as Manager – Environment, in response to the advertisement, inviting applications for the subject position, on assessment and interview before the Services Selection Committee on 06.01.2022, the Competent authority has been pleased to offer the contractual engagement as Manager (Environment) in Deendayal Port Trust, purely on contractual basis, subject to the following terms and conditions :

a) Roles & Responsibilities

- Develop, implement and manage long term port environmental programmes such as the Green Marine Programme, sustainability plan, air strategies, tenant environment plan and tenant lease management.
- Represent the Port in local, state and federal agency meetings.
- Assist in the development and updating of the Port's comprehensive scheme of Harbour improvements and strategic plan.
- Monitor and conduct regular mock drills to train the employees at different levels.

b) Remuneration :-

Your consolidated remuneration per month will be Rs.1,00,000/- (Rupees One Lakh Only). Suitable increase depending upon the performance and variation in the AICP index may be given after successful completion of yearly service. Applicable taxes will be deducted at the time of payment.

c) Period of Contract :

The contract will be for a period of 3 years, extendable by another two years, subject to satisfactory performance.

d) Duty Hours :

You may be posted at/under any department/authority of Deendayal Port Trust, as per requirement, Duty Hours are from 10.00 AM to 06.00 PM or as may be decided by the Administration from time to time. In case of requirement, you may have to work beyond the normal duty hours, for which no other compensation, monetary or otherwise will be considered.

Contd....

(Mukkannawar Utkarsh Suresh)

You will normally be entitled to a weekly off on Sunday. If situation warrants, the weekly day of rest may be changed with prior intimation. For work on any weekly day off / declared national holiday in exigencies of work, a compensatory day of rest as per the convenience of the Administration, in lieu thereof, will be granted and for which no other compensation, monetary or otherwise will be considered.

Failure to report for duty will entail deduction of wages on pro-rata basis.

e) Medical facility : Only Outdoor Medical treatment facility for self and your spouse will be provided in the Port Trust Hospital. No other medical facilities will be provided to you/ your family.

f) Leave entitlement : 10 days leave in a year and National Holidays will be given. No other leave will be admissible and for any absence beyond the said leave, pro-rata deduction will be made from the consolidated remuneration.

g) Accommodation : Suitable accommodation, if available, may be provided, subject to recovery of charges under FR-45A, and the element of HRA excluded from the lumpsum remuneration.

h) Your engagement on contractual basis is subject to strict adherence to the norms and conduct.

i) The engagement can be terminated by giving one month's notice in writing from either side. However, in case of unsatisfactory performance or for any act considered derogatory/ detrimental to the interest of Deendayal Port Trust, this contractual engagement will be terminated forthwith.

j) If you leave without notice or without acceptance of notice of termination, the amount due i.e., consolidated remuneration payable will be forfeited.

k) You shall not claim any right/title/interest on par with the regular employees of the Port or otherwise.

l) You shall not have any claim/right whatsoever for regular appointment / absorption in Deendayal Port Trust under any circumstances.

m) Your contractual engagement is subject to verification of antecedents by the police. If any adverse report is received from the Police, your contractual services are liable to be terminated forthwith.

n) You will not be permitted to take any other assignment during the period of contract with Deendayal Port Trust.

.....

Contd....

(Mukkannawar Utkarsh Suresh)

l) On official tour outside Head Quarters, you will be entitled to TA/DA as admissible under the rules.

m) The terms and conditions shall be amended / modified depending upon the requirement of the Port. Any dispute(s)/difference(s) shall be decided solely by the Chairman, Deendayal Port Trust, which shall be final and binding.

n) You are required to submit discharge letter / relieving letter from your present employer at the time of joining Deendayal Port Trust, without you may not be allowed to join.

o) The contractual engagement is subject to your being found medically fit as per the requirements of Deendayal Port Trust.

2. You have to report for medical examination before the Medical Board of DPT at Gopalpuri Hospital on any working day between 10.00 hrs to 12.00 hrs.

3. If you agree to the above terms and conditions, you may convey acceptance by signing the duplicate of the letter in token of your acceptance and submit the same to this office and call at this office with all certificates and two copies of passport size photographs latest by 27th January, 2022 failing which the offer of contractual engagement stands automatically cancelled.

Secretary
Deendayal Port Trust

To
Shri. Mukkanawar Utkarsh Suresh,
21/1, Madhukunj Housing Society,
Near Canara Bank, Panchavati,
Pashan, Pune, Maharashtra - 411008.
Email : utkaish@gmail.com

I accept the above terms and conditions and will report for duty on _____.

Name :

Date :

Copy to: CMO – for conducting Medical Examination.

DEENDAYAL PORT TRUST

Certified under ISO 9001 : 2008 & ISO 14001 : 2004

Ph. : 02836-220167
Fax : 02836-233172
e-mail : sras@deendayalport.gov.in
Website : www.deendayalport.gov.in

General Administration Deptt.
Administration Office Building,
Post Box No. 50,
Gandhidham (Kutch) 370 201

No. GA/PS/4292/HE(PF)/2017/ 419

Dated, the 31 January, 2022

To
Shri Mukkannawar Utkarsh Suresh,
21/1, Madhukunj Housing Society,
Near Canara Bank,
Panchvati, Pashan, Pune,
Maharashtra - 411008

Sub:- Offer of engagement for the post of Manager(Environment) on contract basis in DPT [extension] – Reg.

Sir,

Reference this Offer Letter No.GA/PS/4292/HE(PF)/2017/304 dated 17th January, 2022 and your e-mail dated 19 January, 2022, on the above subject.

2. In this context, it is informed that the Competent Authority has acceded your request and accorded approval for extension of time of 11 days i.e., from 28.01.2022 to 07.02.2022 to take up your assignment at DPT, as 'Manager (Environment)'.

3. You are, therefore, requested to report to DPT latest by 08th February 2022 as 'Manager(Environment)' on the terms & conditions as mentioned in our offer letter dated 17/01/2022 on due observance of formalities as mentioned therein. However, no further extension will be granted, which may please be noted.

Yours Sincerely,

31/01/2022

Secretary
Deendayal Port Trust

28/1/22 1 28/1/2022 28/1/2022

Date : 07.02.2022

To
The Secretary,
Deendayal Port Trust,
Gandhidham

Sub : Duty Report.

Sir,

I have been offered the appointment to the post of Manager(Environment) vide your offer letter No. GA/PS/4292/HE(PF)/2017/304 dated 17.01.2022.

Therefore, I hereby submit my duty report today i.e. 07.02.2022(FN).

Thanking you,

Yours faithfully,

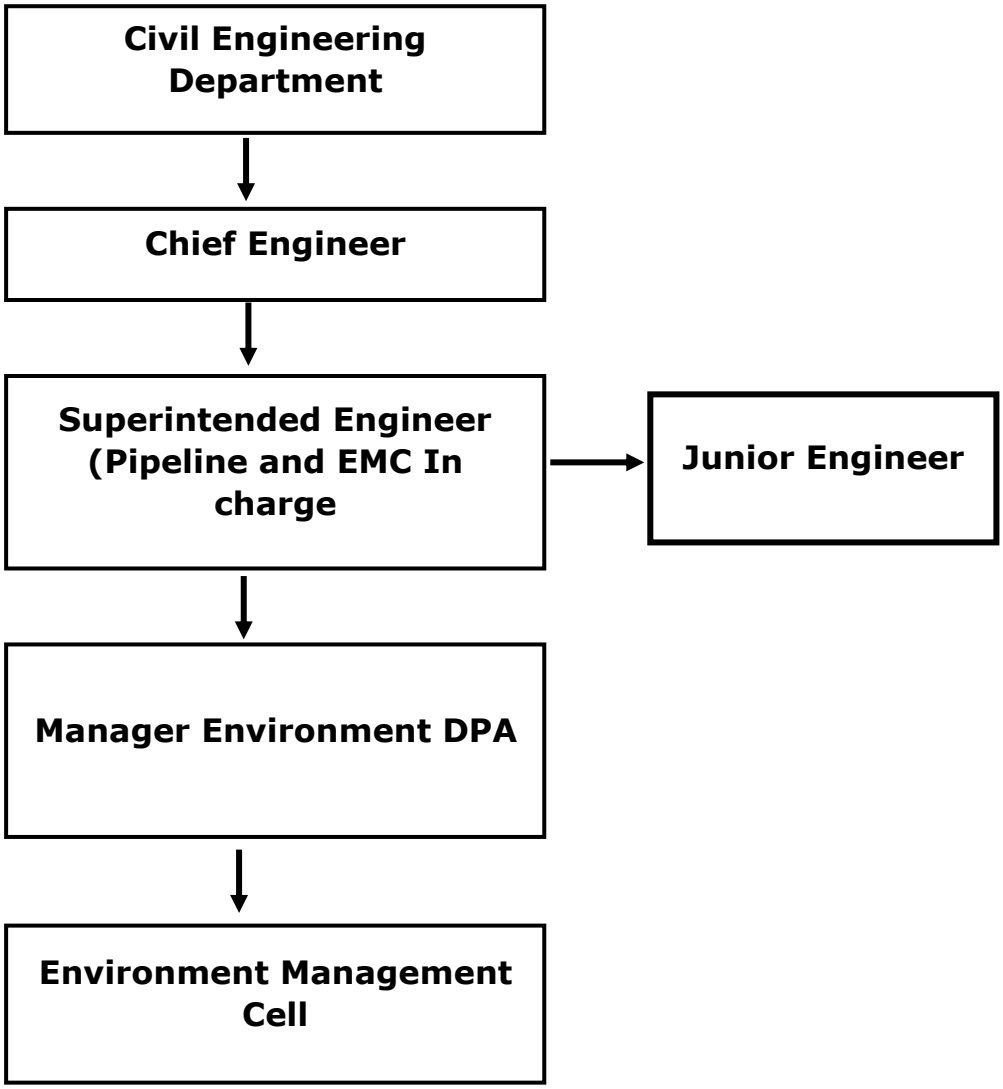
(Dr.Mukkapnawar Utkarsh Suresh)

GEN ADM DEPT
Inward No. 525/11
Date 07/02/2022

ANNEXURE – S

Organogram of EMC

ORGANIZATION CHART OF EMC



ANNEXURE – II

Certified Compliance Report dated 14/11/2022

भारत सरकार
GOVERNMENT OF INDIA
पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय
MINISTRY OF ENVIRONMENT, FOREST & CLIMATE CHANGE
एकीकृत क्षेत्रीय कार्यालय, गांधीनगर / **Integrated Regional Office, Gandhinagar**

ए 407 , 409 "अरण्य भवन ", सीएच-3 सर्कल के पास, सेक्टर-10ए, गांधीनगर-382010/ A-407& A-409, "ARANYA BHAWAN" Near CH-3 Circle, Sector-10A, **Gandhinagar**-382010
दूरभाष/**Tel No:** +9179-23255067 **Email:** iro.gandhingr-mefcc@gov.in

Dated:14th November, 2022

To
The Additional Director/ Scientist 'E'
Monitoring Cell
Ministry of Environment, Forest and Climate change,
Indira Paryavaran Bhawan, Jorbagh Road, Aliganj,

New Delhi-110003

Subject: Certified Compliance to M/s Deen Dayal Port Authority, Gandhidham, Kutch, Gujarat -reg.

Ref: GPCB Consent Letter No - GPCB/CCA-Kutch-812(5)/GPCB ID-28494 dated 22/01/2021.

Madam/Sir,

With reference to the cited subject, it is brought to your kind notice that the aforesaid project was inspected on 6th September 2022 by the undersigned for the purpose of issuing certified compliance report.

2. Accordingly, a detailed monitoring report (copy enclosed) along with observations is being attached herewith for perusal and further appropriate action.

Encl: As above

Yours Sincerely

(Dr. Yogesh Kumar)
Deputy Director (S)/Scientist- 'C'
IRO Gandhinagar, MoEFCC

Copy to: -

1. The Member Secretary, SEIAA Gujarat, Sector 10A, Gandhinagar (msseiaagj@gmail.com).
2. The Chairman, M/s Deen Dayal Port Authority, Administrative office Building, Gandhidham, Kutch, Gujarat -37020.

Compliance Report Up to June, 2022

Subject: Point wise compliance report of stipulated conditions mentioned in the Consolidated Consent & Authorization order no AWH-110594 dated 22/01/2021 to Deendayal Port Trust, (New Name) PCB ID -28494

Reference: CCA issued vide consent order no. GPCB/CCA-Kutch-812(5)/GPCB ID-28494 dated 22/01/2021

Sr. No	Conditions	Compliance Status
1	**Specific Conditions**	
1	Unit shall strictly adhere to compliance ministry in its letter file no. 11-82/2011-IA-III, dated 2016	**Agreed to comply by the project proponent.** As per the records furnished during the visit it was observed that the DPA has already obtained valid CCA from board (Consent Order No. AWH-110594 issued on 8/12/2020 and valid up to 21/7/2025) and CCA compliance report was also presented for inspection. It was also observed that the DPA has been regularly submitting the six-monthly compliance reports of stipulated conditions of EC & CRZ clearance granted by the MoEF&CC, GoI, to the concerned authority. Last compliance report was submitted on 07/10/2021 and acknowledgement copy for the same was presented for inspection. Further, the project proponent has assured that DPA is complying with the specific condition as well as conditions mentioned under air, water and hazardous waste management by adhering to all the stipulations made by Gujarat Pollution Control Board, State Government and any statutory authority.
2	Unit shall strictly adhere to all conditions of Environment and CRZ clearance issued by MoEF vide letter no. F. No. 11-70/2006-IA-III	**Agreed to comply by the project proponent.** It is hereby assured that DPA is complying with all the conditions of EC and CRZ clearance issued by MoEF vide letter no. F. No. 11-70/2006-IA-III and regularly submitting the compliance report to the ministry. Last compliance report was submitted on 07/10/2021 and acknowledgement copy for the same was presented for inspection.
3	Applicant shall comply with Manufacture, storage and import of Hazardous Chemicals Rules-1989 (MSIHC) as amended time to time.	**Complied.** During the visit it was informed that as per the lease deed all the statutory clearance and its compliance needs to be done by the plot allotee/BOT operator. All plot allotees/BOT operators are complying with the said rules. The project proponent has agreed that DPA will assure strict compliance of all conditions of Manufacture, storage and import of Hazardous Chemicals Rules-1989 (MSIHC) as amended time to time.

Sr. No	Conditions	Compliance Status
4	Applicant shall ensure that all storage terminal located within DPT area shall strictly comply with MSIHC rules including site notification & submit details periodically to board with relevant details.	**Agreed to comply by the project proponent.** Kindly refer above condition. It is hereby assured that DPA will ensure that all storage terminal located within DPT area will strictly comply with MSIHC rules including site notification & submit details periodically to board with relevant details.
5	Applicant shall renew Public Liability Insurance time to time & submit a copy to this Board.	**Complied.** As per the records furnished during the visit it was observed that public liability insurance is renewed time to time as required and its copy is submitted to the board with the six-monthly compliance reports. The public liability insurance was last renewed from The New India Insurance Company Limited on 22/07/2021 and is valid till 22/07/2022.
6	Unit shall notify site under MSIHC Rule – 1989 from component authority as mentioned in Schedule – 5 of MSIHC notification.	**Agreed to comply by the project proponent.** Kindly refer specific condition no. 3.
7.	Industry shall not withdraw groundwater without prior NOC from CGWA as per Hon. National Green tribunal order.	**Agreed to comply by the project proponent.** During the visit it was informed that all plot allottees and BOT Operators have confirmed that Water requirement is being met through GWSSB (Narmada Pipeline) & through private tankers. Further, the project proponent has assured that no groundwater was used during the compliance period and DPA will not withdraw groundwater without prior NOC from CGWA as per Hon. National Green tribunal order.
8.	Industry shall manage Solid waste generated from Industrial activities as per Solid Waste Management Rules-2016 (Solid waste as defined in Rule -3 (46))	**Complied.** During the visit it was observed that garbage facility is provided as per MARPOL Act 73/78 to the vessel berthed at Deendayal Port Trust. A copy of "Grant of Permission / License for removal of Dry Solid Waste (Non-Hazardous) from Vessels calling at Deendayal Port" was presented for inspection. It was informed that companies authorized by Central Pollution Control Board (CPCB) and State Pollution Control Board (SPCB) have been awarded the work of collection, transporting and disposal of solid waste by the Deendayal Port Trust. In additional to the above, DPT has invited a tender for Appointment of Advisor for "Preparation of Plan for Management of Plastic Wastes, Solid waste including C&D wastes, E-wastes, Hazardous wastes including Biomedical". The tender is under evaluation.

Sr. No	Conditions	Compliance Status
9.	Industry shall comply with Plastic Waste Management Rules – 2016 and amendments made therein	**Complied.** During the visit it was observed that DPT is managing its plastic waste as per Plastic Waste Management Rules – 2016 and amendments made therein. In order to strictly implement the said rules, DPT had issued a circular regarding plastic waste minimization, source segregation, recycling etc. vide its Circular no. EG/WK/4751/Part 243(A) dated 03/09/2021. Kindly refer above condition.
10.	Industry shall strictly comply with coal handling guidelines of this board.	**Partly Complied.** As per the records furnished during the visit it was observed that DPT vide its circular no. TF/SH/Circulars/2019/1256 dated 10/10/2019 has issued a circular for "controlling of Dust pollution arising out of Coal Handling" and same was presented for inspection. It is relevant to mention here that DPT has installed mist canon at the port area to minimize the coal dust. The work related to construction of protection wall with wind screen to prevent coal dust deposition in building has already been completed during the year 2011-2012. DPT appointed M/s Detox Corporation, Surat (NABL Accredited laboratory) for regular Monitoring of environmental parameters since the year 2016. The work is in progress & DPT submitted monitoring data regularly to all the concerned authorities along with compliance reports submitted. The Environmental Monitoring Reports as submitted by M/s Detox Corporation for the period March 2021 to February 2022 was presented for inspection. As per the suggestion in the report it was inferred that PM_{10} values at Coal storage area, Marine Bhavan, Oil Jetty and Tuna Port were occasionally found above the permissible standards and $PM_{2.5}$ was occasionally found above permissible limits at Coal storage area (100 $\mu g/m^3$ for PM_{10} & 60 $\mu g/m^3$ for $PM_{2.5}$). It was mentioned that the principal reason for higher PM_{10} values at Coal Storage and Marine Bhavan was bulk handling of coal, other dry cargo and heavy traffic of transport vehicles. The unit is directed to take appropriate and strict measures to control the air pollution at the DPT.
11.	Industry shall provide dedicated storage facility	**Complied.**

Sr. No	Conditions	Compliance Status
	for dry cargo and ensure to take adequate measure to prevent dusting.	During the visit it was observed that DPT has provided dedicated storage facilities for all type of Cargo including 33 warehouse and 67 open storage space. Kindly refer above condition. Further to prevent the dusting DPT invited the tender for "Appointment of consultant for the study & preparation of techno economic feasibility report for mechanized handling of cargo at DPT". The tender is in scrutiny stage.
12.	The applicant shall ensure that there shall be no damage to the existing mangrove patches near site and also ensure the free flow of water to avoid damage to the mangroves.	**Complied.** During the visit it was informed that as per the directions of the GCZMA and MoEF&CC,GoI, till date, DPT had already undertaken Mangrove Plantation in an area of 1500 Ha. till date since the year 2005. A statement showing details of mangrove plantation at various locations with cost incurred around 419.7 lakhs was presented for inspection. It is also relevant to submit here that, as per the direction of the Gujarat Coastal Zone Management Authority, DPT had already prepared & submitted a report on mangrove conservation and management plan formulated by Gujarat Institute of Desert Ecology during the study period of Jan-April, 2015. In addition to the above, DPT appointed M/s GUIDE, Bhuj vide work order dated 1/9/2017 for "Regular Monitoring of Mangrove Plantation carried out by DPT" (period 15/9/2017 to 14/9/2018). Further, DPT vide work order dated 3/5/2021 has assigned work to M/s GUIDE, Bhuj for monitoring of mangrove plantation carried out by DPT (Period from 24/5/2021 to 23/5/2022). M/s GUIDE, Bhuj submitted its inception report for the said project on 21/09/2021. All the above-mentioned reports were presented for inspection.
13.	Applicant shall ensure as per EC condition that no creeks or rivers are blocked due to any activities at the site and free flow of water is maintained.	**Complied.** During the visit it was informed that the plot allottees/BOT operators have assured that, no creeks or rivers are being blocked, due to any activities at the project site and free flow of water is being maintained.
14.	Applicant shall provide proper system for collection, storage and treatment and disposal of waste water generated by vessel as per MARPOL & maintain records.	**Complied.** During the visit it was observed that DPT has a dedicated Sewage Treatment Plant (STP) at Deendayal Port, Kandla and Gopalpuri Township, Gandhidham

Sr. No	Conditions	Compliance Status
		for treatment of waste water. The water is being stored at underground tanks at various locations at Kandla. DPT is planning to invite a tender for Construction, Operation and Maintenance of a WTP for 2.5 MLD Capacity at Kandla. The same is in inception stage.
15.	Applicant shall install storm drainage catch basin to avoid directly discharge into surface water.	**Complied.** During the visit it was observed that necessary surface drainage system including storm water network has been provided for proper drainage.
16.	Waste effluent accumulated with port activities including storm water & sewage from port operation including sewage ballast water, bilge water & clean waste from ships shall be as per MARPOL norms.	**Complied.** During the visit it was observed that a copy of grant of license/permission to carry out the work of collection and disposal of "Hazardous Waste/Sludge/ Waste Oil" from Vessels calling at Deendayal Port" was presented for inspection.
17.	Applicant shall make separate records regarding generation, collection, transportation and disposal of waste generation from ship & maintain its records.	**Partly Complied.** The unit is directed to submit the data regarding generation, collection, transportation and disposal of waste generation from ship during the compliance period to this office.
18.	Applicant shall made necessary arrangement for plastic waste, solid waste or other waste generation due to port activities & for facilitation of reception facilities under MARPOL & Environment (Protection) Act – 1986 rules etc.	**Complied.** Kindly refer specific condition no. 8 and 9.
19.	Ports shall obtain approval of their oil spill contingency plan (OSCP) as required under national oil spill disaster contingency plan (NOS-DCP) of coast guard. Ministry of defense, govt. of India.	**Complied.** During the visit it was observed that DPT is already having Oil Spill Contingency Plan which was presented for inspection.
20.	Best environmental practices by ports maybe uploaded on "Indian ports Association" as well as the same may be linked to websites of CPCB and respective SPCBs.	**Complied.** During the visit it was observed that DPT is ISO 14001:2015 certified port for "Providing port facility and related maritime services for vessel and Cargo handling including storage" with certificate no. E:201002 valid up to 1st January 2023 and certificate copy was presented for inspection. As per the directions of the GCZMA and MoEF&CC,GoI, till date, DPT had already undertaken Mangrove Plantation in an area of 1500 Ha. till date since the year 2005. A statement showing details of mangrove plantation at various locations with cost incurred around 419.7 lakhs was presented for inspection. DPT has appointed M/s GEMI, Gandhinagar for the work "Making Deendayal Port a Green Port– Intended

Sr. No	Conditions	Compliance Status
		Sustainable Development under the Green Port Initiatives". M/s GEMI, Gandhinagar had submitted the Final Report on 10/03/2021 which was presented for inspection. In addition to the above, DPT has been submitting regularly the compliance of the conditions stipulated in Environmental & CRZ Clearance, CRZ recommendation and CTE to MoEF&CC along with all statutory bodies. The same is being uploaded in MoEF&CC parivesh portal on regular basis. DPT also has been regularly submitting Annual Return of Hazardous waste in Form IV and Environmental Statement in Form V for the entire port area and uploading the same in GPCB site on regular basis. Form IV and V for the year 2021-22 was presented for inspection.
21.	Manually handling of cargo should be converted into mechanized system, in time bound manner.	**Complied.** During the visit it was informed that DPA is in process for mechanization of solid cargo handling and it will be implemented Q2-2022. In view of the same, DPA has invited tenders for "Development of Mechanized Fertilizer & Other Clean Cargo Handling Facilities on DBOT basis under PPP mode". The same is under evaluation stage. DPA has also invited tender for "Appointment of consultant for the study & preparation of techno economic feasibility report for mechanized handling of cargo at DPA". The same is also under evaluation stage.
3.	**Conditions Under Water Act - 1974**	
3.1	Source of Water – GWIL	**Complied.** During the visit it was informed that all plot allottees and BOT Operators have confirmed that Water requirement is being met through GWSSB (Narmada Pipeline) & through private tankers.
3.2	There shall be no industrial water consumption and waste water generation from manufacturing process and other ancillary operations.	**Not applicable.** During the visit it was informed that no manufacturing process or any other ancillary operations involved.
3.3	The quantity of the fresh water consumption for domestic purpose shall not exceed 1300 KLD	**Partly Complied.** As per the records furnished during the visit it was observed that DPA has been regularly submitting Environmental Statement in Form V for the entire port area and uploading the same on XGN website of GPCB on regular basis. Form V for the year 2021-22 which includes total water consumption for the period from April 2021 to

<table>
<tr><th>Sr. No</th><th>Conditions</th><th>Compliance Status</th></tr>
<tr><td></td><td></td><td>March 2022 was 741205.47 KL hence, average water consumption for per day – 2030.7 KLD which is 56% more than the prescribed limit.
The unit is directed to submit the details for increase in water consumption during the compliance period to this office.</td></tr>
<tr><td>3.4</td><td>The quantity of domestic waste water shall not exceed 800 KLD</td><td>Partly Complied.
The unit is directed to submit the data of domestic waste water generation during the compliance period to this office which was not mentioned in Form-V.</td></tr>
<tr><td>2.5</td><td>Domestic effluent shall be treated effluent conforming to following norms shall be discharged on land within premises strictly for gardening and plantation & no sewage shall be disposed outside premises in any manner.
<table>
<tr><td>Parameters</td><td>Permissible Limit</td></tr>
<tr><td>pH</td><td>6.5 to 8.5</td></tr>
<tr><td>BOD(5 days at 20 ^{0}C)</td><td>30 mg/lit</td></tr>
<tr><td>Suspended Solid</td><td>100 mg/lit</td></tr>
<tr><td>Fecal coli form</td><td>< 1000 MPN/100 ml</td></tr>
</table></td><td>Complied.
As per the records furnished during the visit it was observed that DPA appointed M/s Detox Corporation, Surat (NABL Accredited laboratory) for regular Monitoring of environmental parameters since the year 2016. The work is in progress & DPA submitted monitoring data regularly to all the concerned authorities along with compliance reports submitted.

As per the Environmental Monitoring Reports submitted by M/s Detox Corporation, it was observed that the drinking water was safe for human consumption as per tested parameters only at all drinking water monitoring stations.</td></tr>
<tr><td>3.6</td><td>Treated domestic effluent confirming to above norms shall be discharged on land only for gardening & plantation within premises.</td><td>Complied.
During the visit it was observed that sewage is treated in the STP of Kandla and Gopalpuri Residential Colony. The treated effluent from STP is utilized for gardening purpose.

It was also observed that a new STP with improved capacity of 1.5 MLD at Deendayal Port is operational which is working as per the standards of CPCB/GPCB.</td></tr>
<tr><td>3.7</td><td>Unit shall provide flow meter at inlet & outlet of STP & maintain its record.</td><td>Complied.
During the visit it was observed that DPA has appointed M/s Patel construction for operation and maintenance of the STP at Kandla.

Both the sewage treatment plants at Kandla and Gopalpuri residential colonies are equipped with flow meters at inlet and outlet and record is being maintained.</td></tr>
<tr><td>3.8</td><td>Disposal system for storm water shall be provided separately, in no case storm water and sewage from port facilities shall not be discharged into surface water.</td><td>Complied.
During the visit it was observed that necessary surface drainage system including storm water network has been provided for proper drainage.</td></tr>
</table>

<table>
<tr><th>Sr. No</th><th>Conditions</th><th>Compliance Status</th></tr>
<tr><td>4.</td><td colspan="2">Conditions under air act 1981:</td></tr>
<tr><td>4.1</td><td>The following shall be used as a fuel in D.G sets
<table>
<tr><td>Sr.No.</td><td>Utility</td><td>Fuel</td><td>Quantity</td></tr>
<tr><td>1.</td><td>D.G Set</td><td>HSD</td><td>500 Ltr/Hr</td></tr>
</table></td><td>Complied.
As per the records furnished during the visit it was observed that total consumption of HSD during the compliance period is as below: -

D.G -1 – 1050 L for the year 2021
D.G -2 – 105 L for the year 2021</td></tr>
<tr><td>4.2</td><td>The applicant shall install & operate air pollution control system efficiently in order to achieve prescribed norms.</td><td>Complied.
During the visit it was observed that DPA is taking measures for mitigation of air pollution:

- DPA appointed M/s Detox Corporation, Surat (NABL Accredited laboratory) for regular Monitoring of environmental parameters since the year 2016. The work is in progress & DPA submitted monitoring data regularly to all the concerned authorities along with compliance reports submitted.
- Further, DPA has already invited tender for ‘Online Continuous Ambient Air Quality Monitoring (CAAQM) For the Period of Three Years at Deendayal Port Authority’. The same is under evaluation stage.
- Regular sprinkling of water is being done to suppress the fugitive dust. In addition, DPA has installed mist canon at various strategic locations to suppress dust from port operations.
- DPA is in process for mechanization of dry cargo handling. In this regard, Tender has been invited for “Appointment of consultant for the study & preparation of techno economic feasibility report for mechanized handling of cargo at DPA”. The same is under evaluation.
- Deendayal Port Authority had taken up massive greenbelt development activities in and around Kandla, Residential colony, administrative building etc.
- DPA had entrusted the work to Forest Department, Gujarat for developing green belt in and around Port area at a cost of Rs. 352 lakhs in an area of about 32 hectares and the work is completed.</td></tr>
<tr><td>4.3</td><td>The flue gas emission through stack attached to D.G sets shall confirm to the following standards
<table>
<tr><td>Sr. No.</td><td>Stack attached to</td><td>Stack height in meter</td><td>APCM</td><td>Parameter</td><td>Permissible limit</td></tr>
<tr><td>1.</td><td>D.G sets</td><td>15 each</td><td>--</td><td>PM</td><td>150</td></tr>
</table></td><td>Partly Complied.
As per the records furnished during the visit it was observed that DPA appointed M/s Detox Corporation, Surat (NABL Accredited laboratory) for regular monitoring of environmental parameters since the year 2016. The work is in progress & DPA submitted monitoring data regularly to all the concerned</td></tr>
</table>

<table>
<tr><th>Sr. No</th><th>Conditions</th><th>Compliance Status</th></tr>
<tr><td></td><td>
<table>
<tr><td></td><td>(2 No.s) (1010 KVA)</td><td></td><td></td><td>SO2
NOx</td><td>mg/NM3
100 ppm
50 ppm</td></tr>
</table>
</td><td>authorities along with compliance reports submitted.

The Environmental Monitoring Reports as submitted by M/s Detox Corporation for the period March 2021 to February 2022 was presented for inspection. As per the suggestion in the report it was inferred that PM_{10} values at Coal storage area, Marine Bhavan, Oil Jetty and Tuna Port were occasionally found above the permissible standards and $PM_{2.5}$ was occasionally found above permissible limits at Coal storage area (100 µg/m^3 for PM_{10} & 60 µg/m^3 for $PM_{2.5}$). It was mentioned that the principal reason for higher PM_{10} values at Coal Storage and Marine Bhavan was bulk handling of coal, other dry cargo and heavy traffic of transport vehicles.

The unit is directed to take appropriate and strict measures to control the air pollution at the DPT.</td></tr>
<tr><td>4.4</td><td>There shall be no process gas emission from manufacturing in the ambient air within the premises of the industry and a distance of 10 meters form the source other than the stack/vent shall not exceed the following levels.</td><td>Not applicable.
During the visit it was informed that no manufacturing process or any other ancillary operations involved.</td></tr>
<tr><td>4.5</td><td>The concentration of the following parameters in the ambient air within the premises of the industry and a distance of 10 meters from the source other than the stack/vent shall not exceed the following levels.
<table>
<tr><th>Sr. no.</th><th>Pollutant</th><th>Time weighted Average</th><th>Concentration in ambient air in µg/m^3</th></tr>
<tr><td>1.</td><td>Sulphur Dioxide (SO_2)</td><td>Annual
24 Hour</td><td>50
80</td></tr>
<tr><td>2.</td><td>Nitrogen Dioxide (NO_2)</td><td>Annual
24 Hour</td><td>40
80</td></tr>
<tr><td>3.</td><td>Particulate matter (size less than 10 µm) or PM_{10}</td><td>Annual
24 Hour</td><td>60
100</td></tr>
<tr><td>4.</td><td>Particulate matter (size less than 2.5 µm) or $PM_{2.5}$</td><td>Annual
24 Hour</td><td>40
60</td></tr>
</table>
</td><td>Agreed to comply by the project proponent.</td></tr>
<tr><td>4.6</td><td>The applicant shall provide portholes, ladder, platform etc at chimney (s) for monitoring the air emissions and the same shall be open for inspection to/and for use of Board’s staff. The chimney(s) vents attached to various sources of emission shall be designated by number such as S-1, S-2, etc and these shall be painted/ displayed</td><td>Agreed to comply by the project proponent.</td></tr>
</table>

<table>
<tr><th>Sr. No</th><th>Conditions</th><th>Compliance Status</th></tr>
<tr><td></td><td>to facilitate identification.</td><td></td></tr>
<tr><td>4.7</td><td>The industry shall take adequate measures for control of noise levels from its own sources within the premises so as to maintain ambient air quality standards in respect of noise to less than 75 dB(A) during day time and 70 dB(A) during night time. Daytime is reckoned in between 6:00 am and 10:00 pm and night time is reckoned between 10:00 pm and 6:00 am</td><td>Complied.
As per the records furnished during the visit it was observed that DPA appointed appointed M/s Detox Corporation, Surat (NABL Accredited laboratory) for regular monitoring of environmental parameters since the year 2016. The work is in progress & DPA submitted monitoring data regularly to all the concerned authorities along with compliance reports submitted.
The Environmental Monitoring Reports as submitted by M/s Detox Corporation for the period March 2021 to February 2022 was presented for inspection. As per the report it was inferred that the day and night time noise quality was found within the permissible limits of the Noise Pollution (Regulation and Control) rules, 2000. The Day Time and Night Time Average Noise Level (SPL) in all ten locations at Deendayal Port were within the permissible limits of 75 dB(A) (for day time) and 70 dB(A) (for the night time) for an industrial area.</td></tr>
<tr><td>5.</td><td colspan="2">Authorization as per Hazardous And Other Waste (Management and Transboundary) Rules, 2016 form -2 [see rule 6 (2)]</td></tr>
<tr><td>5.1</td><td>Authorization order no. AWH-110594 date of issue: 08/12/2020</td><td>Noted.</td></tr>
<tr><td>5.2</td><td>M/s. Kandla Port Trust is hereby granted an authorization to operate facilities for following hazardous waste on the premises situated at Kandla, A.O building Gandhidham Tal.: Gandhidham, Dist: Kutch
<table>
<tr><th>Sr. No</th><th>Waste</th><th>Quantity/ Year</th><th>Schedule & Category</th><th>Facility</th></tr>
<tr><td>1.</td><td>Used spent oil</td><td>1125 MT</td><td>1-5.1</td><td>Collection, Storage, transportation And disposal by selling to Authorized Recycler</td></tr>
<tr><td>2.</td><td>Waste Residue Containing oil</td><td>3344.43 MT</td><td>1-5.2</td><td>Collection, Storage, transportation And disposal by selling to Authorized Recycler</td></tr>
</table></td><td>Partly Complied.
As per the records furnished during the visit it was observed that DPA has been regularly submitting Annual Return of Hazardous waste in Form IV for the entire port area and uploading the same on XGN website of GPCB on regular basis.
Form IV for the year 2021-22 which was submitted vide letter no. EG/WK/EMC/Part(III)/131 dated 06/07/2022 includes hazardous waste generation (i.e. used oil/waste residue containing oil) for the period from April 2021 to March 2022 was 9585.85 MT/annum. It was inferred that hazardous waste generation was 114% more than the prescribed limit.
The unit is directed to submit the details for increase in hazardous waste generation during the compliance period to this office.</td></tr>
<tr><td>5.3</td><td>The authorization shall be valid up to 21/07/2025</td><td>Noted.</td></tr>
<tr><td>5.4</td><td>The authorization is subject to the conditions stated below and such other conditions as may be specified in the rules from time to time under the</td><td>Agreed to comply by the project proponent.</td></tr>
</table>

Sr. No	Conditions	Compliance Status
	Environment (Protection) Act – 1986.	
5.5	The authorization is granted to operate a facility for collection, storage within factory premises transportation and ultimate disposal of hazardous wastes as per conditions no. 5.2 to the industry having valid CCA of this board.	**Noted.**
5.6	**Terms and Condition of Authorization**	
1.	The applicant shall comply with the provision of the Environment (Protection) Act-1986 and the rules made there under	**Agreed to comply by the project proponent.**
2.	The authorization or its renewal shall be produced for inspection at the request of an officer authorized by the Gujarat pollution Control Board.	**Agreed to comply by the project proponent.**
3.	The person authorized shall not rent, lend, sell, and transfer or otherwise transport the hazardous wastes without obtaining prior permission of the Gujarat Pollution Control Board.	**Agreed to comply by the project proponent.**
4.	Any unauthorized change in personnel, equipment or working conditions as mentioned in the authorized order by the persons authorized shall constitute a beach of this authorization	**Agreed to comply by the project proponent.**
5.	The person authorized shall implement Emergency Response Procedure (ERP) for which this authorization is being granted considering all site-specific possible scenarios such as spillages, leakages, fire etc, and their possible impact and also carry out mock drill in this regard at regular interval of time.	**Complied.** As per the records furnished during the visit it was observed that DPA has already prepared disaster management plan considering all site-specific possible scenarios such as spillages, leakages, fire etc, and their possible impact. In addition to the above mock drills are also carried out regularly for effective implementation of the same.
6.	The person authorized shall comply with the provisions outlined in the Central Pollution Control Board guidelines on "Implementing Liabilities for Environmental damages due to handling and disposal of Hazardous waste and penalty."	**Agreed to comply by the project proponent.**
7.	It is the duty of the authorized person to take prior permission of the Gujarat Pollution Control Board to close down the facility.	**Agreed to comply by the project proponent.**
8.	An application for the renewal of an authorization shall be made as laid down in rules 6 (2) under Hazardous and other wastes rules, 2016	**Agreed to comply by the project proponent.**
9.	The imported hazardous and other wastes shall be fully insured for transit as well as for any accidental occurrence and its clean-up operation.	**Not applicable.** During the visit it was informed that DPA is not involved in import of any kind of hazardous waste.
10.	The record of consumption and fate of the imported hazardous and other wastes shall be	**Not applicable.** Kindly refer above condition.

Sr. No	Conditions	Compliance Status
	maintained.	
11.	The hazardous and other wastes which gets generated during recycling or reuse or recovery or pre-processing or utilization of imported hazardous or other wastes shall be treated and disposed of as per specific conditions of authorization.	**Not applicable.**
12.	The importer or exporter shall bear the cost of import or export and mitigation of damage if any.	**Noted.**
13.	Any other conditions for compliance as per the guidelines issued by the ministry of Environment, Forest and climate change or Central Pollution Control Board from time to time.	**Noted.**
14.	The waste generator shall be totally responsible for (i.e collection, storage, transportation and ultimate disposal) the wastes generated.	**Agreed to comply by the project proponent.**
15.	Record of waste generation, its management and annual return shall be submitted to Gujarat Pollution Control board in form -4 by 30th day of June of every year for the preceding period April to March.	**Complied.** As per the records furnished during the visit it was observed that DPA has been regularly submitting Annual Return of Hazardous waste in Form IV for the entire port area and uploading the same on XGN website of GPCB on regular basis. Form IV for the year 2021-22 was submitted vide letter no. EG/WK/EMC/Part(III)/131 dated 06/07/2022 which includes hazardous waste generation (i.e. used oil/waste residue containing oil) for the period from April 2021 to March 2022.
16.	In case of any accidents, details of the same shall be submitted on Form-11 to Gujarat Pollution Control Board.	**Agreed to comply by the project proponent.**
17.	As per "Public Liability Insurance Act – 91" company shall get Insurance policy, if applicable.	**Complied.** Kindly refer specific condition no. 5.
18.	Empty drums and containers of toxic and hazardous material shall be treated as per guidelines published for "Management and Handling of discharged containers" records of the same shall be maintained and forwarded to Gujarat Pollution Control Board regularly.	**Agreed to comply by the project proponent.**
19.	In case of transport of hazardous waste to a facility for (i.e treatment, storage and disposal) existing in a state other than the state where hazardous wastes generated, the occupier shall obtain "No Objection Certificate" from the State Pollution Control Board or Committee of the concerned state of Union Territory Administration where facility exists.	**Complied.** As per the records furnished during the visit it was observed that DPA has appointed CPCB approved vendors for collection and disposal of "Hazardous Waste/Sludge/ Waste Oil". Kindly refer specific condition no.16.

Sr. No	Conditions	Compliance Status
20.	Unit shall all concrete measures to show tangible results in waste generation, reduction, avoidance, reuse and recycle. Actions taken in this regard shall be submitted within three months and also along with form -4	**Partly Complied.** The unit is directed to submit what appropriate measures are taken for waste generation, reduction, avoidance, reuse and recycle.
21.	Industry shall have to display the relevant information with regards to hazardous waste as indicated in the Hon. Supreme Court's Order in WP No. 657 of 1995 dated 14th October 2003.	**Agreed to comply by the project proponent.**
22.	Industry shall have to display on-line data outside the main factory gate with regard to quantity and nature of hazardous chemicals being handled in the plant, including wastewater and air emissions and solid hazardous wastes generated within the factory premises.	**Partly Complied.** The unit is directed to display on-line data outside the main factory gate with regard to quantity and nature of hazardous chemicals being handled in the plant, including wastewater and air emissions and solid hazardous wastes generated within the factory premises.
6.	**Specific Conditions: -**	
6.1	The authorized actual user of hazardous and other waste shall maintain records of hazardous and other wastes purchased in a passbook issued by the State Pollution Control Board along with the authorization.	**Agreed to comply by the project proponent.** The project proponent has assured that DPA will ensure that authorized recycler must maintain records of hazardous and other wastes purchased in a passbook issued by the State Pollution Control Board along with the authorization.
6.2	Handling over of the hazardous and other wastes to the authorized actual user shall be only after making the entry in the passbook of the actual user.	**Agreed to comply by the project proponent.** During the visit it was informed that DPA is keeping the details of hazardous waste handed over to the authorized recycler and has been regularly submitting Annual Return of Hazardous waste in Form IV for the entire port area and uploading the same in GPCB site on regular basis.
6.3	In case of renewal of authorization, a self-certified compliance report in respect of effluent, emission standards and the conditions specified in the authorization for hazardous and other wastes shall be submitted SPCB.	**Noted.**
6.4	The occupier of the facility shall comply standard operating procedure/guidelines published by MoEF&CC or CPCB or GPCB from time to time.	**Agreed to comply by the project proponent.**
6.5	Unit shall comply provisions of E-waste management Rules - 2016	**Agreed to comply by the project proponent.** It is relevant to mention here, that DPA has invited tender for Appointment of Advisor for "Preparation of Plan for Management of Plastic Wastes, Solid waste including C&D wastes, E-wastes, Hazardous wastes including Biomedical". The tender is under evaluation.
6.6	The disposal of hazardous waste shall be carried out as per the waste management hierarchy.	**Complied.** During the visit it was informed that waste

Sr. No	Conditions	Compliance Status
		management heirarchy i.e. prevent, reduce, reuse, recycle, recover and disposal is being strictly followed in order by the CPCB approved vendors appointed for the collection of hazardous waste.
6.7	The occupier of facilities shall not store the hazardous and other wastes for a period not exceeding ninety days. Prior permission of the board shall be obtained for extension of the storage period.	**Complied.** During the visit it was informed that DPA appointed CPCB approved vendors for collection of hazardous waste and they are collecting and disposing it on regular intervals.
6.8	The occupier shall maintain the records of generation, sale, storage, transport, recycling, co-processing and disposal of hazardous waste and make available during the inspection.	**Complied.** As per the records furnished during the visit it was observed that DPA maintains the record of all type of waste. DPA also has been regularly submitting Environmental Statement in Form V for the entire port area and uploading the same in GPCB site on regular basis. Form V for the year 2021-22 was also presented for inspection.
6.9	The transportation of the hazardous waste shall be carried out in GPS mounted dedicated vehicles.	**Complied.** During the visit it was informed that DPA has appointed CPCB authorized vendors for collection and transportation of Hazardous waste. DPA ensures that transportation of the hazardous waste is carried out in GPS mounted dedicated vehicles.
7.	**General Conditions: -**	
7.1	Any change in personnel, equipment or working conditions as mentioned in the consents from order should immediately be intimated to this Board.	**Agreed to comply by the project proponent.**
7.2	Applicant shall also comply with the general conditions given in Annexure 1	**Agreed to comply by the project proponent.**
7.3	Wherever due to accident or other unforeseen act or ever, such emissions occur or apprehend to occur in excess of standards laid down such information shall the forthwith reported to board, concerned police station office of Directorate of Health Service, Department of explosive, Inspectorate of Factories and local body.	**Agreed to comply by the project proponent.**
7.4	In case failure of pollution control equipments, the production process connected to it shall be stopped. Remedial actions/measures shall be implemented immediately to bring entire situation normal.	**Not applicable.** During the visit it was informed that DPA is not involved in any production activity.
7.5	The Environment management Unit/cell shall be setup to ensure implementation on and monitoring of Environmental safeguards and other conditions stipulated by statutory authorities. The Environment management Cell/Unit shall directly report to the Chief	**Partly Complied.** During the visit it was informed that DPA is already having environment management cell. Further, DPA has also appointed expert agency for providing Environmental Experts from time to time. DPA appointed M/s Precitech Laboratories, Vapi for

Sr. No	Conditions	Compliance Status
	executive of the organization and shall work as a focal point for internalizing environmental issues. These cells/units also coordinate the exercise of environmental audit and preparation of environmental statements.	providing Environmental Experts vide work order dated 5/2/2021. Further DPA has appointed manager Environment on contractual basis for the period of 3+2 years. The unit is directed to submit the organogram of environment management cell to this office.
7.6	The environmental audit shall be carried out yearly and the environmental statements pertaining to the previous year shall be submitted to this State Board latest by 30th September every year.	**Not applicable.** During the visit it was informed that as per Environment Audit Scheme, DPA is not a Schedule 1 or Schedule 2 industry. Hence, no Environmental Audit is required for the unit.
7.7	The Board reserves the right to review and/or revoke the consent and/or make variation in the conditions, which the Board deems, fit in accordance with section 27 of the Act.	**Noted.**
7.8	In case of change of ownership/management the name and address of the new owners/partners/directors/proprietor should immediately be intimated to the Board.	**Noted.**
7.9	Industry shall have to display relevant information with regard to hazardous waste as indicated in the Hon. Supreme order in w.p no. 657 of 1995 dated 14th October 8	**Noted.**

Summary note:

i. Implementation of conditions:

Out of total 81 conditions, it may be seen that 30 are complied, 9 are partly complied, 26 are agreed to comply by the project proponent, 7 are not applicable and 9 conditions are noted by the unit. These have been explained in the foregoing compliance report against each of the conditions, and the project proponent needs to take necessary and time bound action for early compliance in respect of the relevant conditions. A time targeted action taken report shall be furnished to MoEF&CC, IRO Gandhinagar in this regard within 30 days of receipt of the said letter.

ii. General observations

a. The cleanliness around hazardous waste storage area must be strengthened.
b. Good housekeeping practices must be strengthened.
c. The unit should maintain the records of welfare activities undertaken with necessary bills, documents and details of beneficiaries.
d. The raw material transfer points must be strengthened.

iii. Court cases and show cause/closure notices:

As per the records furnished during the site visit, it was noted that there are no court cases against the project and the unit has not received Show Cause Notice/ Notice of Direction from GPCB.

(Dr. Yogesh Kumar)
Deputy Director (S)/Scientist- 'C'
IRO Gandhinagar, MoEFCC

डॉ. योगेश कुमार / Dr. Yogesh Kumar
वैज्ञानिक 'सी' / Scientist 'C'
पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय,
Ministry of Enviroment, Forest & Climate Change,
भारत सरकार / Govt. of India
ए. क्षे. का., गाँधीनगर (गुजरात) / IRO,Gandhinagar(Gujarat)

ANNEXURE – III

Action Taken report submitted by DPA dated 21/12/2022

DEENDAYAL PORT AUTHORITY
(Erstwhile : DEENDAYAL PORT TRUST)

Administrative Office Building
Post Box NO. 50
GANDHIDHAM (Kutch).
Gujarat: 370 201.
Fax: (02836) 220050
Ph.: (02836) 220038

www.deendayalport.gov.in

EG/WK/4751/Part (CCA Renewal 1) Dated : 21/12/2022

To,
Dr. Yogesh Kumar, Deputy Director (S)/Scientist C,
Integrated Regional Office, MoEF&CC,
Office : A - 407 & A-409 , "ARANYA BHAWAN",
Near CH- 3 Circle, Sector – 10 A,
Gandhinagar – 382 010.

Sub: Certified Compliance Report issued by the Integrated Regional Office, MoEF&CC,GoI, Gandhinagar – **Submission of time targeted action taken report for partially complied conditions mentioned in the CCR reg.**

Ref: Certification Compliance Report issued by the Integrated Regional Office, MoEF&CC, Gandhinagar vide dated 14/11/2022.

Sir,

Kindly refer above cited reference for the said subject.

In this regard, it is to state that, as desired by the MoEF&CC,GoI (Ref.: EDS raised by the Member Secretary, EAC (Infra.1) – On line proposal filed by DPA vide proposal no. 280634 in PARIVESH PORTAL), the Integrated Regional Office, MoEF&CC, Gandhinagar has issued certified compliance report vide communication dated 14/11/2022, in respect of stipulated conditions mentioned in the Consolidated Consent & Authorization (CCA) issued by the GPCB vide dated 22/1/2021.

In the CCR issued, it was requested that, a time targeted action taken report shall be furnished to MoEF&CC,,IRO, Gandhinagar.

Accordingly, as desired, kindly find attached herewith time targeted action taken report in respect of partly complied conditions as **Annexure A**.

This has approval of the Chief Engineer, Deendayal Port Authority.

Yours faithfully,

22/12/22

Encl.: As above

Superintending Engineer (Design) & EMC (I/c)
Deendayal Port Authority

Copy for kind information to:
Shri Amardeep Raju,
Scientist E, Ministry of Environment, Forest and Climate Change,
& Member Secretary (EAC-Infra.1),
Indira Paryavaran Bhawan,
3rd Floor, Vayu Wing, Jor Bagh Road, Aliganj,
New Delhi- 110 003; E-mail:ad.raju@nic.in

TIME TARGETED ACTION TAKEN REPORT FOR THE CERTIFIED COMPLAINCE REPORT OF DEENDAYAL PORT AUTHORITY, GANDHIDHAM, KUTCH, GUJARAT VIDE FILE NO. J-11/77-2022-IROGNR Dated 14/11/2022

Sr. No.	Condition	Status and observation of RO	Time Targeted Action taken by DPA
	Specific Condition		
10.	Industry shall strictly comply with coal handling guidelines of this board	**Partly Complied.** As per the records furnished during the visit it was observed that DPT vide its circular no. TF/SH/Circulars/2019/1256 dated 10/10/2019 has issued a circular for "controlling of Dust pollution arising out of Coal Handling" and same was presented for inspection. It is relevant to mention here that DPT has installed mist canon at the port area to minimize the coal dust. The work related to construction of protection wall with wind screen to prevent coal dust deposition in building has already been completed during the year 2011-2012. DPT appointed M/s Detox Corporation, Surat (NABL Accredited laboratory) for regular Monitoring of environmental parameters since the year 2016. The work is in progress & DPT submitted monitoring data regularly to all the concerned authorities along with compliance reports submitted. The Environmental Monitoring Reports as submitted by M/s Detox Corporation for the period March 2021 to February 2022 was presented for inspection. As per the suggestion in the report it was inferred that PM10 values at Coal storage area, Marine Bhavan, Oil Jetty and Tuna Port were occasionally found above the permissible standards and PM2.5 was occasionally found above permissible limits at Coal storage area (100 µg/m3 for PM10 & 60 µg/m3 for PM2.5). It was mentioned that the principal reason for higher PM10 values at Coal Storage and Marine Bhavan was bulk handling of coal, other dry cargo and heavy traffic of transport vehicles.	It is submitted that, the continuous steps are being taken by DPA to control/minimize dust pollution within Port area, which are enumerated as under: • DPA already installed Sprinkling system inside Cargo Jetty area for Coal Dust Suppression in Coal Yard (40 Ha. area) at the cost of Rs. 14.44 crores. Continues water sprinkling is being carried out on the heap of coal, at regular intervals to prevent dusting, fire and smoke. • For the newly developed area of 34 hectares for coal storage, the work of installation of sprinkling system is in progress. • Two Road sweeper machines with compressor have been deployed along with two mist cannon machine for a contract period of 3 years, which are being operated continuously. • The work for protection wall along with wind screen at the periphery of coal storage yard is in progress (about 50% work completed). • Most of the roads and plots inside Port area are paved in order to prevent dusting. • The directions have already been issued from time to time to all the traders in order to ensure that all trucks before leaving the storage yards will be covered with tarpaulin, no overloading of trucks are allowed and there should not be spillage of cargo during transportation.

		The unit is directed to take appropriate and strict measures to control the air pollution at the DPT.	• DPA has appointed Gujarat Institute of Desert Ecology (GUIDE) for ***"Green belt development in Deendayal Port Authority and its Surrounding Areas, Charcoal site' (Phase-I)"*** vide Work Order No.EG/WK/4757/Part [Greenbelt GUIDE, dated 31st May, 2022. The work is in progress. • In order to check the efficiency of Mist Cannon by monitoring of SPM (PM 10 and PM2.5) before running of the mist canon van and after running of the van, an appointment of accredited agency is in process. It is once again relevant to submit here that, a continuous monitoring of Environmental parameters is being carried out through NABL accredited firm, M/s Detox Corporation, Surat in order to continuous check on Air quality & other parameters and accordingly, it is assured that, all further required & appropriate steps/measures will be taken to control the air pollution at the DPA.
17.	Applicant shall make separate records regarding generation collection, transportation and Disposal of waste generation from ship & maintain its records.	**Partly Complied.** ***The unit is directed to submit the data regarding generation, collection, transportation and disposal of waste generation from ship during the compliance period to this office***	It is relevant to submit here that, wastes received from the ships is being collected at the reception facility and is being handed over to the Authorized recyclers for disposal of the same. The data regarding Waste Generation from the ships for the period April, 2021 to March, 2022 is attached herewith as **Annexure – I.**
3.	**Conditions Under Water Act - 1974**		
3.3	The quantity of the fresh water consumption for domestic purpose shall not exceed 1300 KLD	**Partly Complied.** As per the records furnished during the visit it was observed that DPA has been regularly submitting Environmental Statement in Form V for the entire port area and uploading the same on XGN website of GPCB on regular basis.	DPA has submitted actual water consumption (741205.47 KL – Avg. per day – 2030.7 KLD) for the period from April, 2021 to March, 2022 in the Form V submitted to the GPCB.

<table>
<tr><td></td><td></td><td>Form V for the year 2021-22 which includes total water consumption for the period from April 2021 to March 2022 was 741205.47 KL hence, average water consumption for per day – 2030.7 KLD which is 56% more than the prescribed limit.

The unit is directed to submit the details for increase in water consumption during the compliance period to this office.</td><td>The main reason for increase in water consumption is due to expansion of Deendayal Port, Kandla viz. development of berths & associated back up area and ancillary infrastructure facilities.

It is hereby assured that, necessary amendment in CCA issued by the GPCB, will be obtained for increased water consumption for domestic purpose, immediately.

The details of actual water consumption for the period of April, 2021 to March, 2022 is attached herewith as <u>Annexure II</u>.</td></tr>
<tr><td>3.4</td><td>The quantity of domestic waste water shall not exceed 800 KLD</td><td>Partly Complied.

The unit is directed to submit the data of domestic waste water generation during the compliance period to this office which was not mentioned in Form-V.</td><td>It is submitted that, Avg. domestic waste water generation is 160 KLD. The details of Domestic waste water generation for the year 2021-22 is attached herewith as Annexure – III.</td></tr>
<tr><td>4.</td><td colspan="3">Conditions under air act 1981:</td></tr>
<tr><td>4.3</td><td>The flue gas emission through stack attached to D.G sets shall confirm to the following standards

<table><tr><td>Sr. no.</td><td>Stack attached to</td><td>Stack height in</td><td>APCM</td><td>parameter</td><td>Permissible limit</td></tr><tr><td>1.</td><td>D.G set (2 No.s 1010 KVA)</td><td>15 each</td><td>--</td><td>PM

SO2
NOx</td><td>150 mg/NM3
100 ppm
50 ppm</td></tr></table></td><td>Partly Complied.
As per the records furnished during the visit it was observed that DPA appointed M/s Detox Corporation, Surat (NABL Accredited laboratory) for regular monitoring of environmental parameters since the year 2016. The work is in progress & DPA submitted monitoring data regularly to all the concerned authorities along with compliance reports submitted.

The Environmental Monitoring Reports as submitted by M/s Detox Corporation for the period March 2021 to February 2022 was presented for inspection. As per the suggestion in the report it was inferred that PM10 values at Coal storage area, Marine Bhavan, Oil Jetty and Tuna Port were occasionally found above the permissible standards and PM2.5 was occasionally found above permissible limits at Coal storage area (100 µg/m3 for PM10 & 60 µg/m3 for PM2.5). It was mentioned that the principal reason for higher PM10 values at Coal Storage and Marine</td><td>It is submitted that, the continuous steps are being taken by DPA to control/minimize dust pollution within Port area, which are enumerated as under:

• DPA already installed Sprinkling system inside Cargo Jetty area for Coal Dust Suppression in Coal Yard (40 Ha. area) at the cost of Rs. 14.44 crores. Continues water sprinkling is being carried out on the heap of coal, at regular intervals to prevent dusting, fire and smoke.

• For the newly developed area of 34 hectares for coal storage, the work of installation of sprinkling system is in progress.

• Two Road sweeper machines with compressor have been deployed along with two mist cannon machines for a</td></tr>
</table>

<table>
<tr>
<td></td>
<td></td>
<td>Bhavan was bulk handling of coal, other dry cargo and heavy traffic of transport vehicles.

The unit is directed to take appropriate and strict measures to control the air pollution at the DPT.</td>
<td>contract period of 3 years, which are being operated continuously.

• The work for protection wall along with wind screen at the periphery of coal storage yard is in progress (about 50% work completed).

• Most of the roads and plots inside Port area are paved in order to prevent dusting.

• The directions have already been issued from time to time to all the traders in order to ensure that all trucks before leaving the storage yards will be covered with tarpaulin, no overloading of trucks are allowed and there should not be spillage of cargo during transportation.

In addition to above, it is relevant to submit here that, D.G sets are being used as and when the power shut down or failure takes place.

Out of 2 DG set, one set is under B/D and the 2nd one is also not in operation as the alternate source of power supply has been arranged from thermal power substation which is alternate source during power failure.</td>
</tr>
<tr>
<td>5.</td>
<td colspan="3">Authorization as per Hazardous and Other Waste (Management and Transboundary) Rules, 2016 form -2 [see rule 6 (2)]</td>
</tr>
<tr>
<td>5.2</td>
<td>M/s. Kandla Port Trust is hereby granted an authorization to operate facilities for following hazardous waste on the premises situated at Kandla, A.O building Gandhidham Tal.: Gandhidham, Dist: Kutch
<table>
<tr><th>Sr. no.</th><th>Waste</th><th>Qty</th><th>Sch & Cat.</th><th>Facility</th></tr>
<tr><td>1.</td><td>Used Oil</td><td>1125 MT</td><td>1-5.1</td><td>Collection, storage, transportation and disposal by selling to authorized recycler</td></tr>
</table></td>
<td>Partly Complied.
As per the records furnished during the visit it was observed that DPA has been regularly submitting Annual Return of Hazardous waste in Form IV for the entire port area and uploading the same on XGN website of GPCB on regular basis. Form IV for the year 2021-22 which was submitted vide letter no. EG/WK/EMC/Part(III)/131 dated 06/07/2022 includes hazardous waste generation (i.e. used oil/waste residue containing oil) for the period from April 2021 to March 2022 was 9585.85 MT/annum. It</td>
<td>DPA is not generating any kind of hazardous waste, it is only a facilitator for the safe disposal of waste. DPA is having Port Reception Facility for the waste received by ships. Wastes received from the ships is being collected at the reception facility and is being handed over to the Authorized recycler.

It is submitted that, at the time of application to the GPCB for renewal of Consent Order, DPA vide letter dated</td>
</tr>
</table>

	2.	Waste residue containing oil	3344.43 MT	1-5.2	Collection, storage, transportation and disposal by selling to authorized recycler	was inferred that hazardous waste generation was 114% more than the prescribed limit. ***The unit is directed to submit the details for increase in hazardous waste generation during the compliance period to this office***	20/06/2020 **(Copy attached)** had communicated to the GPCB about total quantity to be incorporated in the renewal of CCA order viz. Cargo Handling Capacity : 215.5 MMTPA (envisaged based to increased traffic of Liquid as well as Dry Cargo to DPA) , Quantity of Used Spent Oil/Waste residue Containing Oil : 10819 MT/year (calculated based on the actual quantity of waste generated during period 2019-20 and by adding 10% increase each year). However, the quantity of used oil/waste residue containing Oil mentioned in the CCA renewed by the GPCB vide order dated 22/1/2021 are same as was stipulated in earlier CCA obtained (amendment in CCA during 2019). Subsequently, DPA taken up the matter with the GPCB regarding incorporation of envisaged quantity. However, the GPCB directed DPA to submit online amendment application for incorporation of the said increased quantity. The main reason for increase in hazardous waste quantity (used spent Oil) is due to larger ship size coming to DPA as compared to earlier trend and also due to increased Cargo traffic at DPA. However, it is hereby assured that, necessary amendment in CCA issued by the GPCB, will be obtained for increased hazardous waste quantity, immediately.
20.	Unit shall all concrete measures to show tangible results in waste generation, reduction, avoidance, reuse and recycle. Actions taken in this regard shall be submitted within three months and also along with form -4					**Partly Complied.** ***The unit is directed to submit what appropriate measures are taken for waste generation, reduction, avoidance, reuse and recycle***	Since DPA is not generating the waste and its purely depend on the basis of visiting ships. DPA is having Port Reception Facility for the waste received by ships. Wastes received from the ships is being collected at the reception facility and is being handed over to the Authorized recycler. Hence, DPA submitted actual waste received from the Ships in the return filed from time to time in Form IV to the GPCB.

			It is relevant to mention here that DPA is in process of engaging agency for "Preparation of Plan for Management of Plastic Wastes, Solid waste including C&D wastes, E-wastes, Hazardous wastes including Biomedical and Non-hazardous waste in the Deendayal Port Authority Area".
22.	Industry shall have to display on-line data outside the main factory gate with regard to quantity and nature of hazardous chemicals being handled in the plant, including wastewater and air emissions and solid hazardous wastes generated within the factory premises	**Partly Complied.** ***The unit is directed to display on-line data outside the main factory gate with regard to quantity and nature of hazardous chemicals being handled in the plant, including wastewater and air emissions and solid hazardous wastes generated within the factory premises***	It is relevant to submit here that, DPA is already having display board at various locations viz. Main Port area (Dry Cargo Berths as well as Oil Jetty area) and at STP premise at Kandla. The relevant details/data are being updated regularly on the same. With regard to display of online data regarding air emission, DPA is in process of installation of CAAQMS, for which tenders will be invited soon.
7.	**General Conditions: -**		
7.5	The Environment management Unit/cell shall be setup to ensure implementation on and monitoring of Environmental safeguards and other conditions stipulated by statutory authorities. The Environment management Cell/Unit shall directly report to the Chief executive of the organization and shall work as a focal point for internalizing environmental issues. These cells/units also coordinate the exercise of environmental audit and preparation of environmental statements	**Partly Complied.** During the visit it was informed that DPA is already having environment management cell. Further, DPA has also appointed expert agency for providing Environmental Experts from time to time. DPA appointed M/s Precitech Laboratories, Vapi for providing Environmental Experts vide work order dated 5/2/2021. Further DPA has appointed manager Environment on contractual basis for the period of 3+2 years. ***The unit is directed to submit the organogram of environment management cell to this office***	Organogram of the Environment management cell is attached herewith as **Annexure – IV.**

DEENDAYAL PORT TRUST

Administrative Office Building
Post Box NO. 50
GANDHIDHAM (Kutch).
Gujarat: 370 201.
Fax: (02836) 220050
Ph.: (02836) 220038

www.deendayalport.gov.in

EG/WK/4751 (CCA Renewal)

Dated: 20/06/2020

The Environmental Engineer
Gujarat Pollution Control Board
Sector 10/A,
Gandhinagar

Sub: Renewal Application of Consolidated Consent & Authorization issued by the GPCB (Consent Order no-AWH-72820 dated of issue-31/08/2015 & subsequent amendment order issued by the GPCB (for inclusion of 14th & 16th CB) vide no. AWH 101662 dated 6/8/2019) **(GPCB ID 28494 - Inward ID 176457 dated 20/5/2020)** – **Compliance of queries raised by the GPCB reg.**

Ref.: GPCB e- query dated:01/06/2020.

Sir,

Kindly refer above cited reference for the subject mentioned above.

In this regard, in response to renewal application filed by the Deendayal Port Trust dated 20/5/2020, the GPCB has raised e query dated 1/6/2020.

Accordingly, point wise compliance of the queries raised by the GPCB is attached herewith as **Annexure I**, for kind consideration, please.

In addition to above, it is also requested to kindly consider following points for incorporation in the renewed consent to be issued by the GPCB:

Condition No. 2

Sr. No.	Product	Total Quantity as per CCA amendment order	**Total Quantity to be incorporated in CCA (renewal) to be issued by the GPCB.**	Remarks
1	Dry Cargo Handling	265400000 MT	**79.5 MMTPA**	Actual Dry Cargo Handled during 2019-20 - 49.351 MMTPA and by adding 10% avg. dry cargo increase each year up to 5 years.

2	Liquid Cargo Handling	543400000 MT	**118 MMTPA**	Actual Liquid Cargo Handled during 2019-20 – 73.148 MMTPA and by adding 10% avg. Liquid cargo increase each year up to 5 years.
3	Loading & Unloading Operation of 13th & 15th berths	2 MMTPA (Each)	**4.5 MMTPA (Each)**	Capacity finally approved by the Tariff Authority of Major Ports (TAMP).
4	Loading & Unloading operation of 14th & 16th berths	4.5 MMTPA (Each)	**4.5 MMTPA (Each)**	No change
	TOTAL		**215.5 MMTPA**	Needs to be incorporated in CCA (Renewal)

Therefore, now, the total quantity of 215.5 MMTPA to be incorporated in the CCA (renewal) to be issued by the GPCB for Loading & Unloading operation within Deendayal Port Trust limit.

Condition no. 5 (Sub Para 5.2)

Sr. No.	Waste	Total Quantity as per CCA amendment order	**Total Quantity to be incorporated in renewed CCA to be issued by the GPCB**	Remarks
1	Used Spent Oil	1125 MT/Year	**10819.00 MT/Year (Used Spent oil/ Waste Residue Containing Oil)**	Total waste generated during 2019-20 - 6717.69 MT and by adding 10% increase each year up to 5 years.
2	Waste Residue Containing Oil	3344.43 MT/Year		

In view of the same, we request you to kindly consider our case and grant us CCA Renewal at the earliest, please.

Thanking You.

Yours faithfully,

Encl. : As above

20/6/2020

SE (D) & EMC (I/c)
Deendayal Port Trust

ANNEXURE - I

DEENDAYAL PORT AUTHORITY
MARINE DEPARTMENT

Statement of Hazardous & Non Hazardous Waste disposal from the vessels at Kandla & Vadinar Port
YEAR 2021-22

Sr. No.	MONTH	YEAR	Hazardous (Sludge)	Non Hazardous (Garbage)
1	APRIL	**2021**	3006.02	95.13
2	MAY	**2021**	1014.18	118.78
3	JUNE	**2021**	830.21	148.35
4	JULY	**2021**	863.36	105.89
5	AUGUST	**2021**	762.38	133.90
6	SEPTEMBER	**2021**	898.80	208.42
7	OCTOBER	**2021**	193.08	175.53
8	NOVEMBER	**2021**	210.06	194.18
9	DECEMBER	**2021**	381.77	167.02
10	JANUARY	**2022**	261.94	109.80
11	FEBRUARY	**2022**	254.66	96.03
12	MARCH	**2022**	909.39	171.05
	TOTAL		**9585.85**	**1724.08**

Deputy Conservator
Deedayal Port Authority

O/C
28/6/22

Marine Department

Statement showing the Collection and disposal of Hazardous and Non-Harardous Wastes carried out by various parties from April - 2021 to Mar - 2022

Sr. No.	Name of Party	Validity of License	Type of Licence	Apr-21	May-21	Jun-21	Jul-21	Aug-21	Sep-21
1	Alicid Organic Industries Limited	27-Oct-22	Hazardous	-	70.45	-	-	19.81	-
2	Amar Hydrocarbon Pvt. Ltd	22-Feb-23	Hazardous	-	-	-	-	-	-
3	Atlas Organics Pvt. Ltd	17-Oct-22	Hazardous	20.17	-	-	18.78	19.81	50.85
4	Aviation Corporation	14-Jun-22	Hazardous	-	-	-	151.18	71.53	133.63
5	Fine Refiners Pvt. Ltd	22-Jun-22	Hazardous	48.59	31.88	115.80	-	-	14.88
6	Priyansi Corporation	16-Dec-22	Hazardous	-	-	33.83	9.62	-	-
7	Revolution Petrochem LLP	01-Apr-22	Hazardous	2,658.01	531.52	442.73	546.48	524.09	456.01
8	Shana Oil Process	12-Feb-22	Hazardous	-	-	-	-	-	-
9	United Shipping Company	13-Sep-22	Hazardous	279.25	380.33	237.85	137.30	127.14	243.43
10	**Vaccant**	-	-	-	-	-	-	-	-
11	Chitrakut Trading & Industries	17-Nov-22	Non-Hazardous	-	0.98	-	0.65	0.39	-
12	Golden Shipping Services	30-May-23	Non-Hazardous	25.76	19.01	72.77	28.84	36.86	49.81
13	Green Earth Marine Solutions	23-Mar-23	Non-Hazardous	-	-	-	-	-	-
14	Harish A. Pandya	03-Feb-23	Non-Hazardous	4.86	0.68	3.95	0.90	1.23	8.00
15	K M Enterprise	04-May-23	Non-Hazardous	-	57.04	43.81	53.40	29.93	28.26
16	Naaz Shipping Services Ent	05-Jun-22	Non-Hazardous	6.40	-	2.80	-	0.60	12.30
17	New India Marine Works	22-Feb-23	Non-Hazardous	-	-	-	-	-	-
18	Omega Marine Services	28-Jun-22	Non-Hazardous	46.01	30.99	18.29	-	27.59	61.62
19	Vishwa Trade-link Inc.	25-Jun-22	Non-Hazardous	-	-	-	10.80	17.28	15.12
20	V K Enterprise	16-Nov-22	Non-Hazardous	12.10	10.08	6.73	11.30	20.02	33.31
			Hazardous - Total	**3,006.02**	**1,014.18**	**830.21**	**863.36**	**762.38**	**898.80**
			Non-Hazardous - Total	**95.13**	**118.78**	**148.35**	**105.89**	**133.90**	**208.42**

Copy to : GPCB, Gandhidham / Harbour Master

ANNEXURE - II

Statement Showing the quantity of water consumed from GWSSB from April 2021 to March 2022

Sr. No.	Month	Total Quantity Consumed In KL
1.	April 2021	47342.46
2.	May 2021	48920.55
3.	June 2021	47342.46
4.	July 2021	57490
5.	August 2021	67265.75
		2634.25
6.	September 2021	65095.89
		4694.11
7.	October 2021	67265.75
		4794.24
8.	November 2021	65095.89
		4644.11
9.	December 2021	64130
10.	January 2022	58490
11.	February 2022	60756.17
		11343.84
12.	March 2022	63900
Total	**741205.47**	

28/6

SE (PL) and EMC (I/C)

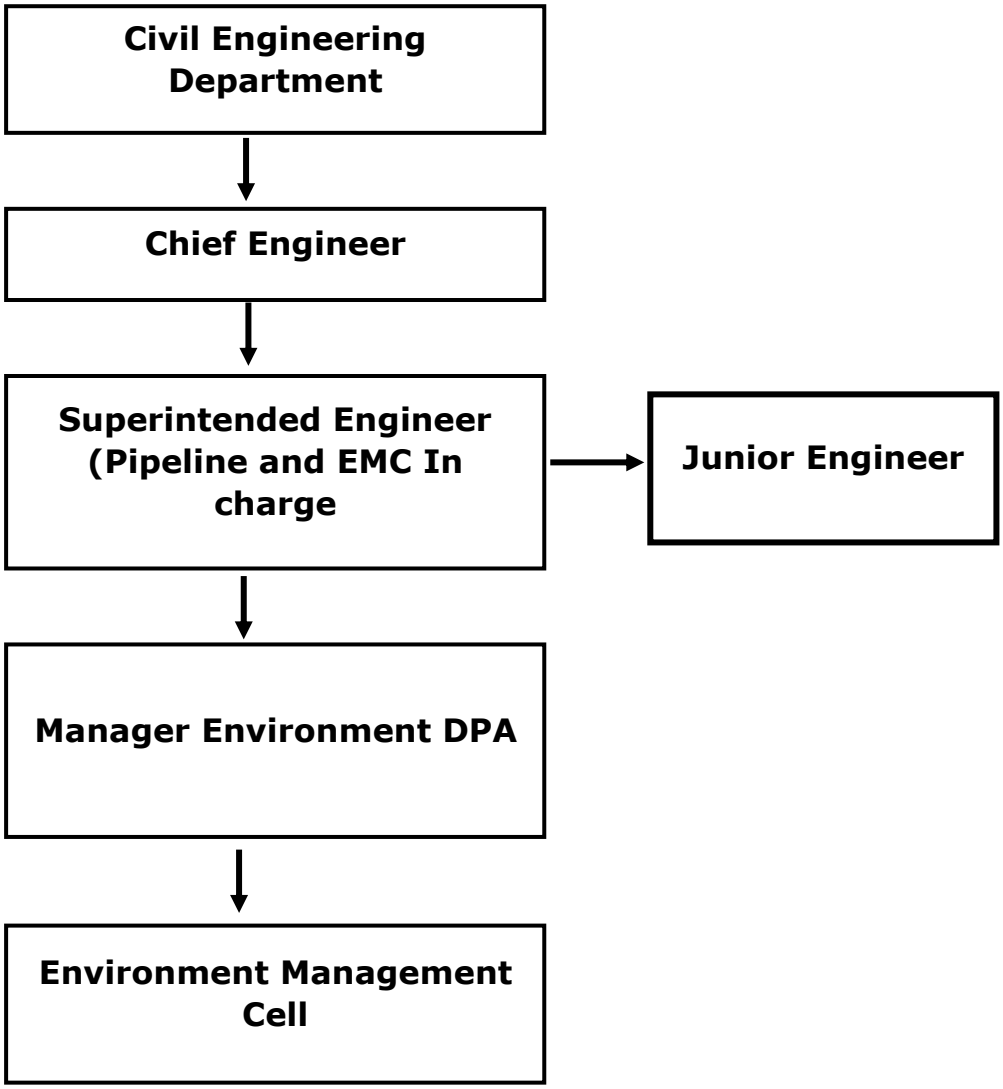
ANNEXURE - III

Statement Showing the quantity of Domestic Waste Water Generation (STP – Kandla) for the period from June 2021 to March 2022

Sr. No.	Month	Average Quantity of Domestic Waste Water Generation (KLD)
1.	June 2021	168.93
2.	July 2021	139.20
3.	August 2021	188.24
4.	September 2021	150.7
5.	October 2021	149.44
6.	November 2021	103.93
7.	December 2021	99.14
8.	January 2022	137.8
9.	February 2022	209.72
10.	March 2022	254.3
Total	**1601.4**	
Average	**160.14**	

XEN (Road)

DEENDAYAL PORT AUTHORITY

ANNEXURE - IV

ORGANIZATION CHART OF EMC