

# DEENDAYAL PORT AUTHORITY

## (Erstwhile: DEENDAYAL PORT TRUST)

Tel(O) : (02836) 220038,  
Fax : (02836) 220050  
E Mail : kptdesignsection@gmail.com  
Website: www.deendayalport.gov.in



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

[www.deendayalport.gov.in](http://www.deendayalport.gov.in)

Ref: - EG/WK/4684(EC)/PartVII/ 297

Date 05/05/2023

To,  
Shri T. C. Patel,  
Environment Engineer,  
Kutch Unit Head,  
Gujarat Pollution Control Board,  
Paryavaran Bhavan, Sector 10A,  
Gandhinagar- 382 010  
Email-[kut-uh-gpcb@gujarat.gov.in](mailto:kut-uh-gpcb@gujarat.gov.in)

**Sub:** "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 (Erstwhile: Deendayal Port Trust)- **Submission of Point-wise Compliance of Conditions stipulated in the NoC/CTE reg.**

**Ref.:** 1) NOC No. 94118 received vide letter no. PC/CCA-Kutch-1524/GPCB ID 56985 Dated 23/07/2018  
2) DPT Letter No. EG/WK/4684(EC)/PartVII/29 dated 29/06/2021  
3) DPT Letter No. EG/WK/4684(EC)/PartVII/141 dated 08/02/2022  
4) DPA letter No. EG/WK/4684(EC)/PartVII/129 dated 30/06/2022

Sir,

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

In this connection, it is to state that, vide above referred Letter No- PC/CCA-Kutch-1524/GPCB ID 56985 Dated 23/07/2018 had granted NoC/CTE with validity up to 03/04/2023. DPA vide above mentioned letters had submitted the compliance report of condition stipulated in CTE/NOC to the GPCB.

Now, please find enclosed herewith, compliance report of conditions stipulated in CTE order (period **upto November, 2022**) along with necessary enclosures as **Annexure I**, for your kind perusal & 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 [kut-uh-gpcb@gujarat.gov.in](mailto:kut-uh-gpcb@gujarat.gov.in).

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

Yours faithfully,

Manager (Env.)

Deendayal Port Authority

Copy to : Regional Officer, (Kutch East)  
Gujarat Pollution Control Board,  
Room No. 215 – 217, Regional Office,  
2<sup>nd</sup> Floor, A.O Building,  
Deendayal Port Trust,  
Gandhidham (Kutch)– 370 201  
Email Id. [ro-gpcb-kute@gujarat.gov.in](mailto:ro-gpcb-kute@gujarat.gov.in)

# **Annexure -I**

**CURRENT STATUS OF WORK PROGRESS (Up to November, 2022)**

<b>Sr. No .</b>	<b>Name of Project</b>	<b>Status</b>
1	Oil Jetty No. 8 (Jetty & allied facilities)	<p>Deendayal Port Authority issued work order to M/s Kargwal KM Joint Venture; Mumbai vide letter no. CN/WK/1571/Work/243 dated 3/2/2021.</p> <p>Work is in progress.</p>
2	Oil Jetties no. 9, 10 & 11 to be implemented on BOT/PPP Mode.	<p>The SFC recommendation and the MoPSW, GoI approval for Oil Jetties 9, 10 &amp; 11, under PPP mode, has been received on 19/04/2021.</p> <p>a)The RFQ pre-qualification process concluded. Four out of five bidders have been prequalified to participate in the RFP (Bid) Stage.</p> <p>b) Bid due date of RFP extended up to 22/12/2022</p> <p>•RFQ for OJ-10 shall be initiated only after 4 months of 'award of concession' for Oil Jetty no 9. Same analogy with OJ-11, in context of OJ-10.</p> <p>No construction activity started yet on project site.</p>
3	Development of Land (area 554 acres) for associated facilities for storage.	<p>LOA has been issued to the Contractor, M/s Nilkanth Industries Pvt. Ltd., Gandhidham on 19/10/2022</p>

**Annexure 1**

**Compliance Report (for the period upto November, 2022)**

**Subject:** Point wise compliance report of conditions stipulated in the NOC/CTE issued by GPCB 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."

**Reference:** NOC No. 94118 received vide letter no. PC/CCA-Kutch-1524/GPCB ID 56985 dated 23/07/2018

Sr. No	Conditions	Compliance Status										
1	Specific Conditions											
1	Proposed jetties shall be handled of 3.5 MMTPA of liquid Cargo of edible oil, Fertilizers & food grains etc.	As per Environmental Clearance granted by MoEF&CC dated 20.11.2020, "the capacity of each jetty is 3.5 MMTPA for handling all types of Liquid Cargo". DPA vide its letter dated 24.07.2018 and reminders letters dated 28.11.2020, 21.04.2021, 09.11.2021, 23.12.2021 and 06.06.2022 had requested GPCB to amend the said condition. However, the same is still awaited.										
2.	Unit shall strictly adhere to all conditions of TOR issued by MoEF&CC. Delhi dated 04/07/2017 & shall not carry out any construction activities till obtaining EC and CRZ from competent authority.	DPA has already received the EC and CRZ clearance from MoEF&CC vide file no. 10-1/2017-1A-111 dated 20/11/2020 and CRZ recommendation from GCZMA vide letter no. ENV-10-2018-24-T cell dated 30/07/2020. <b>(Copies attached as Annexure A &amp; B).</b>										
3.	No ground water shall be withdrawn without prior approval from competent authority.	DPA is not using ground water for any of the purpose.										
2	Conditions Under Water Act											
2.1	There shall be no Industrial water consumption and hence there shall be no generation from manufacturing process and other ancillary industrial operations.	It is here by assured that Water is used only for the domestic purpose and there is no Industrial water consumption and no waste water generation from the Industrial purpose.										
2.2	Domestic water Consumption shall not exceed 20 KL/day	Point noted for the compliance.										
2.3	The quantity of domestic waste water (sewage) shall not exceed 16 KL/day	Point noted for the compliance.										
2.4	<div>The quality of the sewage shall confirm to the following standards<table><tr><td>Parameters</td><td>Permissible Limit</td></tr><tr><td>pH</td><td>6.5-9.0</td></tr><tr><td>BOD (5 days at 20 °C)</td><td>30 mg/lit</td></tr><tr><td>Suspended Solid</td><td>20 mg/lit</td></tr><tr><td>Fecal Coliform</td><td>1000 MPN/100 ml</td></tr></table></div>	Parameters	Permissible Limit	pH	6.5-9.0	BOD (5 days at 20 °C)	30 mg/lit	Suspended Solid	20 mg/lit	Fecal Coliform	1000 MPN/100 ml	DPA has been conducting regular Monitoring of environmental parameters since the year 2016 through NABL Accredited laboratories. The latest monitoring report are attached herewith as <b>Annexure C</b> .
Parameters	Permissible Limit											
pH	6.5-9.0											
BOD (5 days at 20 °C)	30 mg/lit											
Suspended Solid	20 mg/lit											
Fecal Coliform	1000 MPN/100 ml											
2.5	The domestic sewage shall be treated in sewage treatment plant and treated sewage confirming to standard mentioned in 2.4 shall be reused in various activities shall not be used for gardening and plantation purpose in premises.	The domestic sewage is treated in sewage treatment plant of the DPA.										
3	Conditions under air act 1981:											
3.1	There shall be no use of fuel; hence there is no flue gas emission from manufacturing activities and other ancillary operations.	No fuel is being used; hence there is no flue gas emission from manufacturing activities and other ancillary operations.										



3.2	There shall be no process gas emission from manufacturing and other ancillary activities.	No manufacturing process is involved and hence there is no process gas emission from manufacturing and other ancillary activities.															
3.3	<p>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 Emission Standards issued by Ministry of Environment, Forest and Climate Change dated 16<sup>th</sup> November 2009.</p> <table border="1"> <thead> <tr> <th>Parameters</th><th>Time Weighted Average</th><th>Concentration in Ambient air in µg/m<sup>3</sup></th></tr> </thead> <tbody> <tr> <td>Sulphur Dioxide (SO<sub>2</sub>)</td><td>Annual 24 Hours</td><td>50 80</td></tr> <tr> <td>Nitrogen Dioxide (NO<sub>2</sub>)</td><td>Annual 24 Hours</td><td>40 80</td></tr> <tr> <td>Particulate Matter (Size less than 10µm)</td><td>Annual 24 Hours</td><td>60 100</td></tr> <tr> <td>Particulate Matter (Size less than 2.5µm) or PM<sub>2.5</sub></td><td>Annual 24 Hours</td><td>40 60</td></tr> </tbody> </table>	Parameters	Time Weighted Average	Concentration in Ambient air in µg/m <sup>3</sup>	Sulphur Dioxide (SO <sub>2</sub> )	Annual 24 Hours	50 80	Nitrogen Dioxide (NO <sub>2</sub> )	Annual 24 Hours	40 80	Particulate Matter (Size less than 10µm)	Annual 24 Hours	60 100	Particulate Matter (Size less than 2.5µm) or PM <sub>2.5</sub>	Annual 24 Hours	40 60	DPA has been conducting regular Monitoring of environmental parameters since the year 2016 through NABL Accredited laboratories. The latest monitoring report are attached herewith as <b><u>Annexure C</u></b> .
Parameters	Time Weighted Average	Concentration in Ambient air in µg/m <sup>3</sup>															
Sulphur Dioxide (SO <sub>2</sub> )	Annual 24 Hours	50 80															
Nitrogen Dioxide (NO <sub>2</sub> )	Annual 24 Hours	40 80															
Particulate Matter (Size less than 10µm)	Annual 24 Hours	60 100															
Particulate Matter (Size less than 2.5µm) or PM <sub>2.5</sub>	Annual 24 Hours	40 60															
3.4	<p>The level 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 A.M and 6 P.M : 70 dB(A)</p>	DPA has been conducting regular Monitoring of environmental parameters since the year 2016 through NABL Accredited laboratories. The latest monitoring report are attached herewith as <b><u>Annexure C</u></b> .															
<b>4</b>	<b>Conditions under Hazardous waste:</b>																
4.1	The applicant shall provide temporary storage facilities for each type of Hazardous waste as per Hazardous waste (Management, Handling & Transboundary Movement) Rules, 2016 as amended from time to time.	<p>Point Noted for the Compliance.</p> <p>DPA has a contract with the GPCB/CPCB authorized Recycler for disposal of Haz. Waste.</p>															
4.2	The applicant shall be obtain membership of common TSDF site for disposal of Hazardous waste as Categorized in Hazardous waste (Management, Handling & Transboundary Movement) Rules, 2016 as amended from time to time	Not applicable															
<b>5</b>	<b>General Conditions</b>																
5.1	Any change in the personnel, equipment or working conditions as mentioned in the consents form/order should immediately be intimated to this Board.	Point noted for the compliance.															
5.2	The waste generator shall be totally responsible for (i.e Collection, Storage, transportation and ultimate disposal) of the wastes generated.	Point noted for the compliance.															
5.3	Record of Waste generation, its management and annual return shall be submitted to Gujrat pollution Control Board in Form-4 by 31 <sup>st</sup> January of every year.	Point noted for the compliance.															

5.4	In case of any accident, details of the same shall be submitted in Form-5 to Gujrat pollution Control Board	Point noted for the compliance.
5.5	Applicant shall comply relevant provision of "Public Liability Insurance Act-91"	Point noted for the compliance.
5.6	Unit shall take all concrete measures to show tangible results in waste generation, reduction, avoidance, reuse and recycle. Action taken in this regard shall be submitted within three months and also along with Form-4.	Point noted for the compliance.
5.7	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 waste generated within the factory premises.	Point noted for the compliance.
5.8	Adequate plantation shall be carried out all 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 10 meters width shall be developed	Point noted for the compliance.
5.9	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 (Prevention and Control of Pollution) Cess Act - 1977	Only construction work of Oil Jetty No.8 -Jetty and allied facilities is in progress. In the operation phase, DPA shall regularly submit the returns in prescribed form regarding water consumption.

# **Annexure -A**

**File No.: 10-1/2017-IA-III**  
**Proposal No. IA/GJ/MIS/61679/2017**

Government of India  
Ministry of Environment, Forest and Climate Change  
(Impact Assessment Division)

Indira Paryavaran Bhawan,  
Jor Bagh Road, Ali Ganj  
New Delhi – 110 003

**Dated: 20<sup>th</sup> November, 2020**

To

**The Chief Engineer**  
M/s Deendayal Port Trust  
Administrative Office Building  
Post Box No. 50  
Gandhidham (Kutch)  
Gujarat – 30201

**Subject: Expansion of port by 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, Kachchh (Gujarat) by M/s Deendayal Port Trust (formerly known as Kandla Port Trust) - Environmental and CRZ Clearance.**

Sir,

This has reference to your online proposal to this Ministry on 5<sup>th</sup> August, 2020 regarding Environmental and CRZ Clearance for expansion of port by 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, Kachchh (Gujarat) by M/s Deendayal Port Trust (formerly known as Kandla Port Trust)

2. The capacity of each jetty is 3.5 MMTPA for handling all types of liquid cargo. Area proposed for development is 554 acres (Mangrove area including 70 m buffer etc., have been excluded from the total area). Dredging quantity for capital dredging and maintenance dredging will be 16,56,058 m<sup>3</sup> and 1,07,500 m<sup>3</sup>/annum, respectively. The dredged material will be disposed at designated dumping ground (Latitude 22°51'00" & Longitude 70°10'00"). Total plot for storage will be 11 Nos. Tentative Tank Capacity will be 2.28 Million KL and number of Pipelines on each jetty will be 9 (chemicals, Edible Oil, Fire fighting, water supply, air, etc).

3. The project is located at Deendayal Port Trust, Old Kandla, Gandhidham – Kutch, Gujarat with Geo-coordinates Latitude: 23.051704 To 23.069488; Longitude: 70.181017 to 70.219725. The cost of the project is Rs. 1505.74 Crores. Other activities within the DPT had obtained EC's individually, certified compliances are obtained for the same. The project is proposed in the district of Kutch and is located on the West bank of Kandla Creek, which runs into the Gulf of Kutch at a distance of 90 nautical miles from the Arabian Sea. No forest land is involved in the proposed project and hence, forest clearance is not applicable. No. of people to be employed will be 100nos (Indirect employment generation).

4. The other parameters of the project, as per the documents submitted by the project proponent, and also as informed during the above said EAC meeting, are reported to be as under:-



- i. The terrain is flat with elevation from sea level to up to 3m MSL. Topography at the site location is generally flat with average ground level of about 6.5m CD. Topsoil appears marshy. Gulf of Kutch at 11.65km and Sang River at 371.5m. There is no stream or nala is passing through the project site. The area (10 km area) around the project site is drained by Sakar River, Sang River and Churva River. All the rivers in study area are draining towards sea. The entire area is drainage north to south towards sea coast.
- ii. Approx. 20 m<sup>3</sup>/day of water will be required for domestic consumption; the important source of water is the 14.5million m<sup>3</sup> capacity reservoir of Tapar Dam, besides a number of deep tube wells. The project does not lie in Critically Polluted area.
- iii. There is no Protected Areas (PA) including National Parks, Sanctuaries and Tiger Reserves etc located within 10 km of the project boundary. Further there is no Eco-Sensitive Zone (ESZ) or Eco-Sensitive Area (ESA) notified by the MoEF&CC within 10 km radius.
- iv. There would be approximately 100 persons employed in the oil jetties 8 -11 (maximum number of permanent and contract workers at any given time). Expected waste generation quantity from proposed project is approximately 75kg/day (@0.75kg/capita/day) of non-hazardous domestic waste (food waste, general solid waste and plastic waste) that will need collection and disposal. With the implementation of standard waste handling practices in line with MARPOL requirements, potential impacts resulting from the generation of non-hazardous waste is expected to be of low significance. The waste water will be treated in the existing STP of DPT.
- v. No tree cutting is involved in this project. Mangrove plantation is being done by DPT in phased manner. Land clearance will only remove herbs and shrubs of common species. The project is employing renewable energy sources such as day lighting & passive solar panels, using energy efficient electrical appliances, regular maintenance of all powered equipment to ensure appropriate fuel consumption rates.
- vi. A provision for storm water collection has been made for harvesting the rainwater and using it for irrigation or fire fighting purpose. The main storm water drains are proposed as trapezoidal drains of 0.95m base width and 1.3m depth to cater for 10ARI rainfall. The storm water storage proposed will also act as a buffer to cater for the risk for flooding due high intensity rainfall coincident with the high tide.
- vii. The project involves foreshore facilities. Dredging requirement is 16, 56,058 m<sup>3</sup> (Berth basin + Patches in approach channel) and Maintenance Dredging of 1, 07,500 m<sup>3</sup> per annum is required. The dredged material will be disposed at designated dumping ground (Latitude 22°51'00" & Longitude 70°10'00"). Storage of permissible liquid cargo as permitted. 3.5 MMTPA each (3.5 X 4 =14 MMTPA total Capacity) for handling all types of liquid cargo. No handling of dusty cargo is proposed. Oil spill contingency plan has been prepared.

5. The project falls under item 7 (e) – Ports & Harbours of Schedule to the EIA Notification, 2006 and the proposal was considered in earlier meetings of EAC for ToR during 13<sup>th</sup> -15<sup>th</sup> February, 2017 and 27<sup>th</sup> -29<sup>th</sup> June, 2017. The ToR was issued by the Ministry vide F.No: 10-1/2017-IA-III dated 04.08.2017.



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6. The proposal was appraised by the Gujarat Coastal Zone Management Authority (GCZMA) and recommended the proposal vide letter No. ENV-10-2018-24-T cell dated 30<sup>th</sup> July, 2020.

7. The Public Hearing for the project was exempted by the EAC as per para 7 (II) of the EIA notification, 2006, as it was held earlier in November, 2014 for the same area.

8. The project proponent along with the EIA consultant M/s SV Enviro Labs & Consultants, Enviro House, made a presentation through Video Conferencing during 246<sup>th</sup> meeting of Expert Appraisal Committee (EAC) on 20<sup>th</sup> – 21<sup>st</sup> October, 2020. The EAC based on the information submitted and clarifications provided by the project proponent and detailed discussions held on all the issues, recommended the project for grant of environmental and CRZ clearance with stipulated specific conditions along with other Standard EC Conditions as specified by the Ministry vide OM dated 4<sup>th</sup> January, 2019 for the said project/activity

9. The Ministry of Environment, Forest and Climate Change has considered the proposal based on the recommendations of the Expert Appraisal Committee (Infrastructure, CRZ and other Miscellaneous projects) and hereby decided to grant Environmental and CRZ Clearance for the "Expansion of port by 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, Kachchh (Gujarat) by M/s Deendayal Port Trust (formerly known as Kandla Port Trust)" under the EIA Notification, 2006 as amended and CRZ Notification 2011, subject to strict compliance of the following specific conditions, in addition to all standard conditions applicable for such projects.

- (i) The Environmental and CRZ Clearance to the project is primarily under provisions of EIA Notification, 2006 and CRZ Notification, 2011. It does not tantamount to approvals/consent/permissions etc required to be obtained under any other Act/Rule/regulation. The Project Proponent is under obligation to obtain approvals /clearances under any other Acts/ Regulations or Statutes as applicable to the project.
- (ii) The project proponent shall abide by all the commitments and recommendations made in the Form-II, EIA and EMP report and also that have been made during their presentation to EAC.
- (iii) Construction activity shall be carried out strictly according to the provisions of the CRZ Notification, 2011. No construction works other than those permitted in Coastal Regulation Zone Notification shall be carried out in Coastal Regulation Zone area.
- (iv) All the recommendations and conditions specified by the Gujarat Coastal Zone Management Authority (GCZMA) vide letter No. ENV-10-2018-24-T cell dated 30<sup>th</sup> July, 2020 shall be complied with.
- (v) 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. Creek water monitoring program shall be implemented during the construction phase
- (vi) Dredging shall not be carried out during the fish breeding season. Dredging, etc. shall be carried out in confined manner to reduce the impacts on marine environment. Silt curtains shall be used to minimize spreading of silt plume during dredging using online



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monitoring system. Turbidity should be monitored during the dredging. No removal of silt curtain unless baseline values are achieved.

- (vii) As proposed the dredged material can be used to provide an engineered base for marine terminal i.e., oil jetties 8-11 and construction yard. The impact of dredging on the marine environment should be monitored and necessary measures shall be taken on priority basis if any adverse impact is observed.
- (viii) Marine ecological monitoring and its mitigation measures for protection of phytoplankton, zooplanktons, macrobenthos, estuaries, sea-grass, algae, sea weeds, Crustaceans, Fishes, coral reefs and mangroves and migratory birds etc. as given in the EIA-EMP Report shall be complied with in letter and spirit through a reputed university/institute with financial support as desired. Six monthly report of the studies to be provided to the regional office of MoEFCC.
- (ix) Continuous online monitoring of air and water covering the total area shall be carried out and the compliance report of the same shall be submitted along with the 6 monthly compliance report to the regional office of MoEF&CC.
- (x) The actions shall be in accordance with proposed landscape planning concepts to minimise major landscape changes. The change in land use pattern shall be limited to the proposed port limits and be carried out in such a way as to ensure proper drainage by providing surface drainage systems including storm water network.
- (xi) Suitable preventive measures be taken to trap spillage of fuel / engine oil and lubricants from the construction site. Measures should be taken to contain, control and recover the accidental spills of fuel during cargo handling.
- (xii) 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 the RO, MoEF&CC along with half yearly compliance report.
- (xiii) The company shall draw up and implement Corporate Social Responsibility Plan as per the Company's Act of 2013.
- (xiv) As per the Ministry's Office Memorandum F. No. 22-65/2017-IA.III dated 30th September, 2020, the project proponent, based on the commitments made during the public hearing, shall include all the activities required to be taken to fulfill these commitments in the Environment Management Plan along with cost estimates of these activities, in addition to the activities proposed as per recommendations of EIA Studies and the same shall be submitted to the ministry as part of the EIA Report. The EMP shall be implemented at the project cost or any other funding source available with the project proponent.
- (xv) In pursuance of Ministry's OM No stated above the project proponent shall add one annexure in the EIA Report indicating all the commitments made by the PP to the public during public hearing and submit it to the Ministry and the EAC.

## **B. STANDARD CONDITIONS:**

### **I. Statutory compliance:**

- (i) Construction activity shall be carried out strictly according to the provisions of CRZ Notification, 2011 and the State Coastal Zone Management Plan as drawn up by the State



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Government. No construction work other than those permitted in Coastal Regulation Zone Notification shall be carried out in Coastal Regulation Zone area.

- (ii) A certificate of adequacy of available power from the agency supplying power to the project along with the load allowed for the project should be obtained.
- (iii) All other statutory clearances such as the approvals for storage of diesel from Chief Controller of Explosives, Fire Department, Coast Guard, Civil Aviation Department shall be obtained, as applicable by project proponents from the respective competent authorities.

## **II. Air quality monitoring and preservation:**

- (i) The project proponent shall install system to carryout Ambient Air Quality monitoring for common/criterion parameters relevant to the main pollutants released (e.g. PM<sub>10</sub> and PM<sub>2.5</sub> in reference to PM emission, and SO<sub>2</sub> and NO<sub>x</sub> in reference to SO<sub>2</sub> and NO<sub>x</sub> emissions) within and outside the project area at least at four locations, covering upwind and downwind directions.
- (ii) Appropriate Air Pollution Control (APC) system shall be provided for all the dust generating points including fugitive dust from all vulnerable sources, so as to comply prescribed emission standards.
- (iii) Shrouding shall be carried out in the work site enclosing the dock/proposed facility area. This will act as dust curtain as well achieving zero dust discharge from the site. These curtain or shroud will be immensely effective in restricting disturbance from wind in affecting the dry dock operations, preventing waste dispersion, improving working conditions through provision of shade for the workers.
- (iv) Dust collectors shall be deployed in all areas where blasting (surface cleaning) and painting operations are to be carried out, supplemented by stacks for effective dispersion.
- (v) The Vessels shall comply the emission norms prescribed from time to time.
- (vi) Diesel power generating sets proposed as source of backup power should be of enclosed type and conform to rules made under the Environment (Protection) Act, 1986. The height of stack of DG sets should be equal to the height needed for the combined capacity of all proposed DG sets. Use of low sulphur diesel. The location of the DG sets may be decided with in consultation with State Pollution Control Board.
- (vii) A detailed traffic management and traffic decongestion plan shall be drawn up to ensure that the current level of service of the roads within a 05 kms radius of the project is maintained and improved upon after the implementation of the project. This plan should be based on cumulative impact of all development and increased habitation being carried out or proposed to be carried out by the project or other agencies in this 05 Kms radius of the site in different scenarios of space and time and the traffic management plan shall be duly validated and certified by the State Urban Development department and the P.W.D./ competent authority for road augmentation and shall also have their consent to the implementation of components of the plan which involve the participation of these departments.

## **III. Water quality monitoring and preservation:**

- (i) 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.

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- (ii) Appropriate measures must be taken while undertaking digging activities to avoid any likely degradation of water quality. Silt curtains shall be used to contain the spreading of suspended sediment during dredging within the dredging area.
- (iii) No ships docking at the proposed project site will discharge its on-board waste water untreated in to the estuary/ channel. All such wastewater load will be diverted to the proposed Effluent Treatment Plant of the project site.
- (iv) Measures should be taken to contain, control and recover the accidental spills of fuel and cargo handle.
- (v) The project proponents will draw up and implement a plan for the management of temperature differences between intake waters and discharge waters.
- (vi) Spillage of fuel / engine oil and lubricants from the construction site are a source of organic pollution which impacts marine life. This shall be prevented by suitable precautions and also by providing necessary mechanisms to trap the spillage.
- (vii) Total fresh water use shall not exceed the proposed requirement as provided in the project details. Prior permission from competent authority shall be obtained for use of fresh water.
- (viii) Sewage Treatment Plant shall be provided to treat the wastewater generated from the project. Treated water shall be reused for horticulture, flushing, backwash, HVAC purposes and dust suppression.
- (ix) A certificate from the competent authority for discharging treated effluent/ untreated effluents into the Public sewer/ disposal/drainage systems along with the final disposal point should be obtained.
- (x) No diversion of the natural course of the river shall be made without prior permission from the Ministry of Water resources.
- (xi) All the erosion control measures shall be taken at water front facilities. Earth protection work shall be carried out to avoid erosion of soil from the shoreline/boundary line from the land area into the marine water body.

#### **IV. Noise monitoring and prevention:**

- (i) Noise level survey shall be carried as per the prescribed guidelines and report in this regard shall be submitted to Regional Officer of the Ministry as a part of six-monthly compliance report.
- (ii) Noise from vehicles, power machinery and equipment on-site should not exceed the prescribed limit. Equipment should be regularly serviced. Attention should also be given to muffler maintenance and enclosure of noisy equipments.
- (iii) Acoustic enclosures for DG sets, noise barriers for ground-run bays, ear plugs for operating personnel shall be implemented as mitigation measures for noise impact due to ground sources.
- (iv) The ambient noise levels should conform to the standards prescribed under E(P)A Rules, 1986 viz. 75 dB(A) during day time and 70 dB(A) during night time.

#### **V. Energy Conservation measures:**

- (i) Provide solar power generation on roof tops of buildings, for solar light system for all common areas, street lights, parking around project area and maintain the same regularly;



- (ii) Provide LED lights in their offices and port areas.

#### **VI. Waste management:**

- (i) Dredged material shall be disposed safely in the designated areas.
- (ii) Shoreline should not be disturbed due to dumping. Periodical study on shore line changes shall be conducted and mitigation carried out, if necessary. The details shall be submitted along with the six monthly monitoring reports.
- (iii) Necessary arrangements for the treatment of the effluents and solid wastes must be made and it must be ensured that they conform to the standards laid down by the competent authorities including the Central or State Pollution Control Board and under the Environment (Protection) Act, 1986.
- (iv) The solid wastes shall be managed and disposed as per the norms of the Solid Waste Management Rules, 2016.
- (v) Any wastes from construction and demolition activities related thereto shall be managed so as to strictly conform to the Construction and Demolition Waste Management Rules, 2016.
- (vi) A certificate from the competent authority handling municipal solid wastes should be obtained, indicating the existing civic capacities of handling and their adequacy to cater to the M.S.W. generated from project.
- (vii) Used CFLs and TFLs should be properly collected and disposed off/sent for recycling as per the prevailing guidelines/ rules of the regulatory authority to avoid mercury contamination.
- (viii) Oil spill contingency plan shall be prepared and part of DMP to tackle emergencies. The equipment and recovery of oil from a spill would be assessed. Guidelines given in MARPOL and Shipping Acts for oil spill management would be followed. Mechanism for integration of terminals oil contingency plan with the overall area contingency plan under the co-ordination of Coast should be covered.

#### **VII. Green Belt:**

- (i) Green belt shall be developed in area as provided in project details with a native tree species in accordance with CPCB guidelines.
- (ii) Top soil shall be separately stored and used in the development of green belt.

#### **VIII. Marine Ecology:**

- (i) The dredging schedule shall be so planned that the turbidity developed is dispersed soon enough to prevent any stress on the fish population.
- (ii) While carrying out dredging, an independent monitoring shall be carried out through a Government Agency/Institute to assess the impact and necessary measures shall be taken on priority basis if any adverse impact is observed.
- (iii) A detailed marine biodiversity management plan shall be prepared through the NIO or any other institute of repute on marine, brackish water and fresh water ecology and biodiversity and submitted to and implemented to the satisfaction of the State Biodiversity Board and the CRZ authority. The report shall be based on a study of the impact of the project activities on the intertidal biotopes, corals and coral communities, molluscs, sea grasses, sea weeds, sub-tidal habitats, fishes, other marine and aquatic



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micro, macro and mega flora and fauna including benthos, plankton, turtles, birds etc. as also the productivity. The data collection and impact assessment shall be as per standards survey methods and include underwater photography.

- (iv) Marine ecology shall be monitored regularly also in terms of sea weeds, sea grasses, mudflats, sand dunes, fisheries, echinoderms, shrimps, turtles, corals, coastal vegetation, mangroves and other marine biodiversity components including all micro, macro and mega floral and faunal components of marine biodiversity.
- (v) The project proponent shall ensure that water traffic does not impact the aquatic wildlife sanctuaries that fall along the stretch of the river.

#### **IX. Public hearing and human health issues:**

- (i) The work space shall be maintained as per international standards for occupational health and safety with provision of fresh air respirators, blowers, and fans to prevent any accumulation and inhalation of undesirable levels of pollutants including VOCs.
- (ii) Workers shall be strictly enforced to wear personal protective equipments like dust mask, ear muffs or ear plugs, whenever and wherever necessary/ required. Special visco-elastic gloves will be used by labour exposed to hazards from vibration.
- (iii) Safety training shall be given to all workers specific to their work area and every worker and employee will be engaged in fire hazard awareness training and mock drills which will be conducted regularly. All standard safety and occupational hazard measures shall be implemented and monitored by the concerned officials to prevent the occurrence of untoward incidents/ accidents.
- (iv) Emergency preparedness plan based on the Hazard identification and Risk Assessment (HIRA) and Disaster Management Plan shall be implemented.
- (v) Provision shall be made for the housing of construction labour within the site with all necessary infrastructure and facilities such as fuel for cooking, mobile toilets, mobile STP, safe drinking water, medical health care, crèche etc. The housing may be in the form of temporary structures to be removed after the completion of the project.
- (vi) Occupational health surveillance of the workers shall be done on a regular basis.

#### **X. Environment Responsibility:**

- (i) The company shall have a well laid down environmental policy duly approved by the Board of Directors. The environmental policy should prescribe for standard operating procedures to have proper checks and balances and to bring into focus any infringements/deviation/violation of the environmental / forest /wildlife norms/ conditions. The company shall have defined system of reporting infringements / deviation / violation of the environmental / forest / wildlife norms / conditions and / or shareholders / stake holders. The copy of the board resolution in this regard shall be submitted to the MoEF&CC as a part of six-monthly report.
- (ii) A separate Environmental Cell both at the project and company head quarter level, with qualified personnel shall be set up under the control of senior Executive, who will directly report to the head of the organization.
- (iii) Action plan for implementing EMP and environmental conditions along with responsibility matrix of the company shall be prepared and shall be duly approved by competent authority. The year wise funds earmarked for environmental protection measures shall be kept in separate account and not to be diverted for any other purpose.

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Year wise progress of implementation of action plan shall be reported to the Ministry/Regional Office along with the Six Monthly Compliance Report.

- (iv) Self environmental audit shall be conducted annually. Every three years third party environmental audit shall be carried out.

#### **XI. Miscellaneous:**

- (i) The project proponent shall make public the environmental clearance granted for their project along with the environmental conditions and safeguards at their cost by prominently advertising it at least in two local newspapers of the District or State, of which one shall be in the vernacular language within seven days and in addition this shall also be displayed in the project proponent's website permanently.
- (ii) The copies of the environmental clearance shall be submitted by the project proponents to the Heads of local bodies, Panchayats and Municipal Bodies in addition to the relevant offices of the Government who in turn has to display the same for 30 days from the date of receipt.
- (iii) The project proponent shall upload the status of compliance of the stipulated environment clearance conditions, including results of monitored data on their website and update the same on half-yearly basis.
- (iv) The project proponent shall submit six-monthly reports on the status of the compliance of the stipulated environmental conditions on the website of the ministry of Environment, Forest and Climate Change at environment clearance portal.
- (v) The project proponent shall submit the environmental statement for each financial year in Form-V to the concerned State Pollution Control Board as prescribed under the Environment (Protection) Rules, 1986, as amended subsequently and put on the website of the company.
- (vi) The criteria pollutant levels namely; PM<sub>2.5</sub>, PM<sub>10</sub>, SO<sub>2</sub>, NO<sub>x</sub> (ambient levels) or critical sectoral parameters, indicated for the project shall be monitored and displayed at a convenient location near the main gate of the company in the public domain.
- (vii) The project proponent shall inform the Regional Office as well as the Ministry, the date of financial closure and final approval of the project by the concerned authorities, commencing the land development work and start of production operation by the project.
- (viii) The project authorities must strictly adhere to the stipulations made by the State Pollution Control Board and the State Government.
- (ix) The project proponent shall abide by all the commitments and recommendations made in the EIA/EMP report, commitment made during Public Hearing and also that during their presentation to the Expert Appraisal Committee.
- (x) No further expansion or modifications in the port area shall be carried out without prior approval of the Ministry of Environment, Forests and Climate Change (MoEF&CC).
- (xi) Concealing factual data or submission of false/fabricated data may result in revocation of this environmental clearance and attract action under the provisions of Environment (Protection) Act, 1986.
- (xii) The Ministry may revoke or suspend the clearance, if implementation of any of the above conditions is not satisfactory.


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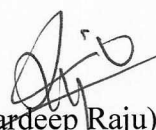
- (xiii) The Ministry reserves the right to stipulate additional conditions if found necessary. The Company in a time bound manner shall implement these conditions.
- (xiv) The Regional Office of this Ministry shall monitor compliance of the stipulated conditions. The project authorities should extend full cooperation to the officer (s) of the Regional Office by furnishing the requisite data / information/monitoring reports.
- (xv) The above conditions shall be enforced, inter-alia under the provisions of the Water (Prevention & Control of Pollution) Act, 1974, the Air (Prevention & Control of Pollution) Act, 1981, the Environment (Protection) Act, 1986, Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 and the Public Liability Insurance Act, 1991 along with their amendments and Rules and any other orders passed by the Hon'ble Supreme Court of India / High Courts and any other Court of Law relating to the subject matter.
- (xvi) Any appeal against this EC shall 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.

7. This issues with the approval of the Competent Authority.

  
(Amardeep Raju)  
Scientist-E

Copy to:

1. The Principal Secretary, Department of Forests & Environment and Chairman, GCZMA, Govt. of Gujarat, Sachivalaya, Gandhinagar, Gujarat
2. The Chairman, Central Pollution Control Board, Parivesh Bhawan, CBD-cum-Office Complex, East Arjun Nagar, Delhi – 32
3. The Member Secretary, Gujarat Pollution Control Board, Sector 10-A, Gandhi Nagar – 382043, Gujarat.
4. The APCCF (C), MoEF& CC, RO (WZ), E-5, Kendriya Paryavaran Bhawan, Arera Colony, Link Road No.3, Ravishankar Nagar, Bhopal –16
5. Monitoring Cell, MoEF&CC, Indira Paryavaran Bhavan, New Delhi.
6. Guard File/Record File
7. Notice Board.

  
(Amardeep Raju)  
Scientist-E

# **Annexure -B**



**S. M. SAIYAD, IFS  
DIRECTOR (ENVIRONMENT)&  
ADDITIONAL SECRETARY**

**GOVERNMENT OF GUJARAT  
Forests & Environment Department  
Block no. 14, 8<sup>th</sup> floor  
Sachivalaya, Gandhinagar - 382 010  
Gujarat, INDIA  
Ph: (079) 23251062,  
Fax: (079) 23252156**

**Email: direnv@gujarat.gov.in**

**Ref: No.ENV-10-2018-24 -T cell**

**July 30, 2020**

**To,  
Shri W. Bharat Singh  
Director(IA.III)  
Ministry of Environment, Forests & Climate Change  
Indira Paryavaran Bhavan, Jor Bugh,  
Aliganj Road New Delhi - 110 003**

***Sub: CRZ Clearance for proposed project for for Creation of water front facilities (Oil Jetties 8,9,10&11) and development of land (1432acres – revised area 554 acres) for associated facilities for storage at Old Kandla, Tal- Gandhidham, Dist. – Kutch, Gujarat by Deendayal Port Trust - reg.***

Dear Sir,

The Deendayal Port Trust ( Formerly known as Kandla Port Trust ), vide its application dated 01.03.2018 has approached this Department seeking recommendations from the GCZMA for obtaining CRZ Clearance from the, Ministry of Environment, Forests and Climate Change, Government of India for their proposed project for Creation of water front facilities (Oil Jetties 8,9,10&11) and development of land (1432acres – revised area 554 acres) for associated facilities for storage at Old Kandla, Gandhidham –Kutch, Gujarat.

Deendayal Port Trust has submitted following documents alongwith application:

1. Various undertakings as per the guidelines.
2. Form-I as per CRZ Notification 2011.
3. EIA prepared by M/s. SV Enviro Labs & Consultants , Visakhapatnam alongwith CRZ map indicating the High Tide Line, Low Tide Line, CRZ Boundary, etc. prepared by the Institute of Remote Sensing (IRS), Anna University, Chennai, alongwith superimposition of the proposed activities on CRZ map.



The EIA report prepared by SV Enviro Labs & Consultants , Visakhapatnam includes the details like Introduction(chapter 1), Project Description(chapter 2), Analysis of Alternatives (chapter 3), Description of the Environment (chapter 4), Anticipated Environmental Impact and Mitigation Measures ( chapter 5), Environmental Monitoring Plan (chapter 6), Additional Studies (chapter 7), Project Benefits (chapter 8), Environmental Management Plan (chapter 9), Summary and Conclusion (chapter 10).

The main findings of EIA report prepared by SV Enviro Labs & Consultants , Visakhapatnam and their presentation made during 49th GCZMA meeting are summarized as follows :-

- I. During construction of the oil jetties, piling of jetty will involve the use of anchored piling barges. The barges/rigs will use diesel generator sets to provide power for the pile hammer and boring equipment. The generators would produce exhaust emissions during the construction period, which could cause temporary and localized adverse impacts on local air quality around these barges. The expected emissions will depend on total diesel combustion, which can vary between 100 to 500 litres per hour.
- II. The proposed project will have no major considerable stress/ pressure on the environment to give rise to any significant adverse impacts on environment. The only major impacts on air during construction phase are predicted to be caused due to airborne dust arising from the construction activities as well as gaseous pollutants from vehicles used for transportation of construction materials & emission from equipment used during construction phase. The dust particles in the form of particulate matter will strongly depend on various activities like movement of vehicles, their speed, excavation of earth, back filling etc during the construction phase.
- III. Exhaust emissions due to vehicular movement for on land transport of construction material may marginally increase the air pollution load along the road. This impact is temporary and localized.
- IV. The probable sources of the dust are the activities of excavation, filling, leveling etc. However it is noticed that, the area of the proposed project is situated close to the creek of Gulf of Kutch; hence the moisture in the soil will not allow the particles to travel to longer distance from the sources.



- V. The dredging quantity is 16, 56,058 M3 will be capital dredging for 8-11 oil jetties. It is proposed that the dredged material would be directly disposed of at the CWPRS (Central Water & Power Research Station) approved site.
- VI. Beside the texture of soil is mostly sandy, hence the size and density of particles also prevent them from longer travelling. However maximum care will be taken to prevent the particles to be airborne by using water sprinkler system & covering the excavated materials. Hence there will be no significant impacts due to the dust particles.
- VII. There is no chemical process or manufacturing activity, hence there will not be any process emission. As the proposed project is only export and import of cargo, increase in vehicular movement and emissions from DG set may affect ambient air quality.
- VIII. Noise generation is due to the noise generation by the operation of the machineries, equipments and some mechanical works. The impacts due to noise of these equipments will be local and temporary as well as negligible due to the efficient implementation of proper mitigation measures like provision of Ear Protective Safety Equipment (ear plug or ear muff) for the personnel likely to be exposed to high noise level. The noise level shall be minimized by proper lubrication, modernization, maintenance, muffling and provision of silencers wherever possible.
- IX. The day and night noise levels near the pile-driving site reduce to within prescribed limits as per "Noise Rules 2000" at distance of 50m and 100m from the source. There is a potential for underwater noise from piling of the jetty to impact marine fauna. As there are no marine mammals identified in the DPT area, it is expected that the noise impact would be of low significance as the piling activity would be localised and temporary in nature and sensitive receptors are not located in the vicinity of the noise generating area.
- X. The major expected source to increase the noise level at the jetty area are arrival of cargo and vehicular movement to transport export and import goods, conveyor system and operation of DG set for emergency power supply. However, this increase in noise level will be lower compared to the construction phase. Proper lubrication, muffling shall be done to reduce the noise, DG set with acoustic enclosure shall be provided.
- XI. The workers working in the high noise area shall be provided with ear protected equipments. The propagation of noise way would be prevented

by creating barrier in form of greenbelt development all around the project area boundary.

- XII. Before commencing any dredging operations the dredging contractor will provide complete details of their vessels and equipment including anticipated noise levels at the source. The noise levels during the activity will also be continuously monitored and mitigated if needed.
- XIII. The Gujarat Water Supply and Sewerage Board (GWSSB) is responsible for providing of water during construction and operation phase. It is estimated that approx. 20KLD will be required once all facilities are functional. Hence there would not be any impact on local water sources and its competitive users.
- XIV. During construction phase, there would be generation of some sewage due to personnel involved in the construction work. With the implementation of mitigation measures, the potential for contamination of surface and ground water resources resulting from sewage disposal is expected to be insignificant.
- XV. During operation phase, the waste water will be treated in a sewage treatment plant. The treated wastewater will be used for flushing, cooling water makeup and landscaping purposes. Disposal of industrial effluent and sewage without proper treatment into water bodies can pollute and degrade the water quality by making it unfit for usage and survival of aquatic life. Hence no waste water should be discharged outside the project premises. This will prevent any direct disposal of waste water in this stream.
- XVI. Storm water drainage system will be developed by DPT at project site for collection of storm water. The storm water drain will be covered by a steel gutter grill that is level with the surrounding pavement. This collected water will be recharged into ground through injection wells. Development of storm water drainage system and RWH structures will regulate the run-off from the site & prevent flooding of the area during heavy rains. Injection well will be interlinked to prevent any overflow or waste of harvested water. Thus, no negative impact is anticipated on drainage of the area. Measures propose to prevent impact of project development on surface water bodies.
- XVII. Land use patterns of the surrounding area would not changed as it already used for port activity with some open land/back-up area. The proposed project is in the water front of marine water course of Gulf of Kutch. The



- project requires 554 acres of land for the development of proposed project. The land is generally barren and saline soil having low nutrients. At present, the site is almost devoid of vegetation, so major clearance of vegetation in site for development of proposed project is not required. Hence there would not be any adverse impacts on land cover is envisaged.
- XVIII. Some degraded mangrove colonies are noticed in the buffer area of the project. The project area is revised to 554 acres from 1432 acres maintaining 70 m buffer all around the mangrove colonies.
- XIX. The proposed jetty site is within the limit of existing port where benthic diversity and abundance in the area is found to be low in comparison with other near-shore areas in the region. This is principally attributed to the fact that the area is surrounded by marine-based development projects related to the extension and development of the Deenadayal Port. Installation of the 210-240 steel piles will take place using a jack up rig, which will need to be repositioned to cover the entire piling operation. Piles shall be driven to the required depth by a suitably sized hydraulic hammer. Based on the geotechnical conditions found at the site no drilling is anticipated as area is known for soft sand.
- XX. The disturbance caused by the direct impacts of the rig could cause a temporary loss in benthic habitat in the area occupied by the steel piles and the legs of the jack up rig (4 no. per pile). This habitat is likely to become re-established after end of rigging. There could also be localized, temporary smothering of habitat with finer materials and suspension of fine sediments into the water column. This could reduce light penetration in the vicinity, impacting the marine environment and directly affecting photosynthetic species, and increased sediment loading in the waters could affect filter feeding organisms. The impact on benthic habitat because of the piling is expected to be temporary and localized and is therefore predicted to be of low significance.
- XXI. None of the species included in Schedule -I of the Indian Wildlife Act was reported from the core area. The project is not expected to bring about any major irreversible change in the terrestrial area. It can therefore be concluded that the proposed project and its activities will not have any adverse impacts in the terrestrial flora and fauna of the core area or its buffer zone.

- XXII. The general water quality, and sediment quality parameters in the Port premises remained within normal limits during study period as ongoing capital and maintenance dredging, and no variations and fluctuations were observed. The phytoplankton, zooplankton, benthic organisms and fish populations in the Kandla did not show any abnormal variations in their quality and quantity during this period. This indicates that the ongoing dredging activities as well as and the port activities have already disturbed the marine environment. The project-specific dredging would cumulatively add to that disturbance though this disturbance will be more localized and for a duration of approximately 18 months. The overall impact of the dredging activities on the marine flora and fauna would be of medium significance, which after the implementation of mitigation measures is expected to be of low significance.
- XXIII. The land is designated port land, which is currently not under any permanent use; hence there are no impacts in terms of displacement or livelihood loss.
- XXIV. The impact significance during operation phase is expected to be low considering the fact the project will be at onshore and offshore with limited impact on socio-economic environment. However, the project will have positive impacts on socio-economic environment by increasing availability of power, creation of employment opportunities and procuring material locally.
- XXV. There would be approximately 100 persons employed in the oil jetties 8 -11 (maximum number of permanent and contract workers at any given time). Expected waste generation quantity from proposed project is approximately 75kg/day (@0.75kg/capita/day) of non-hazardous domestic waste (food waste, general solid waste and plastic waste) that will need collection and disposal. With the implementation of standard waste handling practices in line with MARPOL requirements, potential impacts resulting from the generation of non-hazardous waste is expected to be of low significance.

The Gujarat Coastal Zone Management Authority discussed the proposal of Deendayal Port Trust in its 49<sup>th</sup> meeting, which was held on 15-06-2020 through Video Conferencing, wherein the Authority was apprised that the DPT has submitted Form-1, CRZ map prepared by the Institute of Remote Sensing (IRS), Anna University, Chennai and EIA report prepared by the SV Enviro Labs &



Consultants , Visakhapatnam as per ToR issued by MoEF&CC dated 04<sup>th</sup> August,2017.

The Authority was further apprised that the proposal of DPT was scrutinized by the Team of Officials in its 3rd meeting which was held on 12/04/2018 wherein the representative made a presentation on their proposed activities in CRZ areas, EIA report and CRZ Maps. Then the proposal was discussed in the 40th meeting of GCZMA which was held on 12th June, 2018. After deliberated discussion it was decided to carry out site inspection of the proposal by sub-committee of the GCZMA. Accordingly, the Site visit was carried out by the Sub- Committee of GCZMA on 12-07-2018. During inspection the subcommittee observed that mangroves and its buffer zone is part of the proposed area development. Therefore, the DPT was requested to revised their proposal and exclude the mangroves and its buffer zone and also requested to keep buffer zone of 70 mt. from mangrove areas. Accordingly, the DPT has revised proposal for development of land for 554 acres instead of 1432 acres of land. The revised planning details were superimposed on the Draft CZMP prepared by NCSCM, Chennai. The Representative of the DPT made a presentation before the Authority and submitted that existing Port is having facilities such as –

- 16 Nos.Cargo Berths
- 6 Nos. Oil Jetties
- Barge Jetties (Bunder Basin & IFFCO captive)
- Total custom bonded Port Area inside custom fencing is about 330 Ha.
- Total Storage Capacity: 26.41 Lakh KL. (Chemical & Liquid Handling Complex)

Considering development of the existing port, they had proposed following facilities at the proposed site.

- The proposed project is creation of water front facilities (i.e. construction of oil jetties 8,9,10, &11) and development of lands for associated facilities. Area proposed for development : 1345 acres out of 1432 acres. The proposed jetties will be used for handling all types of Liquid Cargo (Capacity: 4 X 3.5 MMTA = 14 MMTA).
- Each jetty 110 m X 12.8 m (Main Platform) and mooring dolphins.
- Connecting approach each : 90 m X 10 m to common approach trestle of length 1225 m.
- Total plot for storage 22 Nos.

- Pipelines on each jetty 9 Nos. (chemicals, Edible Oil, Firefighting, water supply , air, etc)

It was further submitted that as per the suggestion of the subcommittee of GCZMA, now the revised proposal for facilities at the proposed site.

- The proposed project is creation of water front facilities (i.e. construction of oil jetties 8,9,10, &11) as above.
- Area proposed for development: 554 acres (Mangrove area including 70 m buffer etc., have been excluded from the total area of 1432 acres.)
- Total plot for storage 11 Nos.
- Tentative Tankage Capacity : 2.28 Million KL
- Pipelines on each jetty 9 Nos. (chemicals, Edible Oil, Firefighting, water supply , air, etc)

It was submitted by the representative of the DPT that approx. 16.0 KLD of waste water will be generated from the proposed project, and same will be treated in sewage treatment plant and treated water will be used for dust suppression, greenbelt development and toilet flushing.

It was submitted by the representative of DPT that Capital Dredging Requirement will be 16, 56,058 M3 (Berth basin + Patches in approach channel) and Maintenance Dredging will be 1, 07,500 m3 / Per annum. The dredging activities will be performed by the specialist contractors using purpose-built dredgers and under the active supervision of the port operator.

It was submitted by the representative of DPT that prior to commencing dredging works, a dredging management plan will be prepared; sophisticated dredgers will be used to avoid or minimize scattering of dredged sediments during dredging. Monitoring of turbidity and suspended sediments concentration will be ensured during dredging. They will avoid dredging operations at the time of high tidal disturbances; and Process of dredging and material transfer to be undertaken by experienced personnel only. The dredged material will be disposed of at the designated dumping location identified based on the scientific study done by the CWPRS and approved by the MOEF&CC, GOI.

The representative of DPT further submitted that the EIA study has determined that the construction and operational activities of the proposed project will have some overall low and medium impacts on the local environment. However, with the implementation of proposed pollution control and environment management



measures, it is envisaged that these anticipated impacts will be largely mitigated for land, water, air and Marine environment. It will not create any harmful impact on the surrounding environment.

Chairman, Gujarat Coastal Zone Management Authority asked Bhaskarya Institute for Space Application and Geo-informatics to submit the map to be superimposed on revised proposal of DPT and verify whether the revised areas are as per the proposal submitted by the DPT or not and also superimposed on SCZMP of Kutch prepared by the NCSCM, Chennai duly approved by the MOEF&CC, GOI and submit its report within one week. The Director, BISAG, was agreed upon it. Now GEC and BISAG has prepared map of the project site, copy of the same is put up herewith on pg. no. 151/c and 153/c. As per the map total plot area for development including the existing one is 554 acres.

As per CRZ map prepared by the IRS, Chennai The proposed project site falls under CRZ- IA(existence of mangrove buffer area at proposed site) , CRZ- IB, CRZ – IV. Now mangrove and its buffer zone is excluded, hence falls under CRZ- IB, CRZ- III and CRZ – IV.

***The Gujarat Coastal Zone Management Authority deliberated the proposal of Gujarat Maritime Board and after detailed discussion, it is decided to recommend to the Ministry of Environment, Forests and Climate Change, Government of India to grant CRZ Clearance for the proposed project for Creation of water front facilities (Oil Jetties 8,9,10&11) and development of land (1432acres – revised area 554 acres) for associated facilities for storage at Old Kandla, Gandhidham –Kutch, Gujarat with some specific conditions.***

In view of the above, the State Government hereby recommends to the Ministry of Environment, Forest and Climate Change, Government of India to grant CRZ Clearance for the proposed project for Creation of water front facilities (Oil Jetties 8,9,10&11) and development of land (1432acres – revised area 554 acres) for associated facilities for storage at Old Kandla, Tal – Gandhidham, Dist –Kutch, Gujarat with following specific conditions :-

- 1. The DPT shall strictly adhere to the provisions of the CRZ Notification, 2011 issued by the Ministry of Environment, Forests and Climate Change, Government of India.**

2. Necessary permissions from different departments/ agencies under different laws/ acts shall be obtained before commencing any activity ( including the construction ).
3. The DPT shall ensure that that the all the provisions of CRZ Notification 2011 shall be complied with and storage facilities in CRZ areas shall be in compliance with Annexure-II of the above said Notification
4. There shall not be any blockage of creek due to laying of pipeline. and free flow of water shall be maintained.
5. There shall not be any mangrove destruction/ damage due to proposed activities and adequate buffer zone of 70 mtrs shall be maintained from mangrove areas.
6. The DPT shall effectively implement the Mangrove Development, Protection & Management plan for control of indirect impacts on mangrove habitat.
7. The DPT shall have to make a provision that mangrove areas get proper flushing water and free flow of water shall not be obstructed.
8. The DPT shall have to dispose of the dredged material at the designated dredged material disposal point based on scientific study and approved by the MOEF&CC, GOI
9. The DPT shall have to maintain the record for generation and disposal of capital dredging and maintenance dredging
10. No dredging, reclamation or any other project related activities shall be carried out in the CRZ area categorized as CRZ I (i) (A) and it shall have to be ensured that the mangrove habitats and other ecologically important and significant areas, if any, in the region are not affected due to any of the project activities.
11. *The DPT shall ensure that construction activities like dredging etc shall be carried out in confined manner to reduce the impact on marine environment.*
12. *The DPT shall ensure that the dredging shall not be carried out during the fish breeding season.*
13. *Construction waste including debris and dredged material shall be disposed safely in the designed areas as approved by MoEF&CC, GoI and it shall be ensured that there shall be no impact on flora and fauna.*
14. No effluent or sewage shall be discharged into the sea / creek or in the CRZ area and shall be treated to conform the norms prescribed by the Gujarat



Pollution Control Board and would be reused / recycled as per the approval of the Board.


15. All the recommendations and suggestions given by the Choramandalam MS Risk Services Limited in their Environment Impact Assessment report shall be implemented strictly by DPT.
16. The DPT shall exercise extra precautions to ensure the navigation safety and mitigation of the risk associated with the project activities especially due to collision, sinking or accidents of the vessels and would deploy the latest communication and navigation aids for this purpose. The proposed facilities shall also be covered under the VTMS being developed by the GMB.
17. The cost of the external agency that may be appointed by this department for supervision / monitoring of the project activities during construction/ operational phases shall be paid by DPT
18. The DPT shall contribute financially for any common study or project that may be proposed by this Department for environmental management / conservation / improvement for the Gulf Kutch
19. The piling activities debris and any other type of waste shall not be discharged into the sea or creek or in the CRZ areas. The debris shall be removed from the site immediately after the piling activities are over.
20. The camps shall be located outside the CRZ area and the labour shall be provided with the necessary amenities, including sanitation, water supply and fuel and it shall be ensured that the environmental conditions are not deteriorated by the labours.
21. The DPT shall prepare and regularly update their Local Oil Spill Contingency and Disaster Management Plan in consonance with the National Oil Spill and Disaster Contingency Plan.
22. The DPT shall bear the cost of the external agency that may be appointed by this Department for supervision / monitoring of proposed activities and the environmental impacts of the proposed activities.
23. The groundwater shall not be tapped to meet with the water requirements in any case.
24. DPT shall take up greenbelt development activities in consultation with the Gujarat Institute of Desert Ecology / Forest Department / Gujarat Ecology Commission.
25. The DPT shall have to contribute financially for taking up the socio-economic upliftment activities in this region in consultation with the Forests and

Environment Department and the District Collector / District Development Officer.

26. A six monthly report on compliance of the conditions mentioned in this letter shall have to be furnished by DPT on a regular basis to this Department and MoEF&CC, GoI.
27. The DPT shall ensure that the numbers of the Vessels and machinery deployed during marine construction, which are a source of low level organic and PHC pollution will be optimized to minimize risks of accidents involving these vessels.
28. The noise level during transport and construction of marine facilities shall be kept minimum.
29. The DPT shall regularly conduct the surveys to identify changes in the channel bathymetry to minimize navigation hazards. Proper navigational aids and guidance should be provided to ships navigating the channel and there should be a properly structured vessels traffic management strategy to avoid accidents.
30. The DPT shall carry out separate study for further erosion and deposition pattern in the area after dredging through a reputed agency and shall follow the suggestions of the study done by reputed agency, for maintenance dredging, the recommendations/suggestions of the reputed agency shall be followed by the DPT.
31. Any other condition that may be stipulated by this Department and MoEF&CC, GoI from time to time for environmental protection / management purpose shall also have to be complied with by DPT.

Thanking You,

Yours Sincerely,

  
(S. M. Saiyad)

Encl: As above

Copy to:

The Chairman,  
Deendayal Port Trust,  
Old Kandla, Tal – Gandhidham,  
Dist –Kutch, Gujarat -----for your kind information please.

# **Annexure -C**



## ENVIRONMENTAL MONITORING REPORT FOR DEENDAYAL PORT AUTHORITY



**REPORT** : DCPL/DPA/21-22/31

**Mont** : November 01

**Issue** : 00

**Revision** : 00

**Prepare** : DETOX CORPORATION PVT. LTD.,

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## EXECUTIVE SUMMARY

## **ENVIRONMENTAL MONITORING PLAN FOR DEENDAYAL PORT ENVIRONMENTAL MONITORING 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<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub>, NO<sub>2</sub>, NH<sub>3</sub>, CO<sub>2</sub>, CO, C<sub>6</sub>H<sub>6</sub> 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<sup>3</sup> at Coal Storage area on 25.11.2022 and minimum 107 µg/m<sup>3</sup> at Gopalpuri Hospital on 01.11.2022. The Maximum PM<sub>10</sub> values were 654 µg/m<sup>3</sup> at Coal Storage area on 25.11.2022 and minimum was 67 µg/m<sup>3</sup> at Gopalpuri Hospital 01.11.2022. Maximum PM<sub>2.5</sub> values were 187 µg/m<sup>3</sup> at Coal Storage area on 25.11.2022 and minimum was 34 µg/m<sup>3</sup> at Gopalpuri on 01.11. 2022. The PM<sub>10</sub> and PM<sub>2.5</sub> 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<sub>10</sub> was 127 µg/m<sup>3</sup> & PM<sub>2.5</sub> was 66 µg/m<sup>3</sup> which are slightly exceed the Standard limit (NAAQS).

The AAQ monitoring for Vadinar at Admin building the mean TSPM, PM<sub>10</sub> and PM<sub>2.5</sub> were 237 µg/m<sup>3</sup>, 138 µg/m<sup>3</sup> and 97 µg/m<sup>3</sup> respectively which was exceed the Standard limit (NAAQS) the while at Signal Building the mean TSPM, PM<sub>10</sub> and PM<sub>2.5</sub> were 113 µg/m<sup>3</sup>, 74 µg/m<sup>3</sup> and 38 µg/m<sup>3</sup> respectively slightly exceed the Standard limit (NAAQS).

The overall values of November for Gaseous SO<sub>2</sub>, NO<sub>2</sub>, NH<sub>3</sub>, CO<sub>2</sub>, CO, C<sub>6</sub>H<sub>6</sub> 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<sup>2</sup>. The maximum solar radiation was recorded 759 w/m<sup>2</sup> in 4<sup>th</sup> November, 2022 and the minimum solar radiation was recorded 1.80 w/m<sup>2</sup> in 30<sup>th</sup> 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.



# CHAPTER-1

## INTRODUCTION

### DEENDAYAL PORT AUTHORITY

## **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.

## **CHAPTER-2**

### **AMBIENT AIR QUALITY MONITORING**

## 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, NO<sub>x</sub>, O<sub>3</sub>, SO<sub>2</sub>, 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<sub>10</sub>, PM<sub>2.5</sub>), and gaseous pollutants (SO<sub>2</sub>, and NO<sub>2</sub>) 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	<b>DPA-Kandla</b>
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	<b>DPA-Vadinar</b>
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<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub>, NO<sub>2</sub>, NH<sub>3</sub> & Benzene and Grab-sampling for CO & CO<sub>2</sub> 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<sub>2</sub>:- Absorbing Reagent TCM (Potassium Tetrachloromercurate 0.04M): Mercuric Chloride, Potassium Chloride and EDTA used. For NO<sub>2</sub>:- Absorbing Reagent Sodium Hydroxide (NaOH): Sodium Hydroxide and Sodium Arsenite used. For NH<sub>3</sub> need Conc. Sulphuric Acid and Distilled water was used. By replacing 3 times the reagents per day for each parameter namely, SO<sub>2</sub>, NO<sub>2</sub>, NH<sub>3</sub>. 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<sub>10</sub> & PM<sub>2.5</sub>. 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<sub>10</sub> 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

<b>Table 2 : Results of Air Pollutant Concentration at Marine Bhavan</b>					
	<b>Date</b>	<b>C6H6 [µg/m3]</b>	<b>HC</b>	<b>CO [mg/m3]</b>	<b>CO2 [ppm ]</b>
<b>Sampling Period</b>		<b>8 hr</b>		<b>Grab Sampling</b>	<b>Grab Sampling</b>
<b>NAAQMS limit</b>		<b>5.0 µg/m3</b>	<b>ppm</b>	<b>4.0 mg/m3</b>	<b>-</b>
<b>AL1 – 1</b>	01.11.2022	1.09	BQL	1.44	444
<b>AL1 – 2</b>	04.11.2022	1.2	BQL	1.54	374
<b>AL1 – 3</b>	08.11.2022	1.17	BQL	1.08	538
<b>AL1 – 4</b>	11.11.2022	1.1	BQL	1.14	470
<b>AL1 – 5</b>	15.11.2022	1.11	BQL	1.26	481
<b>AL1 - 6</b>	18.11.2022	1.1	BQL	1.64	500
<b>AL1 - 7</b>	22.11.2022	1.12	BQL	1.35	620
<b>AL1 - 8</b>	25.11.2022	1.16	BQL	1.69	511
<b>AL1 - 9</b>	29.11.2022	1.21	BQL	1.16	522
<b>Monthly Average</b>		<b>1.14</b>	<b>-</b>	<b>1.37</b>	<b>495.56</b>
<b>Standard Deviation</b>		<b>0.05</b>	<b>-</b>	<b>0.22</b>	<b>67.59</b>

\* NMHC- Non- Methane Hydrocarbons

BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

At Marine Bhavan, the overall values of TSPM, PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub>, NO<sub>2</sub> and NH<sub>3</sub> 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<sub>10</sub>. The mean TSPM value at Marine Bhavan was 424 µg/m<sup>3</sup>, the mean PM<sub>10</sub> value was 299 µg/m<sup>3</sup>, and PM<sub>2.5</sub> value was 119 µg/m<sup>3</sup> which is above the permissible limit prescribed by NAAQS. The average values of SO<sub>2</sub>, NO<sub>2</sub> and NH<sub>3</sub> were 4.55 µg/m<sup>3</sup>, 16.33 µg/m<sup>3</sup> & 3.79 µg/m<sup>3</sup> 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<sup>3</sup>, well below the permissible limit of 5.0 µg/m<sup>3</sup>. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.37 mg/m<sup>3</sup>, well below the permissible limit of 4.0 mg/m<sup>3</sup> prescribed by NAAQS.



**Location 3: Oil Jetty (AL2)**

**Table 2 : Results of Air Pollutant Concentration at Oil Jetty**

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

<b>Table 3 : Results of Air Pollutant Concentration at Oil Jetty</b>					
	<b>Date</b>	<b>C<sub>6</sub>H<sub>6</sub> [µg/m<sup>3</sup>]</b>	<b>*NMHC</b>	<b>CO [mg/m<sup>3</sup>]</b>	<b>CO<sub>2</sub> [ppm ]</b>
<b>Sampling Period</b>		<b>8 hr</b>		<b>Grab Sampling</b>	<b>Grab Sampling</b>
<b>NAAQMS limit</b>		<b>5.0 µg/m<sup>3</sup></b>		<b>4.0 mg/m<sup>3</sup></b>	<b>-</b>
<b>AL2-1</b>	01.11.2022	1.17	BQL	1.22	467
<b>AL2-2</b>	04.11.2022	1.01	BQL	1.53	451
<b>AL2-3</b>	08.11.2022	1.1	BQL	1.65	502
<b>AL2-4</b>	11.11.2022	1.19	BQL	1.04	447
<b>AL2 -5</b>	15.11.2022	1.24	BQL	1.27	634
<b>AL2 -6</b>	18.11.2022	1.16	BQL	1.22	531
<b>AL2-7</b>	22.11.2022	1.2	BQL	1.28	800
<b>AL2-8</b>	25.11.2022	1.06	BQL	1.89	1023
<b>AL2-9</b>	29.11.2022	1.22	BQL	1.46	576
<b>Monthly Average</b>		<b>1.15</b>	<b>-</b>	<b>1.40</b>	<b>603.44</b>
<b>Standard Deviation</b>		<b>0.08</b>	<b>-</b>	<b>0.26</b>	<b>193.07</b>

\* NMHC- Non- Methane Hydrocarbons

BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

Oil Jetty Area, the overall values of TSPM, PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub>, NO<sub>2</sub> and NH<sub>3</sub> 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<sup>3</sup>. The mean PM<sub>10</sub> value was 175 µg/m<sup>3</sup> and mean PM<sub>2.5</sub> value was 75 µg/m<sup>3</sup> which was above the permissible limit. The average values of SO<sub>2</sub>, NO<sub>2</sub> and NH<sub>3</sub> were within the permissible limit prescribed by NAAQS. The mean concentration of SO<sub>2</sub>, NO<sub>2</sub> and NH<sub>3</sub> were 3.97 µg/m<sup>3</sup>, 13.70 µg/m<sup>3</sup> and 3.47 µg/m<sup>3</sup> 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<sup>3</sup> which was well below the permissible limit of 5.0 µg/m<sup>3</sup>. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.40 mg/m<sup>3</sup>, well below the permissible limit of 4.0 mg/m<sup>3</sup>.

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

**Table 4 : Results of Air Pollutant Concentration at Estate Office**

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 <sub>6</sub> H <sub>6</sub> [µg/m <sup>3</sup> ]	*NMHC	CO [mg/m <sup>3</sup> ]	CO <sub>2</sub> [ppm]
		8 hr		Grab Sampling	Grab Sampling
		5.0 µg/m <sup>3</sup>		4.0 mg/m <sup>3</sup>	-
NAAQMS limit					
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<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub>, NO<sub>2</sub> and NH<sub>3</sub> 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<sup>3</sup>, the mean PM<sub>10</sub> value was 329 µg/m<sup>3</sup>, and PM<sub>2.5</sub> value was 107 µg/m<sup>3</sup> which was above the permissible limit prescribed by NAAQS. The average values of SO<sub>2</sub>, NO<sub>2</sub> and NH<sub>3</sub> were 3.76 µg/m<sup>3</sup>, 13.77 µg/m<sup>3</sup> and 3.50 µg/m<sup>3</sup> 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<sup>3</sup>, well below the permissible limit of 5.0 µg/m<sup>3</sup>. NMHC's were below the detectable limit and Carbon Monoxide was 1.58 mg/m<sup>3</sup>, well below the permissible limit of 4.0 mg/m<sup>3</sup>.

**Location 4: Gopalpuri Hospital (AL-4)**

**Table 5 : Results of Air Pollutant Concentration at Gopalpuri Hospital**

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	2.22	5.77	6.93	2.42	2.53
					3.02		10.39		4.14	
					2.42		4.62		1.04	
AL4 -2	04.11.2022	177	117	54	0.91	2.22	5.19	10.00	1.61	2.49
					4.53		8.66		2.42	
					1.21		16.16		3.45	
AL4 -3	08.11.2022	148	101	44	1.15	2.21	6.93	9.81	1.73	1.69
					2.88		17.31		2.42	
					2.59		5.19		0.92	
AL4 -4	11.11.2022	184	111	68	1.51	2.62	6.93	12.89	1.04	2.30
					3.63		14.43		2.42	
					2.72		17.31		3.45	
AL4 – 5	15.11.2022	202	125	72	2.12	2.42	12.12	12.70	2.42	2.49
					3.63		8.66		3.45	
					1.51		17.31		1.61	
AL4 – 6	18.11.2022	233	153	78	1.21	2.92	8.66	12.89	2.42	2.49
					4.84		17.89		1.61	
					2.72		12.12		3.45	
AL4 – 7	22.11.2022	268	168	94	0.60	2.22	5.77	12.70	1.73	2.88
					3.32		14.43		3.68	
					2.72		17.89		3.22	
AL4 – 8	25.11.2022	202	142	56	2.12	3.42	14.43	12.50	2.07	2.99
					5.14		17.89		4.03	
					3.02		5.19		2.88	
AL1 – 9	29.11.2022	249	157	91	3.02	4.03	8.66	11.54	1.38	2.49
					6.35		20.20		3.80	
					2.72		5.77		2.30	
Monthly Average		197	127	66		2.70		11.33		2.49
Standard Deviation		50	32	20		0.65		2.05		0.37



<b>Table 5 : Results of Air Pollutant Concentration at Gopalpuri Hospital</b>					
<b>Sampling Period</b>	<b>Date</b>	<b>C<sub>6</sub>H<sub>6</sub> [µg/m<sup>3</sup>]</b>	<b>*NMHC</b>	<b>CO [mg/m<sup>3</sup>]</b>	<b>CO<sub>2</sub> [ppm ]</b>
		<b>8 hr</b>		<b>Grab Sampling</b>	<b>Grab Sampling</b>
<b>NAAQMS limit</b>		<b>5.0 µg/m<sup>3</sup></b>		<b>4.0 mg/m<sup>3</sup></b>	<b>-</b>
<b>AL4 -1</b>	01.11.2022	1.14	BQL	1.26	503
<b>AL4 -2</b>	04.11.2022	1.15	BQL	1.26	450
<b>AL4 -3</b>	08.11.2022	1.03	BQL	1.73	506
<b>AL4 -4</b>	11.11.2022	1.02	BQL	1.82	462
<b>AL4 – 5</b>	15.11.2022	1.09	BQL	1.04	1048
<b>AL4 – 6</b>	18.11.2022	1.14	BQL	1.32	543
<b>AL4 – 7</b>	22.11.2022	1.16	BQL	1.83	758
<b>AL4 – 8</b>	25.11.2022	1.22	BQL	1.8	816
<b>AL4 – 9</b>	29.11.2022	1.16	BQL	1.36	665
<b>Monthly Average</b>		<b>1.12</b>	<b>-</b>	<b>1.49</b>	<b>639.00</b>
<b>Standard Deviation</b>		<b>0.07</b>	<b>-</b>	<b>0.30</b>	<b>201.83</b>

\* NMHC- Non- Methane Hydrocarbons

BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub>, NO<sub>2</sub> and NH<sub>3</sub> 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<sup>3</sup>, the mean PM<sub>10</sub> value was 127 µg/m<sup>3</sup> and PM<sub>2.5</sub> was 66 µg/m<sup>3</sup> which was exceed the standard limit. The average values of SO<sub>2</sub>, NO<sub>2</sub> and NH<sub>3</sub> were 2.70 µg/m<sup>3</sup>, 11.33 µg/m<sup>3</sup> and 2.49 µg/m<sup>3</sup> 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<sup>3</sup>, well below the permissible limit of 5.0 µg/m<sup>3</sup>. NMHC's were below the detectable limit and Carbon monoxide concentration was 1.49 mg/m<sup>3</sup> which is well below the permissible limit of 4.0 mg/m<sup>3</sup>.

Location 5: Coal Storage Area (AL-5)

Table 6 : Results of Air Pollutant Concentration at Coal Storage Area

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	4.33	6.35	16.54	3.68	5.06
					6.65		25.97		8.17	
					3.63		17.31		3.34	
AL6 – 2	04.11.2022	635	492	137	2.12	3.53	23.08	17.70	6.79	6.60
					5.44		12.12		8.17	
					3.02		17.89		4.83	
AL6 – 3	08.11.2022	538	412	125	8.94	5.00	23.66	21.74	2.53	3.88
					3.46		12.12		2.07	
					2.59		29.43		7.02	
AL6 – 4	11.11.2022	815	635	178	4.53	4.73	18.47	17.70	5.87	4.41
					2.72		8.66		2.65	
					6.95		25.97		4.72	
AL6 – 5	15.11.2022	792	614	176	6.35	6.65	18.47	13.66	4.72	3.88
					9.07		10.39		3.68	
					4.53		12.12		3.22	
AL6 – 6	18.11.2022	771	595	171	9.37	7.15	20.20	17.12	4.83	4.37
					5.74		8.08		2.53	
					6.35		23.08		5.76	
AL6 – 7	22.11.2022	706	543	156	4.84	4.53	10.39	18.47	4.83	5.03
					6.04		23.66		5.99	
					2.72		21.35		4.26	
AL6 – 8	25.11.2022	846	654	187	3.32	5.24	17.31	19.81	3.91	4.95
					7.86		25.97		6.91	
					4.53		16.16		4.03	
AL1 – 9	29.11.2022	801	621	172	5.14	5.64	16.16	18.28	3.57	4.30
					9.07		28.86		6.22	
					2.72		9.81		3.11	
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 <sub>6</sub> H <sub>6</sub> [µg/m <sup>3</sup> ]	*NMHC	CO [mg/m <sup>3</sup> ]	CO <sub>2</sub> [ppm ]
		8 hr		Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m <sup>3</sup>		4.0 mg/m <sup>3</sup>	-
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<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub>, NO<sub>2</sub> and NH<sub>3</sub> at Coal Storage Area was comparatively highest among all the locations of Air Quality monitoring in Kandla Port. High values of TSPM, PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub>, NO<sub>2</sub> 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<sup>3</sup>, the mean PM<sub>10</sub> value was 574 µg/m<sup>3</sup>, and the PM<sub>2.5</sub> value was 164 µg/m<sup>3</sup> which was above the permissible limit prescribed by NAAQS. The average values of SO<sub>2</sub>, NO<sub>2</sub> and NH<sub>3</sub> were 5.20 µg/m<sup>3</sup>, 17.89 µg/m<sup>3</sup> and 4.72 µg/m<sup>3</sup> 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<sup>3</sup>, well below the permissible limit of 5.0 µg/m<sup>3</sup>. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.50 mg/m<sup>3</sup>, well below the permissible limit of 4.0 mg/m<sup>3</sup>.

**Location 6: Tuna Port (AL-6)**

**Table 7 : Results of Air Pollutant Concentration at Tuna Port**

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**

		<b>C<sub>6</sub>H<sub>6</sub> [µg/m<sup>3</sup>]</b>		<b>CO [mg/m<sup>3</sup>]</b>	<b>CO<sub>2</sub> [ppm ]</b>
<b>Sampling Period</b>	<b>Date</b>	<b>8 hr</b>	<b>*NMHC</b>	<b>Grab Sampling</b>	<b>Grab Sampling</b>
<b>NAAQMS limit</b>		<b>5.0 µg/m<sup>3</sup></b>		<b>4.0 mg/m<sup>3</sup></b>	<b>-</b>
<b>AL6 -1</b>	01.11.2022	1.12	BQL	1.43	543
<b>AL6 – 2</b>	04.11.2022	1.17	BQL	1.41	463
<b>AL6 – 3</b>	08.11.2022	1.13	BQL	1.39	410
<b>AL6 – 4</b>	11.11.2022	1.13	BQL	1.74	509
<b>AL6 – 5</b>	15.11.2022	1.17	BQL	1.08	911
<b>AL6 – 6</b>	18.11.2022	1.17	BQL	1.1	528
<b>AL6 – 7</b>	22.11.2022	1.06	BQL	1.88	565
<b>AL6 – 8</b>	25.11.2022	1.1	BQL	1.89	999
	29.11.2022	1.22	BQL	1.89	895
<b>Monthly Average</b>		<b>1.14</b>	<b>-</b>	<b>1.53</b>	<b>647.00</b>
<b>Standard Deviation</b>		<b>0.05</b>	<b>-</b>	<b>0.33</b>	<b>222.45</b>

\* 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<sup>3</sup>, the mean PM<sub>10</sub> value was 145 µg/m<sup>3</sup> and the mean PM<sub>2.5</sub> value was 71 µg/m<sup>3</sup> which was exceed the standard limit prescribed by NAAQS. The average values of SO<sub>2</sub>, NO<sub>2</sub> and NH<sub>3</sub> were 2.45 µg/m<sup>3</sup>, 10.69 µg/m<sup>3</sup> and 3.50 µg/m<sup>3</sup> 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/m<sup>3</sup>, well below the permissible limit of 5.0 µg/m<sup>3</sup>. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.53 mg/m<sup>3</sup>, well below the permissible limit of 4.0 mg/m<sup>3</sup>.

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	3.52	9.53	10.59	5.36	5.28
					4.84		16.51		2.81	
					3.52		5.72		7.66	
AL7 -2	04.11.2022	177	115	61	3.08	4.69	17.78	21.81	2.81	6.13
					7.03		21.60		8.93	
					3.96		26.04		6.64	
AL7 -3	08.11.2022	193	113	73	6.15	6.30	6.99	11.43	3.83	7.49
					8.79		20.96		10.47	
					3.96		6.35		8.17	
AL7 -4	11.11.2022	200	121	78	3.96	6.01	17.78	15.24	10.47	6.81
					5.28		22.23		5.87	
					8.79		5.72		4.08	
AL7 -5	15.11.2022	179	108	69	1.76	5.28	7.62	18.00	3.06	5.62
					5.71		26.04		5.87	
					8.35		20.33		7.91	
AL7 -6	18.11.2022	223	121	96	2.64	4.54	8.89	15.03	5.62	5.70
					4.40		16.51		8.17	
					6.59		19.69		3.32	
AL1 -7	22.11.2022	162	104	57	4.84	5.28	14.61	14.61	13.02	9.10
					7.03		5.72		8.68	
					3.96		23.50		5.62	
AL1-8	25.11.2022	237	138	97	6.59	4.40	9.53	15.24	7.91	8.00
					3.96		14.61		5.62	
					2.64		21.60		10.47	
AL1-9	28.11.2022	203	112	87	3.96	3.66	6.99	13.76	5.62	6.04
					2.20		14.61		7.91	
					4.84		19.69		4.60	
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 <sub>6</sub> H <sub>6</sub> [µg/m <sup>3</sup> ]	*NMHC	CO [mg/m <sup>3</sup> ]	CO <sub>2</sub> [ppm ]
		8 hr		Grab Sampling	Grab Sampling
		5.0 µg/m <sup>3</sup>		4.0 mg/m <sup>3</sup>	-
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<sup>3</sup>, the mean PM<sub>10</sub> value was 114 µg/m<sup>3</sup> and the mean PM<sub>2.5</sub> value was 74 µg/m<sup>3</sup> which was slightly exceed the standard limit. The average values of SO<sub>2</sub>, NO<sub>2</sub> and NH<sub>3</sub> concentrations were 4.85 µg/m<sup>3</sup>, 15.08 µg/m<sup>3</sup> and 6.68 µg/m<sup>3</sup> 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<sup>3</sup>, well below the permissible limit of 5.0 µg/m<sup>3</sup>. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.46 mg/m<sup>3</sup>, well below the permissible limit of 4.0 mg/m<sup>3</sup>.

**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 <sub>6</sub> H <sub>6</sub> [µg/m <sup>3</sup> ]		CO [mg/m <sup>3</sup> ]	CO <sub>2</sub> [ppm]
Sampling Period	Date	8 hr	*NMHC	Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m <sup>3</sup>		4.0 mg/m <sup>3</sup>	-
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

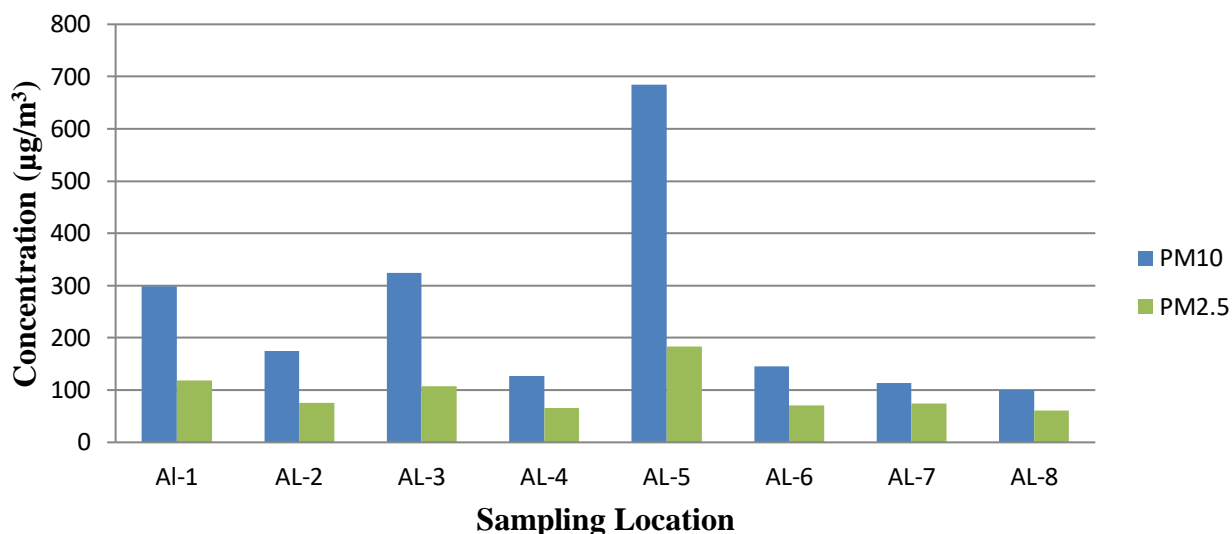
\* NMHC- Non- Methane Hydrocarbon

BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

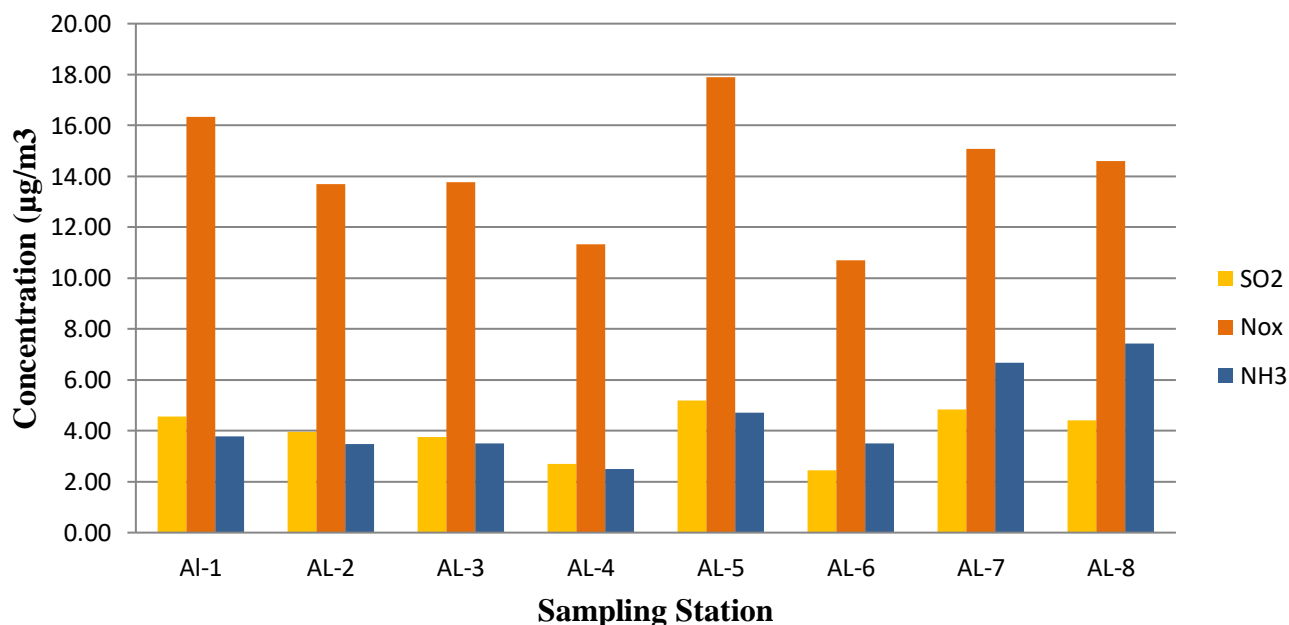
At Signal Building, Vadinar the mean TSPM value was 164 µg/m<sup>3</sup>, the mean PM<sub>10</sub> value was 100 µg/m<sup>3</sup> which was boundary line of the permissible limit, the mean PM<sub>2.5</sub> value was 61 µg/m<sup>3</sup> which was within the permissible limit. The average values of SO<sub>2</sub>, NO<sub>2</sub> and NH<sub>3</sub> concentrations were 4.40 µg/m<sup>3</sup>, 14.59 µg/m<sup>3</sup> and 7.44 µg/m<sup>3</sup> 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<sup>3</sup>, well below the standard limit of 5.0 µg/m<sup>3</sup>. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.46 mg/m<sup>3</sup>, well below the standard limit of 4.0 mg/m<sup>3</sup>.

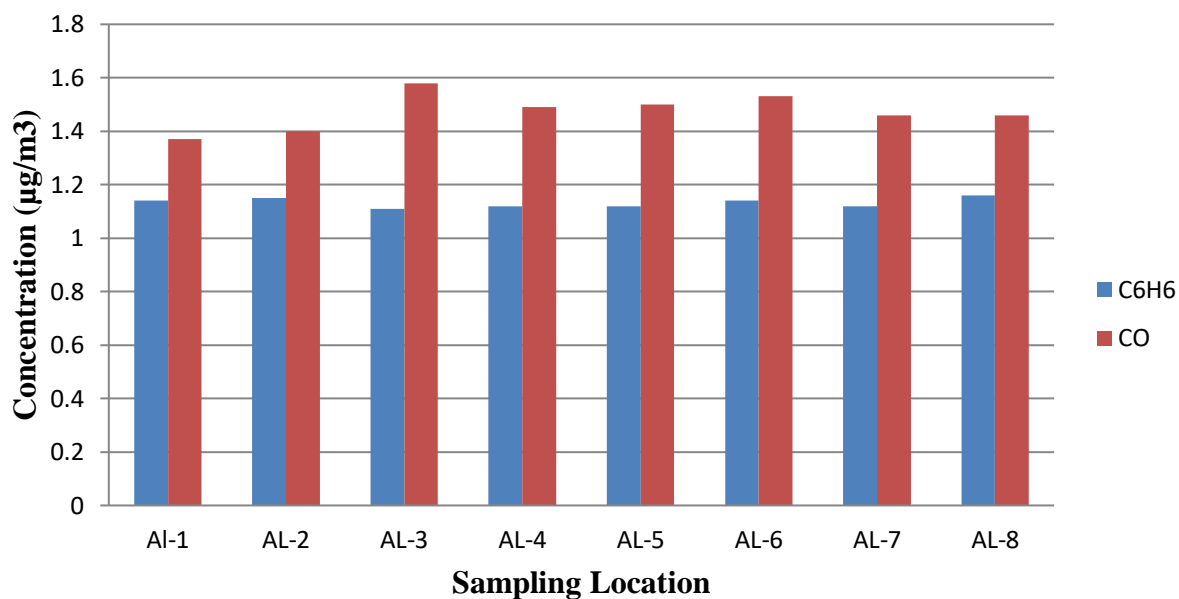
**Fig. No:-1 Average ambient air quality (PM) month of November-2022 at DPA and Vadinar Sampling Station**



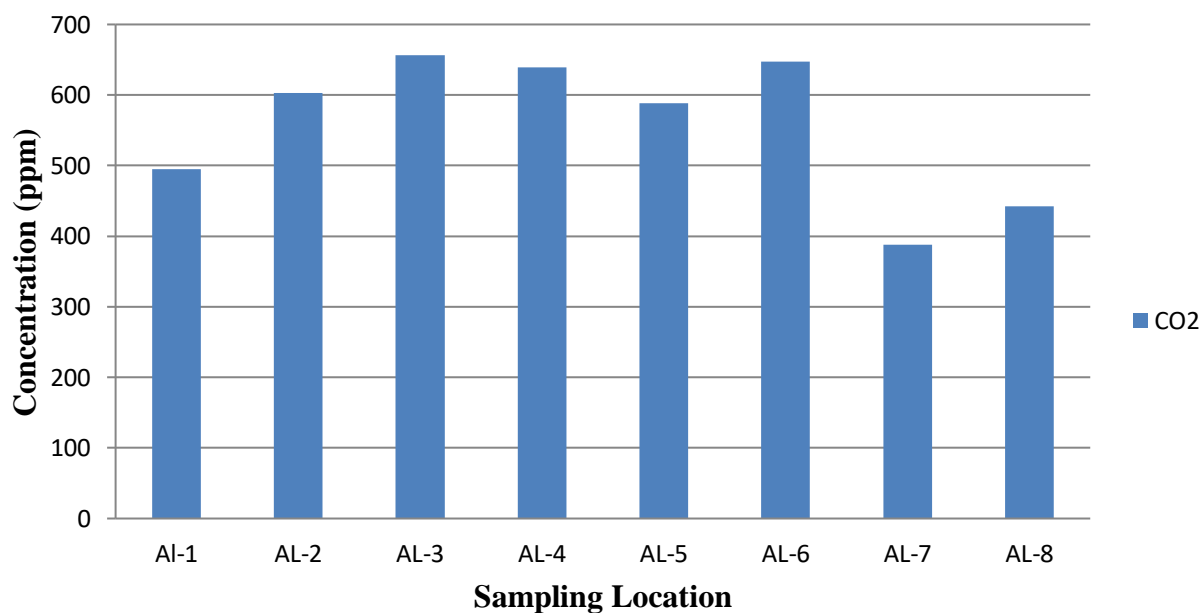
**Fig. No:-2. Average ambient air quality (Gaseous) month of November-2022 at DPA and Vadinar sampling location**



**Fig. No:-3. Average ambient air quality (Gaseous) month of November-2022 at DPA and Vadinar sampling location**



**Fig. No:-4. Average ambient air quality (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<sub>10</sub> and PM<sub>2.5</sub> was found to exceed the limits at locations at all ambient air sampling location.

The concentration of PM<sub>10</sub> and PM<sub>2.5</sub> were slightly exceeded at Gopalpuri and Tuna Port.

The mean concentration of PM<sub>10</sub> and PM<sub>2.5</sub> were slightly exceeded at Admin building Vadinar & at Signal building Vadinar was very close to the standard limit.



## **CHAPTER-3**

### **METEOROLOGICAL OBSERVATIONS**

#### **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<sup>2</sup>) 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<sup>0</sup>C. The average day time temperature was 27.92°C. The night time temperature was range from 20.0-29.7<sup>0</sup>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<sup>2</sup>. The maximum solar radiation was recorded 759.0 w/m<sup>2</sup> in 4<sup>th</sup> November, 2022 and the minimum solar radiation was recorded 1.80 w/m<sup>2</sup> in 30<sup>th</sup> November, 2022.

##### **Rainfall**

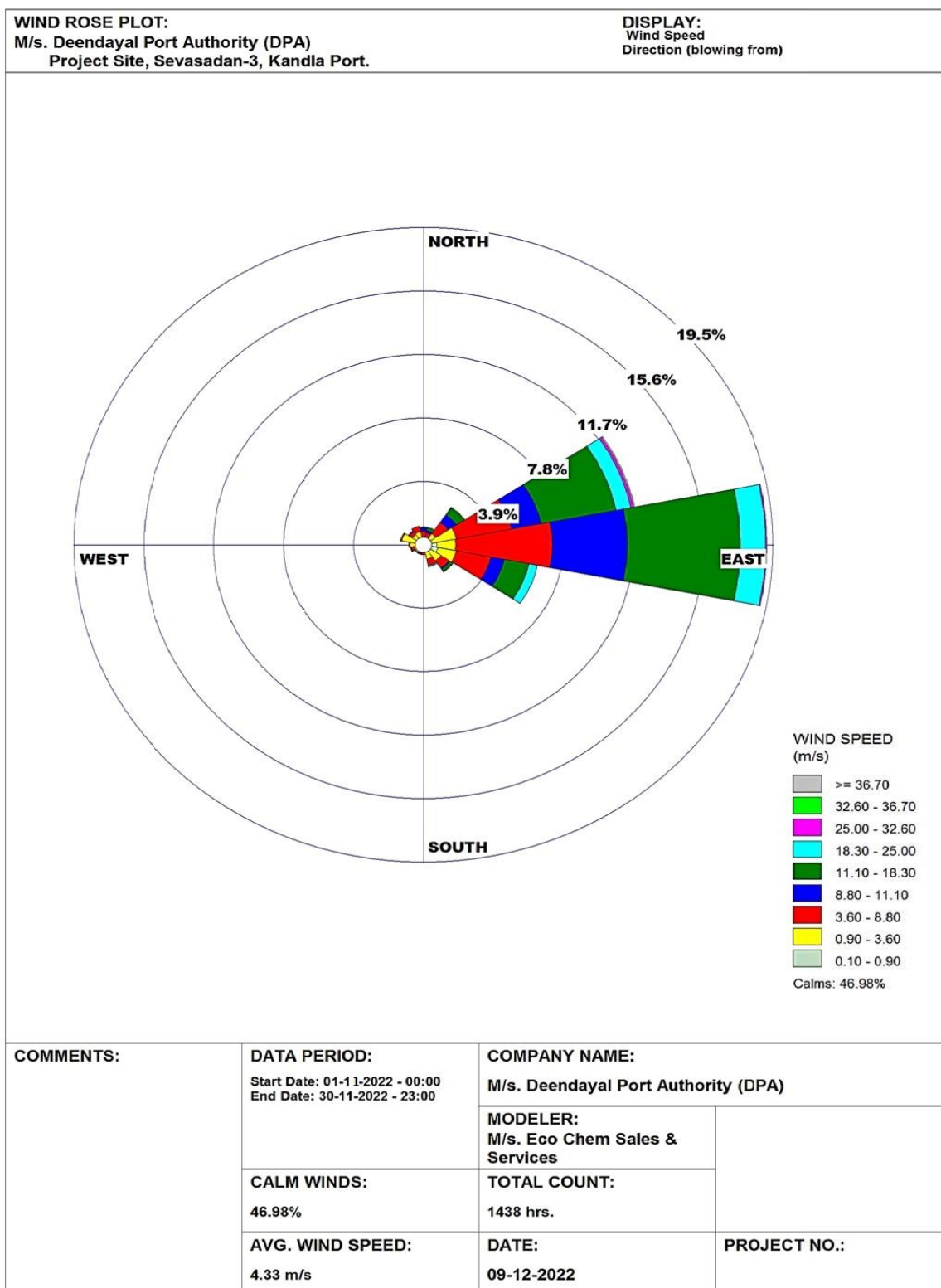
Rain fall of November month was recorded 0.00 mm.

##### **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.



WRPLOT View - Lakes Environmental Software

## CHAPTER-4

### DRINKING WATER QUALITY MONITORING



#### 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<sub>3</sub>, NO<sub>2</sub>, 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 <sub>4</sub>	mg/l	35.80	30.20	28.30	200	400
15	Nitrite as NO <sub>2</sub>	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO <sub>3</sub>	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/10 0ml	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<sup>+6</sup>- 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 SO <sub>4</sub>	mg/l	31.20	28.30	26.00	200	400
15	Nitrite as NO <sub>2</sub>	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO <sub>3</sub>	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 <sub>4</sub>	mg/l	24.90	34.20	27.2	200	400
15	Nitrite as NO <sub>2</sub>	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO <sub>3</sub>	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).

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**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 <sub>4</sub>	mg/l	28.10	24.50	24.50	200	400
15	Nitrite as NO <sub>2</sub>	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO <sub>3</sub>	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 <sub>4</sub>	mg/l	24.90	26.00	30.20	200	400
15	Nitrite as NO <sub>2</sub>	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO <sub>3</sub>	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 <sub>4</sub>	mg/l	26.00	26.10	24.50	200	400
15	Nitrite as NO <sub>2</sub>	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO <sub>3</sub>	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 <sub>4</sub>	mg/l	0.75	0.24	200	400
15	Nitrite as NO <sub>2</sub>	mg/l	BQL	BQL	NS*	NS*
16	Nitrate as NO <sub>3</sub>	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  $\mu\text{S}/\text{cm}$  at Tuna Port to 1821.0  $\mu\text{S}/\text{cm}$  at A.O. Building and mean value was 1381.72  $\mu\text{S}/\text{cm}$  while at Vadinar ranged from 300-570  $\mu\text{S}/\text{cm}$  and mean was 435  $\mu\text{S}/\text{cm}$ .



## **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<sub>2</sub>) and Nitrates (NO<sub>3</sub>)**

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 was 191.8 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.

## CHAPTER-5

### NOISE MONITORING

## 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
<b>Vadinar Port</b>			
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.

## CHAPTER-6

### SOIL MONITORING

## 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  $\mu\text{S}/\text{cm}$  at Nakti Creek (Sand from creek after tide) to 36100  $\mu\text{S}/\text{cm}$  at IFFCO Plant and mean was 27655  $\mu\text{S}/\text{cm}$  while Vadinar soil sampling location conductivity were 155  $\mu\text{S}/\text{cm}$  at DPA Admin Site and 594  $\mu\text{S}/\text{cm}$  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 IFFCO 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 was 11356 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.



## **CHAPTER-7**

### **SEWAGE TREATMENT PLANT MONITORING**

## 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 (1<sup>st</sup> Week)**

<b>Date of Sampling</b>	03.11.2022
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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
<b>Aeration Tank</b>					
6	MLSS	mg/l	14.0		
7	MLVSS	%	99.73		

**Table 23: Sewage Water Monitoring at Kandla STP (2<sup>nd</sup> Week)**

<b>Date of Sampling</b>	10.11.2022
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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
<b>Aeration Tank</b>					
6	MLSS	mg/l	18.0		
7	MLVSS	%	85.00		

**Table 24: Sewage Water Monitoring at Kandla STP (3<sup>rd</sup> Week)**

<b>Date of Sampling</b>	17.11.2022
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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
<b>Aeration Tank</b>					
6	MLSS	mg/l	20.0		
7	MLVSS	%	98.0		

**Table 25: Sewage Water Monitoring at Kandla STP (4<sup>th</sup> Week)**

<b>Date of Sampling</b>	24.10.2022
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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
<b>Aeration Tank</b>					
6	MLSS	mg/l	20.0		
7	MLVSS	%	89.0		

**Table 26: Sewage Water Monitoring at Gopalpuri STP (1<sup>st</sup> Week)**

<b>Date of Sampling</b>	03.11.2022
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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
<b>Aeration Tank</b>					
6	MLSS	mg/l	22.0		
7	MLVSS	%	97.16		

**Table 27: Sewage Water Monitoring at Gopalpuri STP (2<sup>nd</sup> Week)**

<b>Date of Sampling</b>	10.11.2022
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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
<b>Aeration Tank</b>					
6	MLSS	mg/l	16.0		
7	MLVSS	%	89.6		

**Table 28: Sewage Water Monitoring at Gopalpuri STP (3<sup>rd</sup> Week)**

<b>Date of Sampling</b>	17.11.2022
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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
<b>Aeration Tank</b>					
6	MLSS	mg/l	08.0		
7	MLVSS	%	98.0		

**Table 29: Sewage Water Monitoring at Gopalpuri STP (4<sup>th</sup> Week)**

<b>Date of Sampling</b>	24.11.2022
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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
<b>Aeration Tank</b>					
6	MLSS	mg/l	18.0		
7	MLVSS	%	90.0		



**Table 30: Sewage Water Monitoring at Vadinar STP (1<sup>st</sup> Week)**

<b>Date of Sampling</b>	03.11.2022
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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 (2<sup>nd</sup> Week)**

<b>Date of Sampling</b>	10.11.2022
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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 (3<sup>rd</sup> Week)**

<b>Date of Sampling</b>	17.11.2022
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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 (4<sup>th</sup> Week)**

<b>Date of Sampling</b>	24.11.2022
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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.

## CHAPTER-8

### MARINE WATER MONITORING

## **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 01<sup>st</sup> & 02<sup>nd</sup> 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 8<sup>th</sup> & 9<sup>th</sup> 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 Khorī 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 Khorī creek 1 near Vadinar Jetty 1 near 1 <sup>st</sup> SBM
<b>Total Number of locations</b>	<b>8</b>

### 8.1 Marine Water Quality and Results

Marine water quality of marine waters of Deendayal Port Harbor waters, Khorī & 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	
			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/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 Near Coal Berth**

Sr. No.	Parameters	Unit	Near Coal Berth			
			22°59'12"N 70°13'40"E			
			Spring Tide		Neap 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	
			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	
			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-0.1 mg/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	
			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	
			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, Khorī 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).



## CHAPTER-9

### MARINE SEDIMENT MONITORING

## 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 (NO<sub>3</sub>: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 (NO<sub>3</sub>: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, Khorī 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.

## CHAPTER-11

### MARINE ECOLOGICAL MONITORING

## 10.0 INTRODUCTION:

### 10.1 Sampling Stations:

The monitoring of marine environment for the study of biological and ecological Parameters was carried out on 01<sup>st</sup> November 2022 in harbour region of DPA at Kandla Creek, and on 02<sup>nd</sup> 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 08<sup>th</sup> November, 2022 in harbour region of DPA at Kandla Creek and on 09<sup>th</sup> 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 <sup>st</sup> SPM
<b>Total Number of locations</b>	<b>8</b>

### 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.

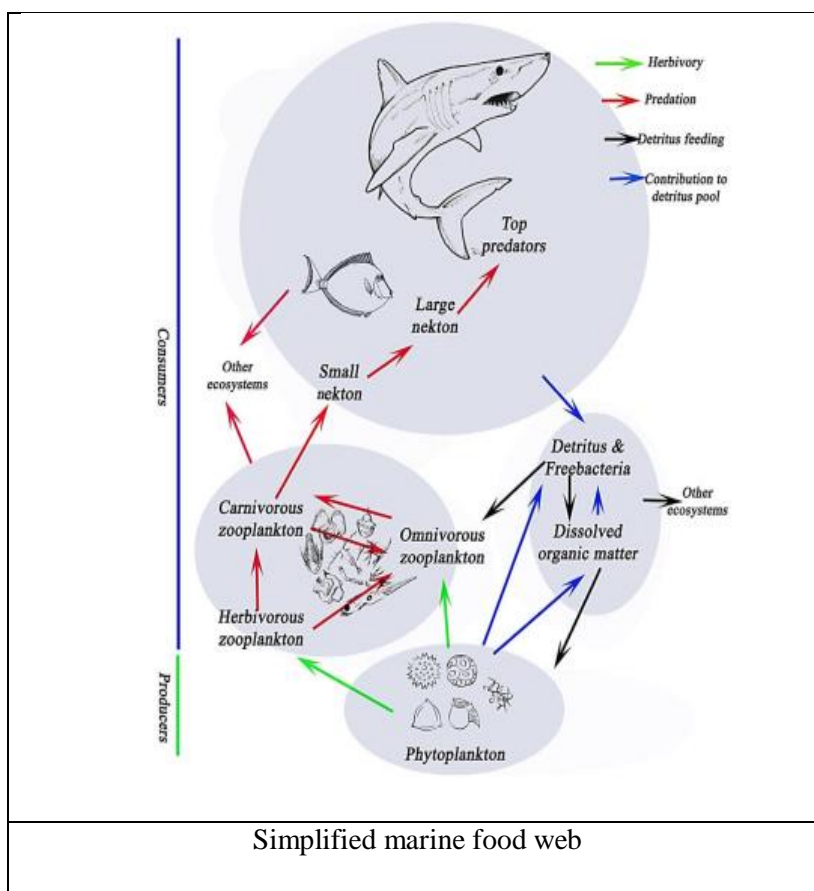
Zooplankton can be subdivided into holoplankton, i.e., permanent members of the plankton (e.g., Calanoid copepods), and meroplankton, i.e., temporary members in the plankton e.g., larvae of fish, shrimp, and crab). The meroplankton group consists of larval and young stages of animals that will adopt 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 (Ghajibhiye, 2002).



### 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.

DCPL/DPA/21-22/31– November-2022

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 November 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:**

##### **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 42 $\mu$  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<sup>2</sup>) 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 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. *et al.* 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 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 taxon. It varies from 0 for communities with only single taxa to high values for community with many taxon 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:

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

In the sub surface water chlorophyll-a was varying from 0.472-0.969 mg/m<sup>3</sup> with an average value 0.645 mg/m<sup>3</sup> 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<sup>3</sup> with an average value 0.552 mg/m<sup>3</sup> 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<sup>3</sup> with an average value 0.437 mg/m<sup>3</sup> in harbour region of DPA in Kandla Creek during sampling done in Neap tide period of November 2022. In the nearby creeks chlorophyll-a was varying from 0.205- 0.440mg/m<sup>3</sup> with an average value 0.370 mg/m<sup>3</sup>. 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<sup>3</sup> 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<sup>3</sup> 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 VADINAR DURING SPRING TIDE IN NOVEMBER 2022**

Sr. No.	Station	Tide	Chlorophyll-a (mg/m <sup>3</sup> )	Pheophytin- a (mg/m <sup>3</sup> )	Algal Biomass (Chlorophyll method) mg/m <sup>3</sup>
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 Khor-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 <sup>3</sup> )	Pheophytin- a (mg/m <sup>3</sup> )	Algal Biomass (Chlorophyll method) mg/m <sup>3</sup>
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 Khor-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 and 115-199 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 Dinoflagellates during Neap 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 from 1.963- 3.589 with an average of 2.835 during 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 3.586 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 2.821- 3.86 with an average of 3.357 during 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 tide at Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.790-0.915 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 0.951 during consecutive low tide at Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton communities in the stations was 1.037 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 and 1.035 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 was 1.036 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 was 0.863 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 <sub>10</sub> )	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 <sub>10</sub> )	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	<b>39-243</b>	<b>34</b>	
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	<b>115-199</b>	<b>34</b>	

**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	<b>43-299</b>	<b>31</b>	
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	<b>143-193</b>	<b>31</b>	

**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 <sub>10</sub> )	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 <sub>10</sub> )	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

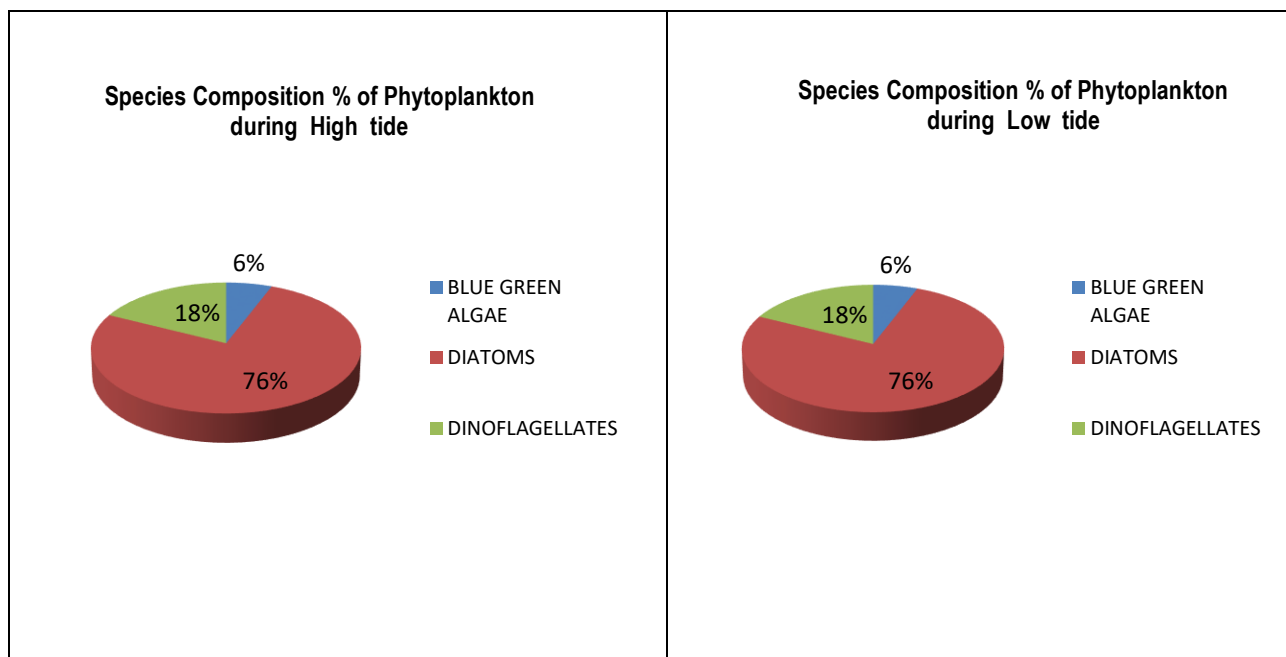
**TABLE:-53 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPAOOT AT PATH FINDER CREEK, VADINAR & NEAR BY SPM, DURING SPRING TIDE IN NOVEMBER 2022**

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	

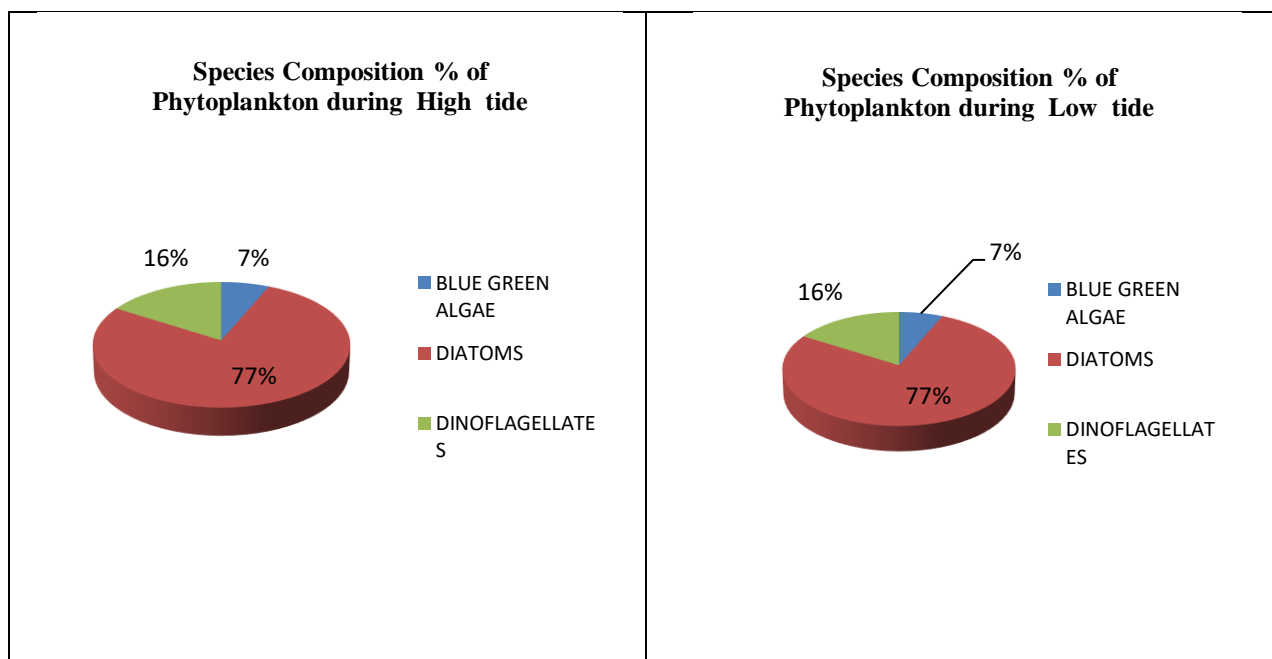
**Table:- 54 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPA OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING NEAP TIDE IN NOVEMBER 2022**

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	<b>244-259</b>		
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	<b>200-294</b>		

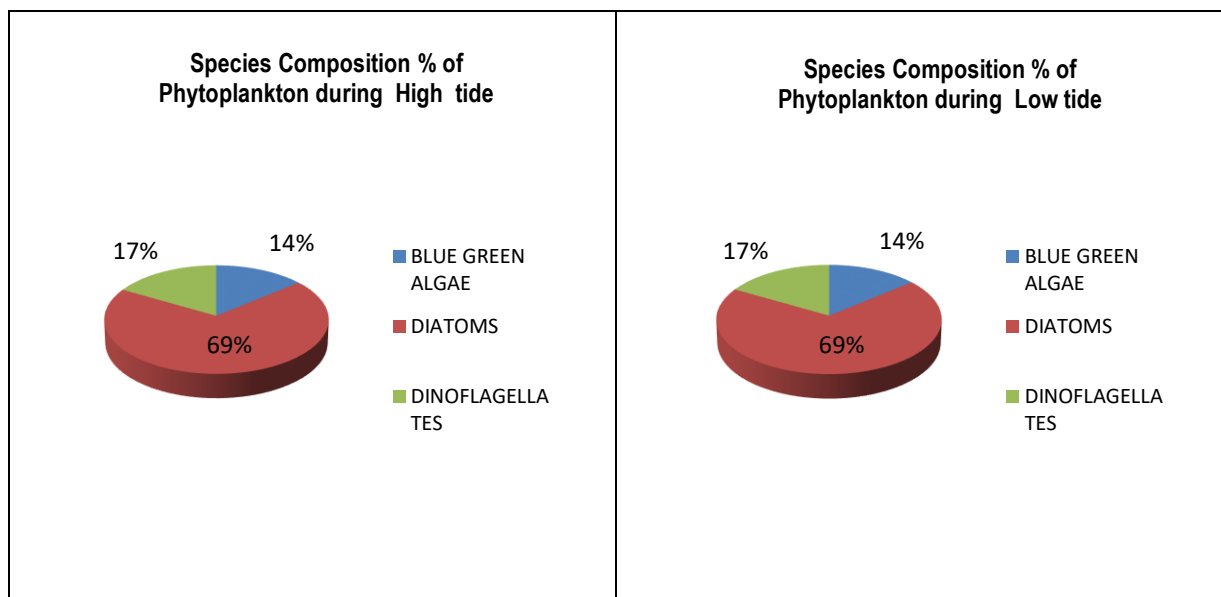
**Species Composition % of Phytoplankton during High tide and Low tide period during spring tide in Kandla creek and nearby creeks**



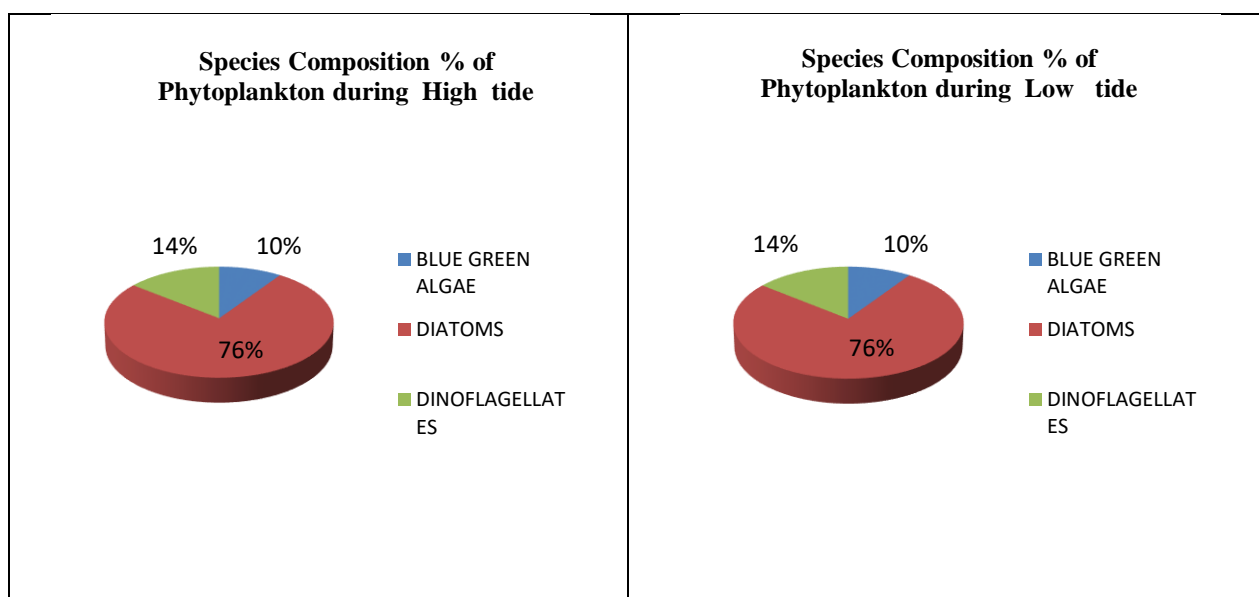
**Species Composition % of Phytoplankton during High tide and Low tide period during Neap tide in Kandla creek and nearby creeks**



**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 represented by 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, Ciliates and 6 larval forms.

Zooplankton of the sampling stations at sub surface layer in the DPA harbour area and nearby creek was varying from  $25-128 \times 10^3 \text{ N/m}^3$  during high tide and  $103-144 \times 10^3 \text{ N/m}^3$  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  $19-114 \times 10^3 \text{ N/m}^3$  during high tide and  $76-106 \times 10^3 \text{ N/m}^3$  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, Ciliates and 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, Urochordata and 5 larval forms.

Zooplankton of the sampling stations at sub surface layer in the DPA OOT Jetty area of path finder creek was  $91 \times 10^3 \text{ N/m}^3$  during high tide and  $86 \times 10^3 \text{ N/m}^3$  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  $101 \times 10^3 \text{ N/m}^3$  during high tide and  $70 \times 10^3 \text{ N/m}^3$  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  $87 \times 10^3 \text{ N/m}^3$  during high tide and  $65 \times 10^3 \text{ N/m}^3$  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  $64 \times 10^3 \text{ N/m}^3$  during high tide and  $87 \times 10^3 \text{ N/m}^3$  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 from 1.358-3.858 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 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 1.995 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 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 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 of 0.939 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 of 0.938 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 0.775-0.751 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 0.780-0.909 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 TIDE IN NOVEMBER 2022**

Tide	Sampling Station	Abundance In $N \times 10^3 / m^3$	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 AREA AT KANDLA CREEK AND NEAR BY CREEKS DURING NEAP TIDE IN NOVEMBER 2022**

Tide	Sampling Station	Abundance In $No \times 10^3 / m^3$	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 <sup>3</sup> / m <sup>3</sup> 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 <sup>3</sup>	<b>25-128</b>	<b>33</b>	
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 <sup>3</sup>	<b>103-144</b>	<b>33</b>	

**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 $\times 10^3 / m^3$ 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 <sup>3</sup>	<b>19-114</b>	<b>32</b>	
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 <sup>3</sup>	<b>76-106</b>	<b>32</b>	

**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 $\times 10^3 N / m^3$	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log <sub>10</sub> )	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 DURING NEAP TIDE IN NOVEMBER 2022**

Tide	Sampling Station	Abundance In $N \times 10^3 / m^3$	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

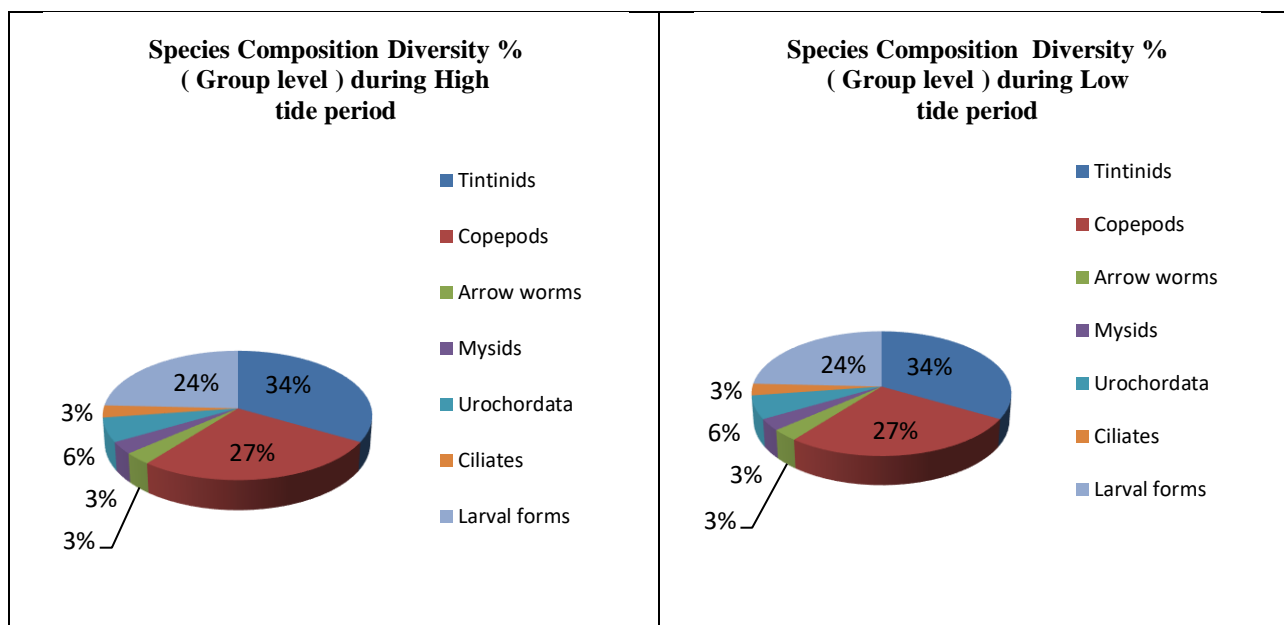
**Table:-61 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA OOT AREA AND PATH FINDER CREEK AND NEAR BY SPM DURING SPRING TIDE IN NOVEMBER 2022**

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $\times 10^3 / m^3$ 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	<b>91-101</b>	<b>20</b>	
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	<b>70-86</b>	<b>20</b>	

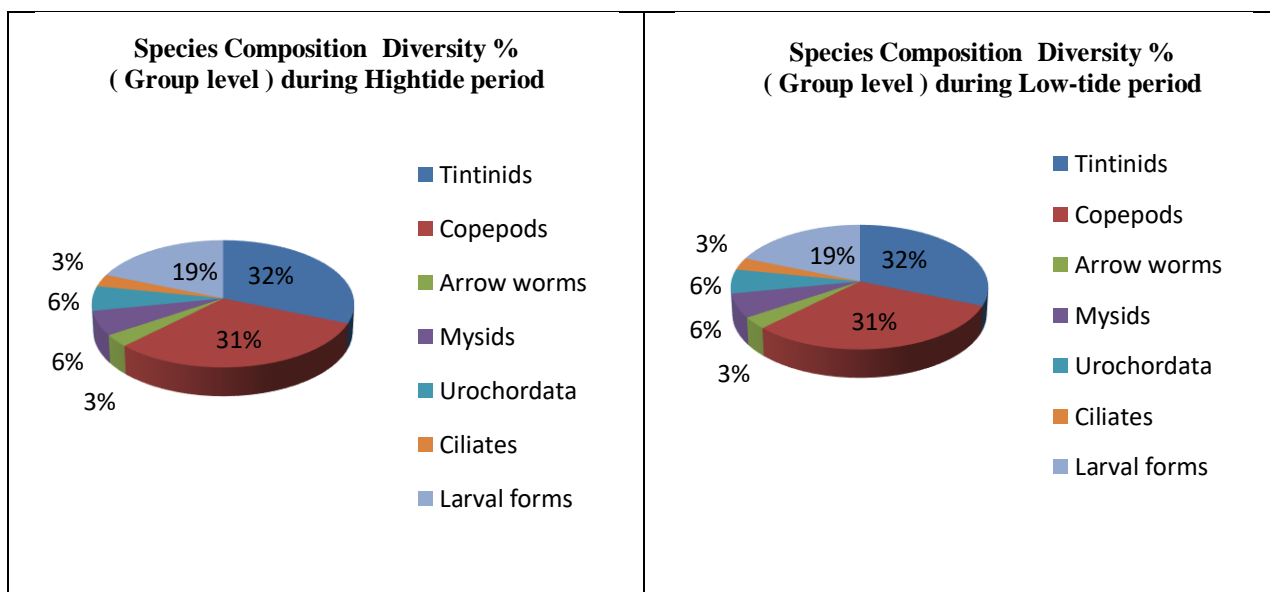
**TABLE:-62 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING NEAP TIDE IN NOVEMBER 2022**

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $\times 10^3 / m^3$ 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	<b>64-87</b>	<b>21</b>	
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	<b>65-87</b>	<b>21</b>	

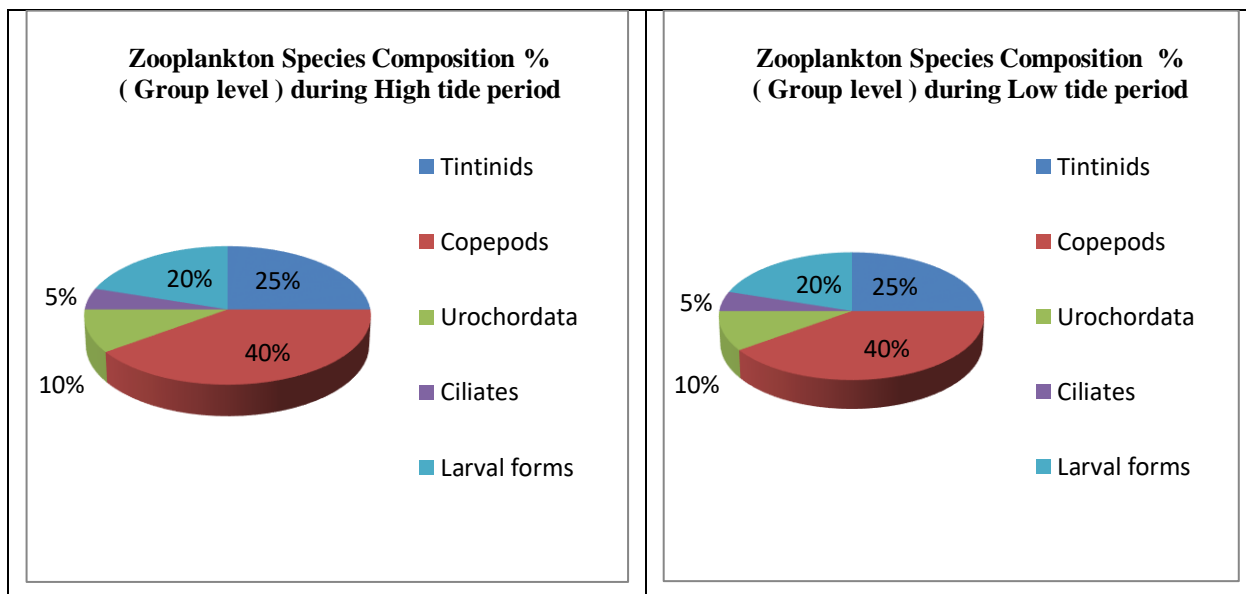
**Species Composition % of Zooplankton during High tide and Low tide period of spring tide In  
Kandla Creek and nearby Creeks**



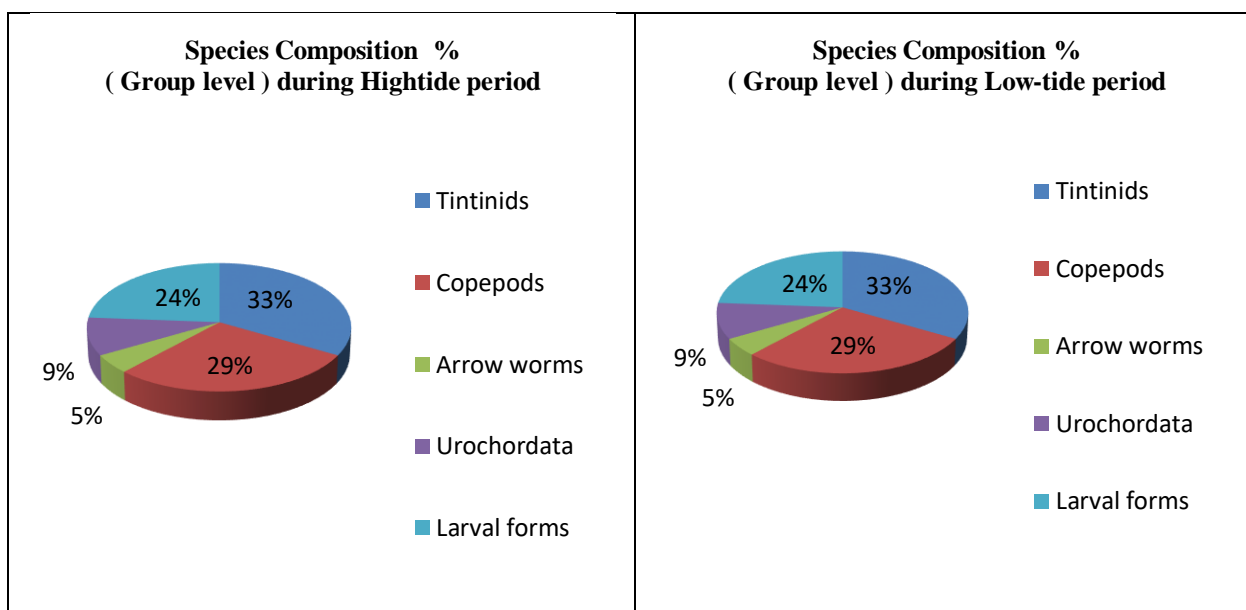
**Species Composition % of Zooplankton during High tide and Low tide period of Neap tide In  
Kandla Creek and nearby Creeks**



**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	<i>Oscillatoria sp.</i>	B1	Very sparse
	Oscillatoriales	Phormidiaceae	<i>Planktothrix sp.</i>	B2	Very sparse
Coccinodiscophyceae	Biddulphiales	Biddulphiaceae	<i>Biddulphiasp</i>	D1	Abundant
	Chaetocerotales	Chaetocerotaceae	<i>Bacteriastrum sp</i>	D2	Very sparse
			<i>Chaetoceros sp.</i>	D3	Scattered
	Corethrales	Corethraceae	<i>Corethron sp</i>	D4	Very sparse
	Coccinodiscales	Coccinodiscaceae	<i>Coccinodiscus sp.</i>	D5	Dominant
	Hemiaulales	Bellerucheaceae	<i>Belleruche sp</i>	D6	Very sparse
		Streptothecaceae	<i>Helicotheca sp</i>	D7	Very sparse
	Rhizosoleniales	Rhizosoleniaceae	<i>Rhizosolenia sp.</i>	D8	Sparse
	Lithodesmiales	Lithodesmiaceae	<i>Ditylum sp</i>	D9	Dominant
	Thalassiosirales	Thalassiosiraceae	<i>Planktoniellasp</i>	D10	Very sparse
		Skeletonemataceae	<i>Skeletonemas sp</i>	D11	Abundant
	Triceratiales	Triceratiaceae	<i>Odontella sp.</i>	D12	Very sparse
			<i>Triceratium sp.</i>	D13	Very sparse
Bacillariophyceae	Bacillariales	Bacillariaceae	<i>Bacillaria sp.</i>	D14	Very sparse
			<i>Nitzschia sp</i>	D15	Sparse
			<i>Pseudo-nitzschia sp.</i>	D16	Very sparse
	Naviculales	<u>Pleurosigmataceae</u>	<i>Pleurosigma sp.</i>	D17	Very sparse
	Surirellales	Entomoneidaceae	<i>Entomoneis sp.</i>	D18	Very sparse
Fragilariophyceae	Fragilariales	Fragilariaceae	<i>Asterionellopsis sp</i>	D19	Scattered
			<i>Fragilariasp</i>	D20	Very sparse
			<i>Synedrassp</i>	D21	Very sparse

	Striatellales	Striatellaceae	<i>Grammatophora sp</i>	D22	Very sparse
	Thalassionematales	Thalassionemataceae	<i>Thalassionema sp.</i>	D23	Sparse
			<i>Thalassiothrix sp.</i>	D24	Very sparse
Noctiluca / Noctiluciphyceae (Dinokaryota)	Noctilucales	Noctilucaceae	<i>Noctiluca sp.</i>	DF1	Sparse
Dinophyceae	Peridinales	Protopteridiniaceae	<i>Protopteridinium sp.</i>	DF2	Very sparse
	Gonyaulacales	Pyrophacaceae	<i>Pyrophacus sp.</i>	DF3	Very sparse
		Ceratiaceae	<i>Ceratium furca</i>	DF4	Very sparse
			<i>Ceratium tripos</i>	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	<i>Oscillatoria</i> sp.	B1	Very sparse
	Oscillatoriales	Phormidiaceae	<i>Planktothrix</i> sp.	B2	Very sparse
Coscinodiscophyceae	Biddulphiales	Biddulphiaceae	<i>Biddulphia</i> sp.	D1	Sparse
	Chaetocerotales	Chaetocerotaceae	<i>Chaetoceros</i> sp.	D2	Abundant
	Corethrales	Corethraceae	<i>Corethron</i> sp.	D3	Very sparse
	Coscinodiscales	Coscinodiscaceae	<i>Coscinodiscus</i> sp.	D4	Abundant
	Rhizosoleniales	Rhizosoleniaceae	<i>Rhizosolenia</i> sp.	D5	Sparse
	Leptocylindrales	Leptocylindraceae	<i>Leptocylindrus</i> sp.	D6	Very sparse
	Lithodesmiales	Lithodesmiaceae	<i>Ditylum</i> sp.	D7	Scattered
	Thalassiosirales	Thalassiosiraceae	<i>Planktoniella</i> sp.	D8	Very sparse
		Lauderiaceae	<i>Lauderia</i> sp.	D9	Very sparse
		Skeletonemataceae	<i>Skeletonemas</i> sp.	D10	Dominant
	Triceratiales	Triceratiaceae	<i>Odontella</i> sp.	D11	Very sparse
			<i>Triceratium</i> sp.	D12	Very sparse
Bacillariophyceae	Bacillariales	Bacillariaceae	<i>Bacillaria</i> sp.	D13	Very sparse
			<i>Nitzschia</i> sp.	D14	Very sparse
			<i>Pseudo-nitzschia</i> sp.	D15	Very sparse
	Naviculales	Naviculaceae	<i>Navicula</i> sp.	D16	Very sparse
		Plagiotropidaceae	<i>Plagiotropis</i> sp.	D17	Very sparse
		<u>Pleurosigmataceae</u>	<i>Pleurosigma</i> sp.	D18	Sparse
	Surirellales	Entomoneidaceae	<i>Entomoneis</i> sp.	D19	Very sparse
		Surirellaceae	<i>Surirella</i> sp.	D20	Very sparse
Fragilariophyceae	Fragilariales	Fragilariaceae	<i>Asterionellopsis</i> sp.	D21	Sparse



			<i>Fragilariasp</i>	D22	Very sparse
			<i>Synedrasp</i>	D23	Sparse
	Striatellales	Striatellaceae	<i>Grammatophora sp</i>	D24	Very sparse
	Thalassionematales	Thalassionemataceae	<i>Thalassionema sp.</i>	D25	Scattered
			<i>Thalassiothrix sp.</i>	D26	Sparse
Noctiluca / Noctiluciphyceae (Dinokaryota)	Noctilucales	Noctilucaceae	<i>Noctiluca sp.</i>	DF1	Sparse
Dinophyceae	Peridiniales	Protoperidiniaceae	<i>Protoperidinium sp.</i>	DF2	Very sparse
	Gonyaulacales	Ceratiaceae	<i>Ceratium breve</i>	DF3	Very sparse
			<i>Ceratium furca</i>	DF4	Very sparse
			<i>Ceratium fusus</i>	DF5	Very sparse
			<i>Ceratium tripos</i>	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	<i>Lyngbya sp.</i>	B1	Very sparse
			<i>Oscillatoria sp.</i>	B2	Very sparse
			<i>Spirulina sp.</i>	B3	Very sparse
	Oscillatoriales	Phormidiaceae	<i>Planktothrix sp.</i>	B4	Very sparse
Coscinodiscophyceae	Biddulphiales	Biddulphiaceae	<i>Biddulphia</i> sp	D1	Scattered
	Chaetocerotales	Chaetocerotaceae	<i>Chaetoceros</i> sp	D2	Scattered
	Corethrales	Corethraceae	<i>Corethron sp</i>	D3	Very sparse
	Coscinodiscales	Coscinodiscaceae	<i>Coscinodiscus sp.</i>	D4	Dominant
	Hemiaulales	Bellerocheaceae	<i>Belleroche</i> sp	D5	Very sparse
		Hemiaulaceae	<i>Cerataulina sp.</i>	D6	Very sparse
			<i>Eucampia sp</i>	D7	Very sparse
		Streptothecaceae	<i>Helicotheca sp</i>	D8	Very sparse
	Leptocylindrales	Leptocylindraceae	<i>Leptocylindrus sp</i>	D9	Very sparse
	Lithodesmiales	Lithodesmiaceae	<i>Ditylum</i> sp	D10	Abundant
	Rhizosoleniales	Rhizosoleniaceae	<i>Dactyliosolen sp.</i>	D11	Very sparse
			<i>Rhizosolenia sp.</i>	D12	Sparse
	Thalassiosirales	Skeletonemataceae	<i>Skeletonema sp.</i>	D13	Abundant
		Lauderiaceae	<i>Lauderia sp</i>	D14	Very sparse
		Thalassiosiraceae	<i>Planktoniella</i> sp	D15	Very sparse
	Triceratiales	Triceratiaceae	<i>Odontella</i> sp	D16	Very sparse
			<i>Triceratium</i> sp	D17	Very sparse
Bacillariophyceae	Bacillariales	Bacillariaceae	<i>Bacillaria</i> sp.	D18	Abundant
			<i>Nitzschia sp</i>	D19	Very sparse

			<i>Pseudo-nitzschiasp</i>	D20	Scattered
	Naviculales	Naviculaceae	<i>Meuniera sp.</i>	D21	Very sparse
			<i>Navicula sp</i>	D22	Very sparse
		Pinnulariaceae	<i>Pinnulariasp</i>	D23	Very sparse
		<u>Pleurosigmataceae</u>	<i>Pleurosigma sp</i>	D24	Very sparse
	Surirellales	Entomoneidaceae	<i>Entomoneis sp.</i>	D25	Very sparse
		Surirellaceae	<i>Surirellasp</i>	D26	Very sparse
Fragilariophyceae	Climacospheniales	Climacospheniaceae	<i>Climacosphenia sp.</i>	D27	Very sparse
	Fragilariales	Fragilariaceae	<i>Asterionellopsis sp.</i>	D28	Very sparse
			<i>Synedra sp.</i>	D29	Very sparse
	Striatellales	Striatellaceae	<i>Striatellasp</i>	D30	Very sparse
	Thalassionematales	Thalassionemataceae	<i>Thalassionema sp.</i>	D31	Sparse
			<i>Thalassiothrix sp.</i>	D32	Sparse
Dinophyceae	Peridinales	Protoperidiniaceae	<i>Protoperidinium sp.</i>	DF1	Very sparse
	Dinophysales	Dinophysaceae	<i>Dinophysis sp.</i>	DF2	Very sparse
	Gonyaulacales	Pyrophacaceae	<i>Pyrophacus sp.</i>	DF3	Very sparse
		Ceratiaceae	<i>Ceratium furca</i>	DF4	Very sparse
			<i>Ceratium fusus</i>	DF5	Very sparse
			<i>Ceratium tripos</i>	DF6	Very sparse

**TABLE:-66 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPAOOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING AND SPRING TIDE OF NOVEMBER 2022:**

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
Cyanophyceae	Chroococcales	Chroococcaceae	<i>Merismopedia sp.</i>	B1	Very sparse
	Nostocales	Oscillatoriaceae	<i>Lyngbya sp.</i>	B2	Very sparse
			<i>Oscillatoria sp.</i>	B3	Sparse
	Oscillatoriales	Phormidiaceae	<i>Planktothrix sp.</i>	B4	Very sparse
	Stigonematales	Stigonemataceae	<i>Stigonema sp.</i>	B5	Very sparse
Coscinodiscophyceae	Biddulphiales	Biddulphiaceae	<i>Biddulphia</i> sp.	D1	Sparse
	Chaetocerotales	Chaetocerotaceae	<i>Chaetoceros sp.</i>	D2	Dominant
	Corethrales	Corethraceae	<i>Corethron sp.</i>	D3	Very sparse
	Coscinodiscales	Coscinodiscaceae	<i>Coscinodiscus sp.</i>	D4	Abundant
	Hemiaulales	Bellerucheaceae	<i>Belleruche sp.</i>	D5	Very sparse
		Hemiaulaceae	<i>Cerataulina sp.</i>	D6	Very sparse
		Streptothecaceae	<i>Helicotheca sp.</i>	D7	Very sparse
	Rhizosoleniales	Rhizosoleniaceae	<i>Rhizosolenia sp.</i>	D8	Scattered
	Leptocylindrales	Leptocylindraceae	<i>Leptocylindrus sp.</i>	D9	Very sparse
	Lithodesmiales	Lithodesmiaceae	<i>Ditylum sp.</i>	D10	Abundant
	Thalassiosirales	Thalassiosiraceae	<i>Planktoniella</i> sp.	D11	Very sparse
		Lauderiaceae	<i>Lauderia sp.</i>	D12	Very sparse
	Triceratiales	Triceratiaceae	<i>Odontella sp.</i>	D13	Sparse
			<i>Triceratium sp.</i>	D14	Very sparse
Bacillariophyceae	Bacillariales	Bacillariaceae	<i>Bacillaria sp.</i>	D15	Scattered
			<i>Nitzschia sp.</i>	D16	Very sparse
			<i>Pseudo-nitzschia</i> sp.	D17	Sparse
	Naviculales	Pinnulariaceae	<i>Pinnularia</i> sp.	D18	Very sparse

		<u>Pleurosigmataceae</u>	<i>Pleurosigma</i> sp.	D19	Very sparse
	Surirellales	Entomoneidaceae	<i>Entomoneis</i> sp.	D20	Very sparse
		Surirellaceae	<i>Surirella</i> sp.	D21	Very sparse
Fragilariophyceae	Fragilariales	Fragilariaceae	<i>Asterionellopsis</i> sp	D22	Sparse
			<i>Synedrassp</i>	D23	Very sparse
	Thalassionematales	Thalassionemataceae	<i>Thalassionema</i> sp.	D24	Sparse
			<i>Thalassiothrix</i> sp.	D25	Very sparse
Dinophyceae	Peridinales	Protoperidiniaceae	<i>Protoperidinium</i> sp.	DF1	Very sparse
	Dinophysales	Dinophysaceae	<i>Dinophysis</i> sp.	DF2	Very sparse
	Gonyaulacales	Pyrophacaceae	<i>Pyrophacus</i> sp.	DF3	Very sparse
		Ceratiaceae	<i>Ceratium furca</i>	DF4	Very sparse
			<i>Ceratium fusus</i>	DF5	Very sparse
			<i>Ceratium tripos</i>	DF6	Very sparse

**TABLE:-67 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM 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
Spirotrichea	Tintinnida	Tintinnidiidae	<i>Leprotintinnus</i> sp.	T1	Very sparse
		Codonellidae	<i>Tintinnopsis dadayi</i>	T2	Very sparse
			<i>Tintinnopsis failakkaensis</i>	T3	Very sparse
			<i>Tintinnopsis gracilis</i>	T4	Very sparse
			<i>Tintinnopsis mortensenii</i>	T5	Very sparse
			<i>Tintinnopsis radix</i>	T6	Very sparse
			<i>Tintinnopsis tocaninensis</i>	T7	Very sparse
		Tintinnidae	<i>Amphorellopsis</i> sp.	T8	Very sparse
			<i>Eutintinnus</i> sp.	T9	Very sparse
		Xystonellidae	<i>Favella</i> sp.	T10	Very sparse
Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	<i>Acrocalanus</i> sp.	C1	Sparse
			<i>Parvocalanus</i> sp.	C2	Very sparse
		Acartiidae	<i>Acartia</i> sp.	C3	Very sparse
		Clausocalanidae	<i>Clausocalanus</i> sp.	C4	Very sparse
		Centropagidae	<i>Centropages</i> sp.	C5	Very sparse
		Temoridae	<i>Temora</i> sp.	C6	Very sparse
	Cyclopoida	Oithonidae	<i>Oithona</i> sp.	C7	Abundant
	Harpacticoida	Ectinosomatidae	<i>Microsetella</i> sp.	C8	Scattered
		Euterpinae	<i>Euterpina</i> sp.	C9	Sparse
	Poecilostomatoida	Oncaeidae	<i>Oncaea</i> sp.	C10	Very sparse
Sagittioidea	Aphragmophora	Sagittidae	<i>Sagitta</i> sp.	A1	Very sparse
Malacostraca	Mysida,	Penaeidae	<i>Metapenaeus</i> sp.	M1	Very sparse
	Decapoda	Solenoceridae	<i>Solenocera</i> sp.	M2	Very sparse

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Appendicularia		Fritillariidae	<i>Fritillaria sp.</i>	U1	Very sparse
		Oikopleuridae	<i>Oikopleura sp.</i>	U2	Very sparse
Oligohymenophorea	Sessilida	Zoothamniidae	<i>Zoothamnium sp.</i>	CI1	Very sparse
Copepoda			Nauplius larvae of copepods	L1	Dominant
Malacostraca			Brachyuran zoea	L2	Very sparse
Decapoda					
Maxillopoda			Cirripede larvae	L3	Very sparse
Thecostraca					
			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 CREEKS DURING SPRING TIDE OF NOVEMBER 2022:**

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
Spirotrichea	Tintinnida	Tintinnidiidae	<i>Leprotintinnus</i> sp.	T1	Scattered
		Codonellidae	<i>Tintinnopsis dadayi</i>	T2	Very sparse
			<i>Tintinnopsis failakkaensis</i>	T3	Very sparse
			<i>Tintinnopsis gracilis</i>	T4	Very sparse
			<i>Tintinnopsis mortensenii</i>	T5	Very sparse
			<i>Tintinnopsis radix</i>	T6	Sparse
			<i>Tintinnopsis tocaninensis</i>	T7	Very sparse
		Metacyclidiidae	<i>Metacyclis</i> sp.	T8	Very sparse
		Tintinnidae	<i>Amphorellopsis</i> sp.	T9	Very sparse
			<i>Eutintinnus</i> sp.	T10	Very sparse
		Xystonellidae	<i>Favella</i> sp.	T11	Sparse
Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	<i>Acrocalanus</i> sp.	C1	Scattered
			<i>Parvocalanus</i> sp.	C2	Very sparse
		Acartiidae	<i>Acartia</i> sp.	C3	Very sparse
		Clausocalanidae	<i>Clausocalanus</i> sp.	C4	Very sparse
		Centropagidae	<i>Centropages</i> sp.	C5	Very sparse
		Eucalanidae	<i>Subeucalanus</i> sp.	C6	Very sparse
	Cyclopoida	Oithonidae	<i>Oithona</i> sp.	C7	Abundant
	Harpacticoida	Ectinosomatidae	<i>Microsetella</i> sp.	C8	Sparse
		Euterpinae	<i>Euterpina</i> sp.	C9	Sparse
Sagittoidea	Aphragmophora	Sagittidae	<i>Sagitta</i> sp.	A1	Very sparse
Malacostraca	Mysida, Decapoda	Solenoceridae	<i>Solenocera</i> sp.	M1	Very sparse

Appendicularia		Fritillariidae	<i>Fritillaria sp.</i>	U1	Very sparse
		Oikopleuridae	<i>Oikopleura sp.</i>	U2	Very sparse
Oligohymenophorea	Sessilida	Zoothamniidae	<i>Zoothamnium sp.</i>	CI1	Very sparse
Copepoda			Nauplius larvae of copepods	L1	Dominant
Malacostraca			Brachyuran zoea	L2	Sparse
Decapoda					
Maxillopoda			Cirripede larvae	L3	Very sparse
Thecostraca					
			Cyphonautes larvae	L4	Very sparse
			Ophiopluteus larvae	L5	Very sparse
Gastropoda			Opisthobranchia larvae	L6	Very sparse
Streptoneura					
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	<i>Leptotintinnussp.</i>	T1	Sparse
		Codonellidae	<i>Tintinnopsisfailakkaensis</i>	T2	Very sparse
			<i>Tintinnopsis gracilis</i>	T3	Very sparse
			<i>Tintinnopsis radix</i>	T4	Very sparse
			<i>Tintinnopsis tocaninensis</i>	T5	Very sparse
		Tintinnidae	<i>Amphorellopsis sp.</i>	T6	Very sparse
		Xystonellidae	<i>Favella sp.</i>	T7	Very sparse
Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	<i>Acrocalanus sp.</i>	C1	Scattered
			<i>Parvocalanus sp.</i>	C2	Very sparse
	Cyclopoida	Oithonidae	<i>Oithona sp.</i>	C3	Abundant
	Harpacticoida	Euterpinae	<i>Euterpina sp.</i>	C4	Very sparse
		Ectinosomatidae	<i>Microsetellasp.</i>	C5	Very sparse
	Poecilostomatoida	Oncaeidae	<i>Oncaea sp.</i>	C6	Very sparse
Sagittioidea	Aphragmophora	Sagittidae	<i>Sagitta sp.</i>	A1	Very sparse
Appendicularia		Fritillariidae	<i>Fritillaria sp.</i>	U1	Very sparse
		Oikopleuridae	<i>Oikopleura sp.</i>	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	<i>Leprotintinnus</i> sp.	T1	Abundant
		Codonellidae	<i>Tintinnopsis gracilis</i>	T2	Very sparse
			<i>Tintinnopsis mortensenii</i>	T3	Very sparse
			<i>Tintinnopsis radix</i>	T4	Very sparse
		Xystonellidae	<i>Favella</i> sp.	T5	Scattered
Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	<i>Acrocalanus</i> sp.	C1	Sparse
			<i>Parvocalanus</i> sp.	C2	Very sparse
		Centropagidae	<i>Centropages</i> sp.	C3	Very sparse
		Tortanidae	<i>Tortanus</i> sp.	C4	Very sparse
	Cyclopoida	Oithonidae	<i>Oithona</i> sp.	C5	Abundant
		Euterpinae	<i>Euterpina</i> sp.	C6	Very sparse
	Harpacticoida	Ectinosomatidae	<i>Microsetella</i> sp.	C7	Scattered
	Poecilostomatoida	Corycaidae	<i>Corycaeus</i> sp.	C8	Very sparse
Appendicularia		Fritillariidae	<i>Fritillaria</i> sp.	U1	Very sparse
		Oikopleuridae	<i>Oikopleura</i> sp.	U2	Very sparse
Oligohymenophorea	Sessilida	Zoothamniidae	<i>Zoothamnium</i> 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 *Nereis sp.* and few Amphipods. Population of benthic fauna was varying from 10-60- N/m<sup>2</sup> during spring tide and 0-80 N/m<sup>2</sup> 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<sup>2</sup> at OOT jetty premises and 80 N/m<sup>2</sup> near the SPM area during spring tide and 50 N/m<sup>2</sup> at OOT jetty premises and 50 N/m<sup>2</sup> 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 <sup>2</sup> DIFFERENT SAMPLING STATIONS						
REPRESENTATION BY GROUP	DPA HARBOUR			CREEKS		
<b>Benthic fauna</b>						
<b>POLYCHAETES</b>	DPA-1	DPA-2	DPA-3	DPA-4	DPA-5	DPA-6
Family : CIRRATULIDAE <i>Tharyxsp.</i>	20	10	10	0	0	NS
Family :NEREIDAE <i>Nereis sp.</i>	0	0	0	20	40	NS
<b>AMPHIPODA</b>	0	0	0		20	NS
TOTAL Benthic Fauna NUMBER/ M <sup>2</sup>	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 <sup>2</sup> DIFFERENT SAMPLING STATIONS						
REPRESENTATION BY GROUP	DPA HARBOUR			CREEKS		
<b>Benthic fauna</b>						
<b>POLYCHAETES</b>	DPA-1	DPA-2	DPA-3	DPA-4	DPA-5	DPA-6
Family :NEREIDAE <i>Nereis sp.</i>	0	0	0	40	60	NS
<i>Amphipoda</i>	0	20	10	10	20	NS
TOTAL Benthic Fauna NUMBER/M <sup>2</sup>	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 <sup>2</sup> DIFFERENT SAMPLING STATIONS		
REPRESENTATION BY GROUP	OOT Jetty Area	SPM area
<b>POLYCHAETES</b>		
Family : Glyceride <i>Glycerasp.</i>	20	40
Family : CIRRATULIDAE <i>Cirratulussp.</i>	0	20
Family: NEREIDAE <i>Nereis sp.</i>	30	10
<i>Amphipoda</i>	10	20
TOTAL Benthic Fauna NUMBER/ M <sup>2</sup>	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 <sup>2</sup> DIFFERENT SAMPLING STATIONS		
REPRESENTATION BY GROUP	OOT Jetty Area	SPM area
<b>POLYCHAETES</b>		
Family : Glyceridase <i>Glycera sp.</i>	20	40
Family: NEREIDAE <i>Nereis sp.</i>	30	10
TOTAL Benthic Fauna NUMBER/ M <sup>2</sup>	50	50

## **CHAPTER-11**

### **CONCLUSIVE SUMMARY & REMEDIAL MEASURES**



### 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 (standards  $100 \mu g/m^3$ ,  $60 \mu g/m^3$ ). 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  $88-175 \mu g/m^3$  and mean value was observed  $145 \mu g/m^3$  which was exceed the prescribed standard limit ( $100 \mu g/m^3$ ), concentration of  $PM_{2.5}$  was ranged from  $47-87 \mu g/m^3$  and mean was found  $71 \mu g/m^3$  which was exceed the standard limit ( $60 \mu g/m^3$ ). At Gopalpuri  $PM_{10}$  concentration ranged from  $67-168 \mu g/m^3$  and mean was  $127 \mu g/m^3$  while  $PM_{2.5}$  concentration ranged from  $34-94 \mu g/m^3$  and mean was  $66 \mu g/m^3$  were found exceed standard limit prescribed by NAAQS.
- At Vadinar, the average concentration of  $PM_{10}$  was  $114 \mu g/m^3$  and  $PM_{2.5}$  was  $74 \mu g/m^3$  at Admin Colony which was slightly exceed the standard limit while at Signal building the mean concentration  $PM_{10}$  was  $100 \mu g/m^3$  and  $PM_{2.5}$  was  $61 \mu g/m^3$  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<sup>2</sup>. The maximum solar radiation was recorded 759 w/m<sup>2</sup> in 4<sup>th</sup> November, 2022 and the minimum solar radiation was recorded 1.80 w/m<sup>2</sup> in 30<sup>th</sup> 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<sub>10</sub>**

- 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<sub>10</sub> & PM<sub>2.5</sub> 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<sub>10</sub>, PM<sub>2.5</sub> 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.

## **CHAPTER-12**

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