DEENDAYAL PORT AUTHORITY
(Erstwhile Deendayal Port Trust)

दीनदयाल पत्तन प्राधिकरण
DEENDAYAL PORT AUTHORITY
www.deendayalport.gov.in

Administrative Office Building
Post Box NO. 50
GANDHIDHAM (Kutch).
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EG/WK/4751/Part (Stage II) / 290

Dated ~~03~~/04/2023
05

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

Sub: Development of Integrated facilities (Stage II) within the existing Deendayal Port Trust (Erstwhile Kandla Port Trust) at District Kutch, Gujarat (1. Setting up of Oil Jetty No. 7 2. Setting up of Barge Jetty at Jafrabadi 3. Setting up of Barge port at Veera 4. Administrative office building at Tuna Tekra 5. Road connecting from Veera barge jetty to Tuna gate by M/s Deendayal Port Authority (Erstwhile Deendayal Port Trust) - **Pointwise Compliance of the conditions stipulated in NOC/CTE issued by GPCB reg.**

Ref.: 1) NOC No. 74134 received vide letter no. GPCB/CCA-Kutch-1319/GPCB ID 48573 Dated 27/11/2015
2) MoEF&CC, GoI granted EC&CRZ vide letter No. F. No. 11-13/2015-IA-III dated 19/02/2020
3) GPCB issued EC to CTE (PCB ID 48573) vide Order dated 13/10/2020
2) DPT Letter EG/WK/4751/Part (Stage II)/54 Dated 29/07/2021
3) DPT Letter EG/WK/4751/Part (Stage II)/145 Dated 08/02/2022
4) DPA letter EG/WK/4751/Part (Stage II)/ 140 dated 11/07/2022

Sir,

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

In this connection, it is relevant to mention here that, the GPCB vide above mentioned letter no. GPCB/CCA-Kutch-1319/GPCB ID 48573 Dated 27/11/2015 had granted the NOC/CTE to the aforesaid project. Subsequently, after obtaining Environmental and CRZ Clearance from MoEF&CC, GoI vide F. No. 11-13/2015-IA-III dated 19/02/2020, DPA obtained EC to CTE (PCB ID 48573) from Gujarat Pollution Control Board vide Order dated 13/10/2020 with a validity period of seven years.

.....Cont.....

Now, please find enclosed herewith compliance report of conditions stipulated in CTE Order (for the period up to November, 2022) along with necessary enclosures as **Annexure I** for 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 in CD as well as through e-mail in ID kut-uh-gpcb@gujarat.gov.in.

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

Thanking you.

Yours faithfully,

Manager (Env.)
Deendayal Port Authority

Encl.: As above

Copy to: Regional Officer,
Gujarat Pollution Control Board,
Regional office,
East Kutch, Gandhidham-370201.
Email Id. ro-gpcb-kute@gujarat.gov.in

Annexure -I

CURRENT STATUS OF WORK (Up to November, 2022)

Subject: **Development of Integrated facilities (Stage-II) within the existing Deendayal Port Trust (Erstwhile Kandla Port Trust) at District Kutch, Gujarat. (1. Setting up of Oil Jetty No.7. 2. Setting up of Barge jetty at Jafarwadi 3. Setting up of Barge port at Veera; 4. An administrative office building at Tuna Tekra; 5. A road connecting from Veera barge jetty to Tuna gate by Deendayal Port Authority (Erstwhile Deendayal Port Trust)**

Sr.No.	Name of Project	Status
1.	**Setting up of Oil Jetty No. 7**	A total of 88% physical work is completed. The work of Jetty head, Central Platform, Berthing Dolphin, Pump House and Approach Jetty completed The work of mooring dolphin is in progress
2.	**Setting up of Barge jetty at Jafarwadi**	No construction activity has started yet
3.	**Setting up of Barge port at Veera**	No construction activity has started yet.
4.	**Administrative office building at Tuna Tekra;**	No construction activity has started yet.
5.	**Road connecting from Veera barge jetty to Tuna gate**	No construction activity has started yet.

Annexure 1

COMPLIANCE REPORT (up to November 2022)

Subject: Point wise compliance of conditions stipulated in NOC Order issued by GPCB, GoG for "Development of Integrated facilities (Stage-II) within the existing Deendayal Port Trust (Erstwhile Kandla Port Trust) at District Kutch, Gujarat. (1. Setting up of Oil Jetty No.7. 2. Setting up of Barge jetty at Jafarwadi 3. Setting up of Barge port at Veera; 4. Administrative office building at Tuna Tekra; 5. Road connecting from Veera barge jetty to Tuna gate by Deendayal Port Authority (Erstwhile Deendayal Port Trust)".

Reference: GPCB issued NOC No. 74134 vide letter no. GPCB/CCA-Kutch-1319/GPCB ID 48573 Dated 27/11/2015. Subsequently, DPA obtained EC to CTE (PCB ID 48573) vide GPCB Order dated 13/10/2020 after obtaining Environmental and CRZ Clearance from MoEF&CC, GoI vide F. No. 11-13/2015-IA-III dated 19/02/2020.

Sr. No	Conditions	Compliance Status
1	**Specific Conditions**	
1	Applicant shall not carry out any kind of activities till Environmental Clearances and CRZ clearances is obtained from the statutory authority.	The MoEF&CC, GoI accorded EC & CRZ Clearance for "Development of Integrated facilities (Stage II) within the existing Deendayal Port Trust (Erstwhile Kandla Port Trust) at District Kutch, Gujarat (1. Setting up of Oil Jetty No. 7 2. Setting up of Barge Jetty at Jafrabadi 3. Setting up of Barge port at Veera 4. Administrative office building at Tuna Tekra 5. Road connecting from Veera barge jetty to Tuna gate by M/s Deendayal Port Trust" vide letter dated 19/2/2020 **(Copy – Annexure A).**
2.	You shall strictly adhere to all conditions of Terms of References (TOR) (vide letter no. F No. 11-13/2015-IA-III) by MoEF&CC, New Delhi.	Based on the TOR issued by the MoEF&CC, GoI dated 23/06/2015, the NABET accredited EIA Consultant had prepared EIA/EMP report as per TOR and accordingly, the MoEF&CC,GoI had accorded the EC & CRZ Clearance dated 19/2/2020.
3.	No ground water shall be used for the project coming under dark zone without permission of competent authority.	No ground water will be used for the project. For construction phase, as per tender clause, the required water for construction activities is being supplied by the contractor. For operational requirement, required water supply will be purchased from GWSSB.
3.	**Conditions Under Water Act**	
3.1	There shall be no Industrial water consumption and hence there shall be no generation from manufacturing process and other ancillary industrial operations.	N/a
3.2	The quantity of domestic waste water (sewage) shall not exceed 18 KL/day	Agreed with the condition

<table>
<tr><td>3.3</td><td>The quality of the sewage shall confirm to the following standards<table><tr><td>Parameters</td><td>Permissible Limit</td></tr><tr><td>BOD (5 days at 20 ^{0} C)</td><td>20 mg/liter</td></tr><tr><td>Suspended Solid</td><td>30 mg/lit</td></tr><tr><td>Residual Chlorine</td><td>Minimum 0.5 mg/liter</td></tr></table></td><td>DPA has been conducting regular Monitoring of environmental parameters since the year 2016 through NABL Accredited laboratory. The work is in progress & DPA submitted monitoring data regularly to all the concerned authorities along with compliance reports submitted. The Environmental Monitoring Reports is enclosed herewith as Annexure B.</td></tr>
<tr><td>3.4</td><td>The sewage shall be treated in sewage treatment plant and confirm above standards shall be utilized for plantation/gardening area of 2,03,775 m^2 within the premises.</td><td>Sewage is being treated in the STP of Kandla (1.5 MLD). The treated sewages from STP of DPA are utilized for plantation / Gardening.
DPA has been conducting regular Monitoring of environmental parameters since the year 2016 through NABL Accredited laboratory. The work is in progress & DPA submitted monitoring data regularly to all the concerned authorities along with compliance reports submitted. The Environmental Monitoring Reports is enclosed herewith as Annexure B.</td></tr>
<tr><td>3.5</td><td>The unit shall install meters at utilities for measuring category wise (category as given in Schedule II of "Water (prevention & control of Pollution) Cess Act-1977 Consumption of Water</td><td>Point noted</td></tr>
<tr><td>4.</td><td colspan="2">Conditions under Air Act 1981:</td></tr>
<tr><td>4.1</td><td>The following shall be used as fuel in the D.G sets as following rates after proposed expansion<table><tr><td>Sr.No.</td><td>Name of Fuel</td><td>Quantity</td></tr><tr><td>1.</td><td>Diesel</td><td>50 Lit/day</td></tr></table></td><td>Point noted.</td></tr>
<tr><td>4.2</td><td>The applicant shall install & Operate air pollution control system in order to achieve process gas emission norms as prescribed below after proposed expansion<table><tr><td>Sr. no.</td><td>Stack Attached to</td><td>Stack Height in meters</td><td>Parameter</td><td>Permissible limit</td></tr><tr><td>1.</td><td>D.G set (50 KV)</td><td>11</td><td>PM
SO2
NOx</td><td>150 mg/NM 3
100 ppm
50 ppm</td></tr></table></td><td>Point noted.</td></tr>
<tr><td>4.3</td><td>The concentration of the following parameters in the ambient air within the premises of the industry shall not exceed</td><td>DPA has been conducting regular Monitoring of environmental parameters since the year 2016</td></tr>
</table>

<table>
<tr><td></td><td>the limits specified hereunder as per National Ambient Air Quality Emission Standards issued by Ministry of Environment, Forest and Climate Change dated 16th November 2009.

<table><tr><td>Parameters</td><td>Time Weighted Average</td><td>Concentra in Amb air in µg/r</td></tr><tr><td>Sulphur Dioxide (SO_2)</td><td>Annual
24 Hours</td><td>50
80</td></tr><tr><td>Nitrogen Dioxide (NO_2)</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 $PM_{2.5}$</td><td>Annual

24 Hours</td><td>40

60</td></tr></table></td><td>through NABL Accredited laboratory. The work is in progress & DPA submitted monitoring data regularly to all the concerned authorities along with compliance reports submitted. The Environmental Monitoring Reports is enclosed herewith as Annexure B.</td></tr>
<tr><td>4.4</td><td>The applicant shall provide portholes, ladder, platform etc at chimney(s) for monitoring the air emission and the same shall be open for inspection. The chimney(s) vents attached to various sources of emission shall be designed by numbers such as S-1, S-2, etc. and these shall be painted/displayed to facilitate identification.</td><td>N/a</td></tr>
<tr><td>4.5</td><td>The Concentration of Noise in ambient air within the premises of industrial unit shall not exceed following levels:;
Between 6 A.M and 10 P.M : 75 dB(A)
Between 10 A.M and 6 P.M : 70 dB(A)</td><td>DPA has been conducting regular Monitoring of environmental parameters since the year 2016 through NABL Accredited laboratories. The work is in progress & DPA submitted monitoring data regularly to all the concerned authorities along with compliance reports submitted. The Environmental Monitoring Reports is enclosed herewith as Annexure B.</td></tr>
<tr><td>5.</td><td colspan="2">Conditions under Hazardous waste:</td></tr>
<tr><td>5.1</td><td>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.</td><td>DPA issued Grant of License/Permission to carry out the work of collection and disposal of “Hazardous Waste/Sludge/ Waste Oil” from Vessels calling at Deendayal Port” through DPA contractors. Further, it is to state that, all ships are required to follow DG Shipping circulars regarding the reception facilities at Swachch Sagar portal.</td></tr>
<tr><td>5.2</td><td>The applicant shall be obtain membership of common TSDF site for disposal of Hazardous</td><td>Not applicable</td></tr>
</table>

	waste as Categorized in Hazardous waste (Management, Handling & Transboundary Movement) Rules, 2008 as amended thereof	
6.	**General Conditions**	
6.1	Unit shall develop green belt within premises as per the CPCB guidelines. However, if the adequate land is not available within premises, the unit shall tie up with local agencies like gram panchayat, school, social forestry office etc, for the plantation at suitable open land in nearby locality and submit an action plan of plantation for next three years to GPCB.	Point noted. DPA had already taken up Green belt development activity through Forest Department GoG at the cost of 352.32 lakhs (Green belt development in DPA area in an area of 31.942 Ha.). Further, it is relevant to mention here that, DPA has appointed Gujarat Institute of Desert Ecology (GUIDE) for "Green belt development in Deendayal Port Authority and its Surrounding Areas, Charcoal site' (Phase-l)" vide Work Order No.EG/WK/4757/Part [Greenbelt GUIDEJ, dated 31st May, 2022 (**Annexure C).** Further, for project at Sr. no. 2 to 5 (construction not yet started), green belt will be developed as per the specified condition.
6.2	Adequate plantation shall be carried out all along the periphery of the industrial premises in such a way that the density of plantation is at least 1000 trees per acre of land and a green belt of 10 meters width is developed.	DPA had already taken up Green belt development activity through Forest Department GoG at the cost of 352.32 lakhs (Green belt development in DPA area in an area of 31.942 Ha.). Further, it is relevant to mention here that, DPA has appointed Gujarat Institute of Desert Ecology (GUIDE) for "Green belt development in Deendayal Port Authority and its Surrounding Areas, Charcoal site' (Phase-l)" vide Work Order No.EG/WK/4757/Part [Greenbelt GUIDEJ, dated 31st May, 2022 (**Annexure C).** Further, for project at Sr. no. 2 to 5 (construction not yet started), adequate plantation will be developed as per the specified condition.
6.3	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	Point noted

	the water (Prevention and Control of Pollution) Cess Act - 1977	
6.4	In case of change of ownership/ management the name and address of the new owners/ partners/ directors/ proprietor should immediately be intimated to the Board.	Point Noted.
6.5	The applicant shall however, not without the prior consent of the Board bring into use any new or altered outlet for the discharge of effluent or gaseous emission or sewage waste from the proposed industrial plant. The applicant is required to make applications to this Board for this purpose in the prescribed forms under the provisions of the of the Water (Prevention and Control of Pollution) Act-1974, the air (Prevention & Control of Pollution) Act - 1981 and the Environment (Protection) Act-1986	Point Noted for the compliance.
6.6	The applicant also comply with the General conditions as per Annexure-I attached herewith (No. 1 to 38) (which ever applicable)	Point Noted for the compliance.
6.7	The overall noise level in and around the plant area shall be kept well within the standards by providing noise control measures including engineering control like acoustic insulation hood, silencers, enclosures etc on all sources of noise generation. The ambient noise level confirm to the standards prescribed under the Environment (Protection) Act, 1989 & Rules.	DPA has been conducting regular Monitoring of environmental parameters since the year 2016 through NABL Accredited laboratories. The work is in progress & DPA submitted monitoring data regularly to all the concerned authorities along with compliance reports submitted. The Environmental Monitoring Reports is enclosed herewith as **Annexure B.**
6.8	Applicant is required to comply with the manufacturing, storage and Import of Hazardous Chemicals Rules-1989 framed under Environment (Protection) Act -1986	Point Noted.
6.9	If it is established by any competent authority that the damage is caused due to their industrial activities to any person or his property, in that case they are obliged to pay the compensation as determined by the competent authority.	Point Noted.
6.10	Applicant shall have to comply with all the guidelines/directives issued/being issued by MoEF/CPCB/DoEF from time to time.	Point Noted.
6.11	Applicant shall not use/withdraw ground water either during construction and/or operation phase.	No ground water will be drawn for the construction/operation phase. For construction phase, as per tender

		clause, the required water for construction activities is being supplied by the contractor. For operational requirement, required water supply will be purchased from GWSSB.
6.12	Environmental cell shall be setup and shall be responsible for the Environmental management.	DPA is already having Environment Management cell. Further, DPA has also appointed expert agency for providing Environmental Experts from time to time. DPA appointed M/s Precitech Laboratories, Vapi for providing Environmental Experts vide work order dated 5/2/2021 **(Copy of work order & scope of work attached as Annexure D).** The organogram is attached herewith as **Annexure E**. Further, DPA has appointed Manager Environment on contractual basis for the period of 3+2 years. A copy of office order is attached herewith as **Annexure F.**
6.13	Monitoring in respect to Air, Water, Noise level shall be carried out and results shall be submitted to GPCB on quarterly basis.	DPA has been conducting regular Monitoring of environmental parameters since the year 2016 through NABL Accredited laboratories. The work is in progress & DPA submitted monitoring data regularly to all the concerned authorities along with compliance reports submitted. The Environmental Monitoring Reports is enclosed herewith as **Annexure B.**

Annexure -A

F.No.11-13/2015-IA-III
Government of India
Ministry of Environment, Forest and Climate Change
(IA.III Section)

Indira Paryavaran Bhawan,
Jor Bagh Road, New Delhi - 3

Date: 19th February, 2020

To,

The Chief Engineer,
M/s Deendayal Port Trust (Erstwhile Kandla Port Trust)
Kandla, Kutch - 370201, Gujarat
E Mail: kptemc@gmail.com

Subject: **Development of Integrated facilities (Stage-II) within the existing Deendayal Port Trust (Erstwhile Kandla Port Trust) at District Kutch, Gujarat. (1. Setting up of Oil Jetty No.7. 2. Setting up of Barge jetty at Jafarwadi 3. Setting up of Barge port at Veera; 4. Administrative office building at Tuna Tekra; 5. Road connecting from Veera barge jetty to Tuna gate by M/s Deendayal Port Trust (Erstwhile Kandla Port Trust) - Environmental & CRZ Clearance - reg.**

Sir,

This has reference to your online Proposal No. IA/GJ/MIS/27227/2015 dated 1st July, 2016, submitted to this Ministry for grant of Environmental and CRZ Clearance in terms of the provisions of the Environment Impact Assessment (EIA) Notification, 2006 and Coastal Regulation Zone (CRZ) Notification, 2011, under the Environment (Protection), Act, 1986.

2. The proposal for 'Development of Integrated facilities (Stage-II) within the existing Deendayal Port Trust (Erstwhile Kandla Port Trust) at District Kutch, Gujarat. (1. Setting up of Oil Jetty No.7. 2. Setting up of Barge jetty at Jafarwadi 3. Setting up of Barge port at Veera; 4. Administrative office building at Tuna Tekra; 5. Road connecting from Veera barge jetty to Tuna gate promoted by M/s Deendayal Port Trust (Erstwhile Kandla Port Trust) was considered by the Expert Appraisal Committee (Infra-2) in the Ministry in its 8th meeting held on 28-29 July, 2016, 19th meeting held on 27-29 June, 2017, 25th meeting held on 29-30 November, 2017, 27th Meeting held on 25th January, 2018 and 28th meeting held on 5th March, 2018 (correction in the minutes).

3. The details 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 proposal is for Development of integrated facilities (Stage-II) within the existing Deendayal Port Trust Limit at Kutchh district of Gujarat by Deendayal Port Trust (1. Setting up of Oil Jetty No.7.; 2. Setting up of Barge jetty at Jafarwadi; 3. Setting up of Barge port at Veera; 4. Administrative office building at Tuna Tekra; and 5. Road connecting from Veera barge jetty to Tuna gate) by M/s Deendayal Port Trust (Deendayal Port Trust).

(ii) Kandla Port is situated at Latitude 23°01'N and Longitude 70°13'E on the shores of the Kandla Creek. It is 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. Total area of the project is 61.75 Ha.

(iii) The *Project Components are as follows:*

- Setting up of Oil Jetty No.7 (Capacity - 2MMTPA, Size - 110m x 12.40m, Approach - 210m - Back up area 1 Ha, Capital dredging - 72000 m^3. Maintenance dredging - @15% per annum i.e. 10800 m^3/year, Cost - 72 Crores), Site location: $23^0$02'37.49" N & $70^0$13'08" E.

- Setting up of Barge jetty at Jafarwadi (On BOT Basis) (Capacity - 3.00 MMTPA, Size - 180 x 20 m, Back up area - 20 Ha., Capital Dredging – 80000 m^3, Maintenance dredging - 15% per annum i.e. 12000 m^3/year, Cost - 105 Crores).
- Setting up of Barge port at Veera (On BOT Basis) (Capacity - 6.29 MMTPA, Size - 160 x 60 m, Back up area - 20 Ha., Cost 160 Crores).
- Construction of Administrative office (Port Operational) building at Tuna Tekra (Build up area - 1600m^2, Plot Area - 15,000m^2, Cost - 10 Crores).
- Road connecting from Veera barge jetty to Tuna Gate (Length - 15500 m, Width - 7.30m, with both sides 1.50m shoulders, Cost - 48.82 Crores).

(iv) Water will be received from high service reservoir near Bhachau and Narmada Canal through 18" pipeline of Gujarat Water supply and Sewerage Board. 34 KLD water will be used for construction purpose and about 23 KLD water will be used for domestic purposes.

(v) Wastewater (18 KLD) will be treated in the modern septic tanks. Treated wastewater will be used for gardening and green belt development activities.

(vi) Solid wastes generated from the colony will be taken care by the waste disposal plan. The construction waste may pose impacts on land environment by contamination of soil and hence the wastes shall be utilized for PCC works, Road construction, and other filling requirement etc the accidental spillage of fuels and lubricants oils will be minimized by proper care. The proposed project does not envisage production of any hazardous waste material.

(vii) Deendayal Port Trust has endeavored in maintaining eco-balance by way of tree plantation in and around port area. Extensive plantation is carried out every year. The survival rate of plants is very low due to saline soil and adverse weather conditions. Ongoing efforts are taken to increase the area under plantation. Additionally, green belt development is undertaken at, roadside and near residential and office buildings at Kandla, Gandhidham town and surrounding villages. The Greenbelt development plan is given in Section 9.8 of Chapter 09 in the EIA report.

(viii) Dredging quantity to be conducted by Deendayal Port Trust (capital as well as maintenance) that will be required to maintain the port initially and throughout the year is as follows: Capital Dredging: 152000 m^3; Maintenance Dredging: 22800 m^3/year. Reclamation is required for backup area i.e 61.75 ha.

(ix) The fugitive dust emission will be controlled by water spraying. Precautions will be taken to use the covered storage area for cargos.

(x) Total cost of the project is 395.82 Crores.

(xi) Terms of Reference was granted by MoEF&CC vide letter No. F.No. 11-13/2015-IA-III dated 23.06.2015. Public Hearing was exempted for the project.

(xii) GCZMA has recommended all these five projects vide Letter No. ENV-10-2015-231-E (T Cell) dated 29.06.2016.

(xiii) Project Benefit: Improvement in the social and physical infrastructure, Employment and other benefits.

(xiv) Employment Potential: 100 people per day.

4. The project/activity is covered under category A of item 7 (e) i.e. Ports, harbours, break waters, dredging' of the schedule to the EIA Notification, 2006 and its subsequent amendments, and requires appraisal at Central level by sectoral EAC.

5. The Expert Appraisal Committee (Infra-2) in its 27th meeting held on 25th January, 2018, after detailed deliberations on the project, has recommended the project for grant of Environmental and CRZ Clearance. As per recommendations of the EAC, the Ministry of

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Environment, Forest and Climate Change hereby accords Environmental and CRZ Clearance for the project 'Development of Integrated facilities (Stage-II) within the existing Deendayal Port Trust (Erstwhile Kandla Port Trust) at District Kutch, Gujarat. (1. Setting up of Oil Jetty No.7. 2. Setting up of Barge jetty at Jafarwadi 3. Setting up of Barge port at Veera; 4. Administrative office building at Tuna Tekra; 5. Road connecting from Veera barge jetty to Tuna gate promoted by M/s Deendayal Port Trust (Erstwhile Kandla Port Trust)', under the provisions of the EIA Notification, 2006 and CRZ Notification, 2011 and amendments thereto and circulars issued thereon and subject to the compliance of the following specific and general conditions as under:-

A. SPECIFIC CONDITIONS:

(i) Construction activity shall be carried out strictly according to the provisions of the CRZ Notification, 2011. No construction work other than those permitted in Coastal Regulation Zone Notification shall be carried out in Coastal Regulation Zone area.

(ii) All the recommendations and conditions specified by the Gujarat Coastal Zone Management Authority vide letter No. ENV-10-2015-231-E (T Cell) dated 29.06.2016 shall be complied with.

(iii) The project proponent shall ensure that the project is in consonance with the new CZMP prepared by the State Government under the provisions of the CRZ Notification, 2011.

(iv) The Project proponent would submit a certificate from Gujarat Water Supply and Sewerage Board (GWSSB) for providing required water. This should be submitted with the first compliance report.

(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.

(vi) Dredging shall not be carried out during the fish breeding season.

(vii) Dredging, etc shall be carried out in the confined manner to reduce the impacts on marine environment.

(viii) Dredged material shall be disposed safely in the designated areas.

(ix) 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 report.

(x) The ground water shall not be tapped within the CRZ areas by the PP to meet with the water requirement in any case.

(xi) While carrying out dredging, an independent monitoring shall be carried out by Government Agency/Institute to check the impact and necessary measures shall be taken on priority basis if any adverse impact is observed.

(xii) Mitigative measures as given in the Marine Bio-diversity Management Plan prepared by CSIR-NIO for protection of marine environment shall be complied with in letter and spirit.

(xiii) A copy of the Marine and riparian biodiversity management plan duly validated by the State Biodiversity Board shall be submitted before commencement of implementation.

(xiv) A continuous monitoring programme covering all the seasons on various aspects of the coastal environs need to be undertaken by a competent organization available in the State or by entrusting to the National Institutes/renowned Universities with rich experiences in marine science aspects. The monitoring should cover various physico-chemical parameters coupled with biological indices such as microbes, plankton, benthos and fishes on a periodic basis during construction and operation

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phase of the project. Any deviations in the parameters shall be given adequate care with suitable measures to conserve the marine environment and its resources.

(xv) 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 as part of the management plan. Marine ecology shall be monitored regularly also in terms of all micro, macro and mega floral and faunal components of marine biodiversity.

(xvi) The project proponents would also draw up and implement a management plan for the prevention of fires due to handling of coal.

(xvii) Spillage of fuel / engine oil and lubricants from the construction site are a source of organic pollution which impacts marine life, particularly benthos. This shall be prevented by suitable precautions and also by providing necessary mechanisms to trap the spillage.

(xviii) 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.

(xix) All the recommendations mentioned in the rapid risk assessment report, disaster management plan and safety guidelines shall be implemented.

(xx) Measures should be taken to contain, control and recover the accidental spills of fuel and cargo handle.

(xxi) Necessary arrangement for general safety and occupational health of people should be done in letter and spirit.

(xxii) The commitments made during the Public Hearing conducted in 2013 for earlier project and recorded in the Minutes shall be complied with letter and spirit. A hard copy of the action taken shall be submitted to the Ministry.

(xxiii) 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.

(xxiv) As per the Ministry's Office Memorandum F.No. 22-65/2017-IA.III dated 1st May, 2018, the project proponent has proposed that an amount of Rs. 2.97 Crore (@ 0.75% of project Cost) shall be earmarked under Corporate Environment Responsibility (CER) for the activities such as Drinking water, Sanitation, Health, Education, Skill Development Roads, Electrification including Solar Power, Scientific support and awareness to local farmers to increase yield of crop and fodder, Rain water harvesting, Soil Moisture Conservation work and Avenue plantation and plantation in community areas. The activities proposed under CER shall be restricted to the affected area around the project. The entire activities proposed under the CER shall be treated as project and shall be monitored. The monitoring report shall be submitted to the Regional Office as a part of half yearly compliance report, and to the District Collector. It should be posted on the website of the project proponent.

B. <u>GENERAL CONDITIONS</u>:

(i) Appropriate measures must be taken while undertaking digging activities to avoid any likely degradation of water quality.

(ii) Full support shall be extended to the officers of this Ministry/ Regional Office at Bhopal by the project proponent during inspection of the project for monitoring purposes by furnishing full details and action plan including action taken reports in respect of mitigation measures and other environmental protection activities.

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(iii) A six-Monthly monitoring report shall need to be submitted by the project proponents to the Regional Office of this Ministry at Bhopal regarding the implementation of the stipulated conditions.

(iv) Ministry of Environment, Forest and Climate Change or any other competent authority may stipulate any additional conditions or modify the existing ones, if necessary in the interest of environment and the same shall be complied with.

(v) The Ministry reserves the right to revoke this clearance if any of the conditions stipulated are not complied with the satisfaction of the Ministry.

(vi) In the event of a change in project profile or change in the implementation agency, a fresh reference shall be made to the Ministry of Environment, Forest and Climate Change.

(vii) The project proponents 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 and the date of start of land development work.

(viii) A copy of the clearance letter shall be marked to concerned Panchayat/local NGO, if any, from whom any suggestion/ representation has been made received while processing the proposal.

(ix) A copy of this clearance letter shall also be displayed on the website of the concerned State Pollution Control Board. The Clearance letter shall also be displayed at the Regional Office, District Industries centre and Collector's Office/ Tehsildar's office for 30 days.

6. Consent to Establish/Operate for the project shall be obtained from the State Pollution Control Board as required under the Air (Prevention and Control of Pollution) Act, 1981 and the Water (Prevention and Control of Pollution) Act, 1974.

7. All other statutory clearances such as the approvals for storage of diesel from Chief Controller of Explosives, Fire Department, Civil Aviation Department, Forest Conservation Act, 1980 and Wildlife (Protection) Act, 1972 etc. shall be obtained, as applicable by project proponents from the respective competent authorities.

8. The project proponent shall advertise in at least two local Newspapers widely circulated in the region, one of which shall be in the vernacular language informing that the project has been accorded Environmental and CRZ Clearance and copies of clearance letters are available with the State Pollution Control Board and may also be seen on the website of the Ministry of Environment, Forest and Climate Change at http://www.envfor.nic.in. The advertisement should be made within Seven days from the date of receipt of the Clearance letter and a copy of the same should be forwarded to the Regional office of this Ministry at Bhopal.

9. This clearance is subject to final order of the Hon'ble Supreme Court of India in the matter of Goa Foundation Vs. Union of India in Writ Petition (Civil) No.460 of 2004 as may be applicable to this project.

10. Any appeal against this clearance 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.

11. Status of compliance to the various stipulated environmental conditions and environmental safeguards will be uploaded by the project proponent in its website.

12. A copy of the clearance letter shall be sent by the proponent to concerned Panchayat, Zilla Parisad/Municipal Corporation, Urban Local Body and the Local NGO, if any, from whom suggestions/representations, if any, were received while processing the

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proposal. The clearance letter shall also be put on the website of the company by the proponent.

13. The proponent shall upload the status of compliance of the stipulated Clearance conditions, including results of monitored data on their website and shall update the same periodically. It shall simultaneously be sent to the Regional Office of MoEF&CC, the respective Zonal Office of CPCB and the SPCB.

14. The project proponent shall also submit six monthly reports on the status of compliance of the stipulated Clearance conditions including results of monitored data (both in hard copies as well as by e-mail) to the respective Regional Office of MoEF&CC, the respective Zonal Office of CPCB and the SPCB.

15. The environmental statement for each financial year ending 31st March in Form-V as is mandated to be submitted by the project proponent to the concerned State Pollution Control Board as prescribed under the Environment (Protection) Rules, 1986, as amended subsequently, shall also be put on the website of the company along with the status of compliance of Clearance conditions and shall also be sent to the respective Regional Office of MoEF&CC by e-mail.

16. The above stipulations would be enforced among others under the provisions of Water (Prevention and Control of Pollution) Act 1974, the Air (Prevention and Control of Pollution) Act 1981, the Environment (Protection) Act, 1986, the Public Liability (Insurance) Act, 1991 and EIA Notification 1994, including the amendments and rules made thereafter.

J. Bose

(Dr. Subrata Bose)
Scientist F

Copy to:

1) The Secretary to Government (Environment and Ecology), Forests & Environment Department, Government of Gujarat Block 14, 8th floor, Sachivalaya, Gandhinagar - 382 010, Gujarat.
2) The Addl. Principal Chief Conservator of Forests (Central) Ministry of Environment, Forest and Climate Change, Regional Office (WZ) E-5, Kendriya Paryavaran Bhawan, E-5 Arera Colony, Link Road-3 Ravishankar Nagar, Bhopal - 462016.
3) The Chairman, Central Pollution Control Board Parivesh Bhavan, CBD-cum-Office Complex, East Arjun Nagar, New Delhi - 110 032.
4) The Member Secretary, Gujarat Pollution Control Board, Paryavaran Bhavan, Sector-10A, Gandhinagar-382010, Gujarat.
5) Monitoring Cell, MoEF&CC, Indira Paryavaran Bhavan, New Delhi.
6) Guard File/ Record File/ Notice Board.
7) Website of MoEF&CC.

J. Bose

(Dr. Subrata Bose)
Scientist F

Annexure -B

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.,

Index

EXECUTIVE SUMMARY

ENVIRONMENTAL MONITORING PLAN FOR DEENDAYAL PORT ENVIRONMENTALMONITORING REPORT- NOVEMBER, 2022

1. EXECUTIVE SUMMARY

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

A) Ambient Air

The monitoring of Ambient Air quality at 6-locations at Deendayal Port Authority Kandla and 2- location at Vadinar Port on 24 hourly basis for TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2, NH_3, CO_2, CO, C_6H_6 and NMHC in twice a week 24 hourly at uniform intervals (as per NAAQS) at Gopalpuri, Tuna Port, Marine Bhavan Building, Coal storage area, Estate building, Oil jetty and at Vadinar port, Vadinar Jetty and Vadinar colony area using respirable dust sampler, Fine particulate sampler and gaseous sampler.

The Maximum TSPM values in month of November 2022 were found 846 µg/m^3 at Coal Storage area on 25.11.2022 and minimum 107 µg/m^3 at Gopalpuri Hospital on 01.11.2022. The Maximum PM_{10} values were 654 µg/m^3 at Coal Storage area on 25.11.2022 and minimum was 67 µg/m^3 at Gopalpuri Hospital 01.11.2022. Maximum $PM_{2.5}$ values were 187 µg/m^3 at Coal Storage area on 25.11.2022 and minimum was 34 µg/m^3 at Gopalpuri on 01.11. 2022. The PM_{10} and $PM_{2.5}$ values were found for all monitoring locations (Marine Bhavan Building, Oil Jetty, Estate Office, Gopalpuri, Coal Storage Area and Tuna Port) to exceed the Standard limit (NAAQS).

At Gopalpuri location the mean concentration of PM_{10} was 127 µg/m^3 & $PM_{2.5}$ was 66 µg/m^3 which are slightly exceed the Standard limit (NAAQS).

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

The overall values of November for Gaseous SO_2, NO_2, NH_3, CO_2, CO, C_6H_6 concentration were within the permissible limit at all location and NMHC were found BQL (Below Quantification Limit).

B) Weather

The mean day time temperature at Deendayal Port was 27.92 °C. The day-time maximum temperature was 32.9°C and minimum was 21.1 °C. The mean night time temperature recorded was 25.47 °C. The night-time maximum temperature was 29.7°C and minimum was 20.0 °C. The mean Solar Radiation in November month was 167.27 w/m^2. The maximum solar radiation was recorded 759 w/m^2 in 4th November, 2022 and the minimum solar radiation was recorded 1.80 w/m^2 in 30th November, 2022. The mean Relative humidity was 69.00 % for the month of November. Maximum Relative humidity was recorded 99.0 % and minimum Relative humidity was recorded 34.0 %. The average wind velocity for the entire month of November was 1.21 m/s. Maximum wind velocity was recorded 10.19 m/s. The wind direction was mostly West-South.

C) Marine Ecology (Flora and Fauna) / Marine Water / Sediments:

The results obtained from the study for the month of November 2022 for biological and ecological parameters in marine water for Arabian Sea at surrounding area of Deendayal Port Authority (DPA) Kandla and Vadinar were not affected by Port activities.

D) Drinking Water Quality

The drinking water being supplied to Deendayal Port Authority was safe for drinking purpose. At all drinking water monitoring stations around port area were in line with the standard limit as per the drinking water specifications given in IS 10500:2012 as per tested parameters only.

The average results for 20 locations were as: pH were found Min 7.24 and maximum 7.52, TDS were found min 300.0 mg/l and Max found 1060.0 mg/l, Chloride were found Min 140.31 mg/l and Max 576.28 mg/l, Total Hardness were found Min 270.0 mg/l and Max 380.0 mg/l and Calcium were found Min 34.47 mg/l and Max 43.29 mg/l, color were colorless and odor were odorless. In all water samples BOD, Heavy metal like manganese, Hexavalent chromium, Copper, Cadmium, Arsenic, Mercury, Lead, zinc all are found BQL (Below Quantification Limit). The bacterial count (E-coli & Coliform) is absent in all drinking water samples.

E) Monitoring Performance of Sewage Treatment Plant

It was seen that the performance of STP at Deendayal Township Gopalpuri, DPA STP Plant Kandla and Vadinar STP plant was satisfactory by overall. The treatment plant was well maintained during [November 2022] with considerable removal efficiency achieving the standards prescribed for final disposal. At Gopalpuri STP, the pollutant removal efficiency for TSS, BOD and COD was ranged from 49.66-81.04%, 58.97-68.42% and 45.45-73.33% respectively. At Kandla STP, removal efficiency for TSS, BOD and COD was ranged from 53.47-73.49%, 46.15-76.74% and 50.00-82.35% respectively & at Vadinar STP removal efficiency for TSS, BOD and COD was ranged from 42.09-56.69%, 50.00-78.12% and 60.00-84.61% respectively. At all STP location treated waste water the pH were ranged from 7.21-7.42,Total Suspended Solids were found 16.9-67.9 mg/l , Residual Chlorine were below Detection Limit (< 0.5) , COD were found 20-60 mg/l and 3day BOD @ 27 °C were found 7.0-16.0 mg/l.

F) Noise

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. The Day Time Noise Level (SPL) in all 10 locations at Deendayal Port Authority ranged from 53.2 dB(A) to 70.4 dB(A) while at Vadinar port 3 location ranged from 52.5 dB(A) to 60.6 dB(A) which was within the permissible limits of 75 dB(A) for the industrial area for the daytime. The Night Time Average Noise Level (SPL) in all locations of Deendayal Port Authority ranged from 45.4 dB to 61.7 dB(A) while at Vadinar port ranged from 52.5 dB (A) to 60.6 dB(A) which was within the permissible limits of 70 dB(A) for the industrial area for the night time.

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, NOx, O_3, SO_2, and CO (Bailey and Solomon 2004). As a consequence, a wide range of options toward "greener" seaports is needed (Bailey and Solomon 2004). Some of these measures are easy to adopt such as the regulation of fuel quality (by using low-sulfur alternative fuels), the speed reduction (Lack et al. 2011), and the use of alternative transportation equipment (Lai et al. 2011).

Clean air is the basic requirement of all living organisms. In recent times, due to population growth, urban sprawl, industrial development, and vehicular boom, the quality of air is deteriorating and being polluted. Pollutants of major public health concerns include particulate matter, carbon monoxide, ozone, nitrogen dioxide, and sulfur dioxide, which pose serious threats to human health and hygiene. In the present study, prime particulate pollutants (PM_{10}, $PM_{2.5}$), and gaseous pollutants (SO_2, and NO_2) were estimated at seven stations in and around Dahej Port, Gujarat, India (Soni and Jagruti Patel, 2017).

Among particulate pollutants, particulate matter (PM) is a ubiquitous entity, and is especially a grave problem due to its higher suspension rate into the atmosphere, and adverse health effects on plants, animals, humans, and materials in the form of visibility reduction, soiling of buildings, etc. (Horaginamani and Ravichandran, 2010; Chaurasia *et al*., 2013).

The sources of air pollutants include vehicles, industries, domestic sources and natural sources. Because of the presence of high amount of air pollutants in the ambient air, the health of the population and property is getting adversely affected. In order to arrest the deterioration in air quality, Govt. of India has enacted Air (Prevention and Control of Pollution) Act in 1981. The responsibility has been further emphasized under Environment (Protection) Act, 1986. It is necessary to assess the present and anticipated air pollution through continuous air quality survey/monitoring programs. Therefore, Central Pollution Control Board had started National Ambient Air Quality Monitoring (NAAQM) Network during 1984 - 85 at national level. The programme was later renamed as National Air Quality Monitoring Programme (NAMP).

2.1 Ambient Air Quality Monitoring

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

Table: 1. Ambient Air Sampling Location

Sr. No.	Name of Location	Location Code	Latitude	Longitude	Remarks
1.	Marine Bhavan	AL-1	23° 0' 26.524"N	70° 13' 22.414"E	**DPA-Kandla**
2.	Oil Jetty	AL-2	23° 1' 45.613"N	70° 13' 11.052"E	
3.	Estate Office	AL-3	23° 1' 11.273"N	70° 12' 48.657"E	
4.	Gopalpuri Hospital	AL-4	23° 4' 53.551"N	70° 8' 7.047"E	
5.	Coal Storage Area	AL-5	22° 59' 31.812"N	70° 13' 9.979"E	
6.	Tuna Port	AL-6	22° 59' 15.291"N	70° 58' 57.018"E	
7.	Signal Building	AL-7	22° 26' 26.750"N	69° 40' 22.127"E	**DPA-Vadinar**
8.	Admin Building	AL-8	22° 26' 25.223"N	69° 40' 19.358"E	

- **Air Quality Monitoring Methodology**

  Air quality is measured in all the stations, for 24 hour for Total Suspended Particulate Matter (TSPM), PM_{10}, $PM_{2.5}$, SO_2, NO_2, NH_3 & Benzene and Grab-sampling for CO & CO_2 measurements. The Air samplers are operated for a period of 24 hours and after a continuous operation of 8 hours for gaseous parameters. The absorbing reagents for SO_2:- Absorbing Reagent TCM (Potassium Tetrachloromercurate 0.04M): Mercuric Chloride, Potassium Chloride and EDTA used. For NO_2:- Absorbing Reagent Sodium Hydroxide (NAOH): Sodium Hydroxide and Sodium Arsenite used. For NH_3 need Conc. Sulphuric Acid and Distilled water was used. By replacing 3 times the reagents per day for each parameter namely, SO_2, NO_2, NH_3. The GFA filter paper and PTFE Membrane bound filter paper are used for a period of 24 hours to obtain one sample each of TSPM, PM_{10} & $PM_{2.5}$. The AAQ samples are collected two consecutive days a week as per CPCB guidelines, from all the eight locations as mentioned in the EMP.

2.2 Results

The ambient air quality monitoring data for six stations, viz. Marine Bhavan, Oil Jetty, Port Colony, Gopalpuri Hospital, Tuna Port and Nr. Coal Storage Area for the month of November 2022 are given in Tables 2 to 7. The ambient air quality monitoring data for two stations at Vadinar (Nr. Admin Building & Nr. Signal Building) are given in Tables 8 to 9.

The Movement of heavy transport with uncovered coal transportation, raw road around ambient location may be causes fugitive dust emission from dry conditions. Particulate Matter then enters the atmosphere through the action of wind, vehicular movement, or other activities. The dust produces tends to float in air and spread all around the vicinity. Direction and speed of wind affect the dispersion of the dust particulate matter. Humidity of air also has strong effect on the spreading of particulate matter. With increasing humidity, moisture particles eventually grow in size to a point where 'dry deposition' occurs, reducing PM_{10} concentrations in the atmosphere.

Location 1: Marine Bhavan (AL1)

Table 2 : Results of Air Pollutant Concentration at Marine Bhavan										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS Limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL1 – 1	01.11.2022	435	302	121	3.93 6.04 1.81	3.93	5.19 23.66 14.43	14.43	2.07 6.33 3.91	4.11
AL1 – 2	04.11.2022	344	228	106	3.32 2.72 1.51	2.52	17.31 8.66 12.12	12.70	2.42 5.18 3.57	3.72
AL1 – 3	08.11.2022	398	281	116	2.31 6.34 2.88	3.84	25.39 17.89 8.66	17.31	4.72 2.42 3.57	3.57
AL1 – 4	11.11.2022	445	315	124	3.63 9.07 6.35	6.35	17.89 12.70 8.66	13.08	4.03 4.72 2.07	3.61
AL1 – 5	15.11.2022	364	253	110	4.53 6.35 2.72	4.53	11.54 19.62 10.39	13.85	4.60 2.88 1.73	3.07
AL1 - 6	18.11.2022	442	315	121	8.46 3.32 2.72	4.84	23.08 8.66 17.89	16.54	3.22 5.87 4.03	4.37
AL1 - 7	22.11.2022	375	266	106	3.32 7.55 2.42	4.43	17.89 25.97 11.54	18.47	4.83 5.87 2.65	4.45
AL1 – 8	25.11.2022	483	350	129	4.53 6.95 2.42	4.63	23.66 28.86 12.12	21.55	3.22 5.29 2.53	3.68
AL1 – 9	29.11.2022	534	383	142	6.35 8.46 2.72	5.84	17.89 25.97 13.27	19.04	3.57 4.95 2.19	3.57
Monthly Average		424	299	119		4.55		16.33		3.79
Standard Deviation		61	48	12		1.12		3.03		0.44

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

* NMHC- Non- Methane Hydrocarbons

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

At Marine Bhavan, the overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 is attributed mainly by motor vehicle emission produced from various types of automobiles (both diesel and petrol driven). Moreover, the loading and unloading of Food Grains and Timber at Jetty no. 1 and 2 also contributes to the high levels of TSPM and PM_{10}. The mean TSPM value at Marine Bhavan was 424 µg/m^3, the mean PM_{10} value was 299 µg/m^3, and $PM_{2.5}$ value was 119 µg/m^3 which is above the permissible limit prescribed by NAAQS. The average values of SO_2, NO_2 and NH_3 were 4.55 µg/m^3, 16.33 µg/m^3 & 3.79 µg/m^3 respectively; these values were within the standard limit prescribed by NAAQS.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Marine Bhavan. The mean Benzene concentration was 1.14 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.37 mg/m^3, well below the permissible limit of 4.0 mg/m^3 prescribed by NAAQS.

Location 3: Oil Jetty (AL2)

Table 2 : Results of Air Pollutant Concentration at Oil Jetty										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS Limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL2 -1	01.11.2022	150	99	50	2.42 4.53 2.72	3.22	6.35 13.27 21.35	13.66	2.88 6.79 3.91	4.53
AL2 -2	04.11.2022	253	180	70	2.72 3.32 4.53	3.53	5.77 17.89 11.54	11.73	0.81 4.03 4.72	3.18
AL2 -3	08.11.2022	235	166	67	2.59 3.46 1.44	2.50	5.19 13.27 23.66	14.04	2.19 2.65 3.57	2.80
AL2 -4	11.11.2022	275	194	76	6.35 4.53 2.72	4.53	10.39 20.20 12.12	14.24	2.42 3.80 1.04	2.42
AL2 – 5	15.11.2022	245	169	71	3.02 6.65 3.93	4.53	8.66 16.16 17.31	14.04	3.57 2.30 1.27	2.38
AL2 – 6	18.11.2022	185	119	53	5.74 2.72 6.35	4.94	14.43 17.31 8.66	13.47	4.95 3.57 2.99	3.84
AL2 – 7	22.11.2022	373	252	109	3.02 6.35 2.72	4.03	20.20 12.12 10.39	14.24	3.80 5.53 2.07	3.80
AL2 -8	25.11.2022	292	199	86	1.81 6.35 3.32	3.83	14.43 19.62 9.23	14.43	3.57 4.72 5.99	4.76
AL1 – 9	29.11.2022	299	194	97	3.63 7.55 2.72	4.63	5.19 23.66 11.54	13.47	2.88 4.95 2.65	3.49
Monthly Average		256	175	75		3.97		13.70		3.47
Standard Deviation		65	45	19		0.79		0.81		0.85

Table 3 : Results of Air Pollutant Concentration at Oil Jetty					
	Date	**C_6H_6 [µg/m^3]**	***NMHC**	**CO [mg/m^3]**	**CO2 [ppm]**
Sampling Period		**8 hr**		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL2-1	01.11.2022	1.17	BQL	1.22	467
AL2-2	04.11.2022	1.01	BQL	1.53	451
AL2-3	08.11.2022	1.1	BQL	1.65	502
AL2-4	11.11.2022	1.19	BQL	1.04	447
AL2 –5	15.11.2022	1.24	BQL	1.27	634
AL2 –6	18.11.2022	1.16	BQL	1.22	531
AL2-7	22.11.2022	1.2	BQL	1.28	800
AL2-8	25.11.2022	1.06	BQL	1.89	1023
AL2-9	29.11.2022	1.22	BQL	1.46	576
Monthly Average		**1.15**	**-**	**1.40**	**603.44**
Standard Deviation		**0.08**	**-**	**0.26**	**193.07**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

Oil Jetty Area, the overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 was mainly by motor vehicle emission produced from various types of vehicles at Oil Jetty Area. The mean TSPM value at Oil Jetty was 256 µg/m^3. The mean PM_{10} value was 175 µg/m^3 and mean $PM_{2.5}$ value was 75 µg/m^3 which was above the permissible limit. The average values of SO_2, NO_2 and NH_3 were within the permissible limit prescribed by NAAQS. The mean concentration of SO_2, NO_2 and NH_3 were 3.97 µg/m^3, 13.70 µg/m^3 and 3.47 µg/m^3 respectively.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Oil Jetty. The mean Benzene concentration was 1.15 µg/m^3 which was well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.40 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

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

Table 4 : Results of Air Pollutant Concentration at Estate Office										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS Limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL3 – 1	01.11.2022	245	172	69	1.51	2.32	10.39	9.62	3.68	5.10
					3.32		13.27		7.02	
					2.12		5.19		4.60	
AL3 – 2	04.11.2022	577	445	130	4.53	2.32	5.19	10.39	3.57	2.49
					1.51		17.31		2.88	
					0.91		8.66		1.04	
AL3 – 3	08.11.2022	440	321	109	6.05	3.94	19.04	12.31	4.72	3.64
					2.59		12.12		2.42	
					3.17		5.77		3.80	
AL3 – 4	11.11.2022	518	403	111	3.32	4.23	18.47	10.58	1.38	2.42
					2.72		8.66		3.57	
					6.65		4.62		2.30	
AL3 – 5	15.11.2022	451	340	107	1.81	3.73	23.08	15.97	3.22	2.42
					6.04		14.43		2.30	
					3.32		10.39		1.73	
AL3 – 6	18.11.2022	459	346	112	4.53	4.43	16.16	15.97	5.76	4.14
					2.72		8.66		4.72	
					6.04		23.08		1.96	
AL3 – 7	22.11.2022	453	325	116	2.42	4.33	19.62	17.31	3.91	3.84
					4.23		23.66		5.18	
					6.35		8.66		2.42	
AL3 – 8	25.11.2022	337	252	83	6.04	3.93	15.00	15.58	3.80	3.91
					3.32		23.08		5.76	
					2.42		8.66		2.19	
AL1 – 9	29.11.2022	491	359	129	4.84	4.63	17.89	16.16	3.57	3.57
					6.95		24.24		5.18	
					2.12		6.35		1.96	
Monthly Average		441	329	107		3.76		13.77		3.50
Standard Deviation		98	80	20		0.87		3.00		0.91

Table 4 : Results of Air Pollutant Concentration at Estate Office					
Sampling Period	**Date**	**C_6H_6 [µg/m³]**	***NMHC**	**CO [mg/m³]**	**CO_2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL3 -1	01.11.2022	1.06	BQL	1.27	508
AL3 -2	04.11.2022	1.1	BQL	1.19	508
AL3 -3	08.11.2022	1.1	BQL	1.65	502
AL3 -4	11.11.2022	1.09	BQL	1.83	429
AL3 – 5	15.11.2022	1.09	BQL	1.76	813
AL3 – 6	18.11.2022	1.2	BQL	1.14	559
AL3 – 7	22.11.2022	1.19	BQL	2.18	1022
AL3 – 8	25.11.2022	1.11	BQL	2	1026
	29.11.2022	1.06	BQL	1.22	537
Monthly Average		**1.11**	**-**	**1.58**	**656.00**
Standard Deviation		**0.05**	**-**	**0.39**	**234.02**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 at Kandla Port Colony (Estate Office) was attributed by vehicle emission produced from trucks and heavy duty vehicles that pass through the road outside Kandla Port Colony. The mean TSPM values at Estate Office were 441 µg/m³, the mean PM_{10} value was 329 µg/m³, and $PM_{2.5}$ value was 107 µg/m³ which was above the permissible limit prescribed by NAAQS. The average values of SO_2, NO_2 and NH_3 were 3.76 µg/m³, 13.77 µg/m³ and 3.50 µg/m³ respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Kandla Port Colony. The mean Benzene concentration was 1.11 µg/m³, well below the permissible limit of 5.0 µg/m³. NMHC's were below the detectable limit and Carbon Monoxide was 1.58 mg/m³, well below the permissible limit of 4.0 mg/m³.

Location 4: Gopalpuri Hospital (AL-4)

Table 5 : Results of Air Pollutant Concentration at Gopalpuri Hospital										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS Limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL4 -1	01.11.2022	107	67	34	1.21	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

Table 5 : Results of Air Pollutant Concentration at Gopalpuri Hospital					
Sampling Period	**Date**	**C_6H_6 [µg/m³]**	***NMHC**	**CO [mg/m³]**	**CO_2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL4 -1	01.11.2022	1.14	BQL	1.26	503
AL4 -2	04.11.2022	1.15	BQL	1.26	450
AL4 -3	08.11.2022	1.03	BQL	1.73	506
AL4 -4	11.11.2022	1.02	BQL	1.82	462
AL4 – 5	15.11.2022	1.09	BQL	1.04	1048
AL4 – 6	18.11.2022	1.14	BQL	1.32	543
AL4 – 7	22.11.2022	1.16	BQL	1.83	758
AL4 – 8	25.11.2022	1.22	BQL	1.8	816
AL4 – 9	29.11.2022	1.16	BQL	1.36	665
Monthly Average		**1.12**	**-**	**1.49**	**639.00**
Standard Deviation		**0.07**	**-**	**0.30**	**201.83**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 at Gopalpuri Hospital was attributed by vehicle emission produced from light motor vehicles of the colony residents. The mean TSPM values at Gopalpuri Hospital were 197 µg/m³, the mean PM_{10} value was 127 µg/m³ and $PM_{2.5}$ was 66 µg/m³ which was exceed the standard limit. The average values of SO_2, NO_2 and NH_3 were 2.70 µg/m³, 11.33 µg/m³ and 2.49 µg/m³ respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Gopalpuri Hospital. The mean Benzene concentration was 1.12 µg/m³, well below the permissible limit of 5.0 µg/m³. NMHC's were below the detectable limit and Carbon monoxide concentration was 1.49 mg/m³ which is well below the permissible limit of 4.0 mg/m³.

Location 5: Coal Storage Area (AL-5)

Table 6 : Results of Air Pollutant Concentration at Coal Storage Area										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS Limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL6 – 1	01.11.2022	779	598	175	2.72 6.65 3.63	4.33	6.35 25.97 17.31	16.54	3.68 8.17 3.34	5.06
AL6 – 2	04.11.2022	635	492	137	2.12 5.44 3.02	3.53	23.08 12.12 17.89	17.70	6.79 8.17 4.83	6.60
AL6 – 3	08.11.2022	538	412	125	8.94 3.46 2.59	5.00	23.66 12.12 29.43	21.74	2.53 2.07 7.02	3.88
AL6 – 4	11.11.2022	815	635	178	4.53 2.72 6.95	4.73	18.47 8.66 25.97	17.70	5.87 2.65 4.72	4.41
AL6 – 5	15.11.2022	792	614	176	6.35 9.07 4.53	6.65	18.47 10.39 12.12	13.66	4.72 3.68 3.22	3.88
AL6 – 6	18.11.2022	771	595	171	9.37 5.74 6.35	7.15	20.20 8.08 23.08	17.12	4.83 2.53 5.76	4.37
AL6 – 7	22.11.2022	706	543	156	4.84 6.04 2.72	4.53	10.39 23.66 21.35	18.47	4.83 5.99 4.26	5.03
AL6 – 8	25.11.2022	846	654	187	3.32 7.86 4.53	5.24	17.31 25.97 16.16	19.81	3.91 6.91 4.03	4.95
AL1 – 9	29.11.2022	801	621	172	5.14 9.07 2.72	5.64	16.16 28.86 9.81	18.28	3.57 6.22 3.11	4.30
Monthly Average		743	574	164		5.20		17.89		4.72
Standard Deviation		99	78	21		1.14		2.22		0.84

Table 6 : Results of Air Pollutant Concentration at Coal Storage Area					
Sampling Period	**Date**	**C_6H_6 [µg/m^3]**	***NMHC**	**CO [mg/m^3]**	**CO_2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL5 – 1	01.11.2022	1.1	BQL	1.12	483
AL5 – 2	04.11.2022	1.06	BQL	1.48	475
AL5 – 3	08.11.2022	1.08	BQL	1.66	421
AL5 – 4	11.11.2022	1.06	BQL	1.69	492
AL5 – 5	15.11.2022	1.06	BQL	1.06	702
AL5 – 6	18.11.2022	1.22	BQL	1.18	483
AL5 – 7	22.11.2022	1.11	BQL	1.86	564
AL5 – 8	25.11.2022	1.2	BQL	1.54	777
AL5 – 9	29.11.2022	1.22	BQL	1.89	895
Monthly Average		**1.12**	**-**	**1.50**	**588.00**
Standard Deviation		**0.07**	**-**	**0.31**	**164.11**

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and NH_3 at Coal Storage Area was comparatively highest among all the locations of Air Quality monitoring in Kandla Port. High values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_2 at this location was due to lifting of coal with grab and other coal handling processes near Berth no. 6 & 7. Moreover, the traffic was also heavy around this place for transport of coal thus emissions produced from heavy vehicles. The mean TSPM values at Coal storage were 743 µg/m^3, the mean PM_{10} value was 574 µg/m^3, and the $PM_{2.5}$ value was164 µg/m^3 which was above the permissible limit prescribed by NAAQS. The average values of SO_2, NO_2 and NH_3 were 5.20 µg/m^3, 17.89 µg/m^3 and 4.72 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Coal Storage Area. The mean Benzene concentration was1.12 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.50 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 6: Tuna Port (AL-6)

Table 7 : Results of Air Pollutant Concentration at Tuna Port										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS Limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL5 -1	01.11.2022	141	88	47	0.91	1.61	2.89	6.16	2.07	2.84
					2.72		12.12		4.03	
					1.21		3.46		2.42	
AL5 – 2	04.11.2022	232	166	64	1.51	2.22	6.35	7.89	1.38	2.76
					3.02		5.19		4.49	
					2.12		12.12		2.42	
AL5 – 3	08.11.2022	184	120	55	1.44	2.40	10.39	13.08	1.73	2.61
					3.46		11.54		2.65	
					2.31		17.31		3.45	
AL5 – 4	11.11.2022	233	153	78	2.12	2.32	11.54	11.54	1.27	1.57
					3.93		17.89		1.04	
					0.91		5.19		2.42	
AL5 – 5	15.11.2022	221	145	74	1.21	2.32	6.35	12.12	3.57	2.49
					3.32		12.12		2.30	
					2.42		17.89		1.61	
AL5 – 6	18.11.2022	248	162	83	1.81	2.01	17.31	17.12	2.30	10.21
					1.21		23.66		15.57	
					3.02		10.39		12.76	
AL5 – 7	22.11.2022	214	139	74	1.51	2.52	8.66	8.46	3.57	2.84
					2.72		12.70		2.88	
					3.32		4.04		2.07	
AL5 – 8	25.11.2022	255	175	77	2.72	3.02	8.66	8.08	3.45	3.30
					4.84		11.54		4.72	
					1.51		4.04		1.73	
AL1 – 9	29.11.2022	245	155	87	1.51	3.63	12.70	11.73	1.04	2.88
					6.04		17.31		5.18	
					3.32		5.19		2.42	
Monthly Average		219	145	71		2.45		10.69		3.50
Standard Deviation		36	27	13		0.58		3.37		2.56

Table 7 : Results of Air Pollutant Concentration at Tuna Port					
	Date	C_6H_6 [µg/m^3]	*NMHC	CO [mg/m^3]	CO_2 [ppm]
Sampling Period		8 hr		Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m3		4.0 mg/m3	-
AL6 -1	01.11.2022	1.12	BQL	1.43	543
AL6 – 2	04.11.2022	1.17	BQL	1.41	463
AL6 – 3	08.11.2022	1.13	BQL	1.39	410
AL6 – 4	11.11.2022	1.13	BQL	1.74	509
AL6 – 5	15.11.2022	1.17	BQL	1.08	911
AL6 – 6	18.11.2022	1.17	BQL	1.1	528
AL6 – 7	22.11.2022	1.06	BQL	1.88	565
AL6 – 8	25.11.2022	1.1	BQL	1.89	999
	29.11.2022	1.22	BQL	1.89	895
Monthly Average		1.14	-	1.53	647.00
Standard Deviation		0.05	-	0.33	222.45

* NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

The mean TSPM values at Tuna Port was 219 µg/m^3, the mean PM_{10} value was 145 µg/m^3 and the mean $PM_{2.5}$ value was 71 µg/m^3 which was exceed the standard limit prescribed by NAAQS. The average values of SO_2, NO_2 and NH_3 were 2.45 µg/m^3, 10.69 µg/m^3 and 3.50 µg/m^3 respectively and were all within the standard limit prescribed by NAAQS.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Tuna Port. The mean Benzene concentration was 1.14 µg/m3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.53 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

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

Table 8 : Results of Air Pollutant Concentration at Admin Building										
	Date	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS Limit			**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL7 -1	01.11.2022	150	98	51	2.20 4.84 3.52	3.52	9.53 16.51 5.72	10.59	5.36 2.81 7.66	5.28
AL7 -2	04.11.2022	177	115	61	3.08 7.03 3.96	4.69	17.78 21.60 26.04	21.81	2.81 8.93 6.64	6.13
AL7 -3	08.11.2022	193	113	73	6.15 8.79 3.96	6.30	6.99 20.96 6.35	11.43	3.83 10.47 8.17	7.49
AL7 -4	11.11.2022	200	121	78	3.96 5.28 8.79	6.01	17.78 22.23 5.72	15.24	10.47 5.87 4.08	6.81
AL7 -5	15.11.2022	179	108	69	1.76 5.71 8.35	5.28	7.62 26.04 20.33	18.00	3.06 5.87 7.91	5.62
AL7 -6	18.11.2022	223	121	96	2.64 4.40 6.59	4.54	8.89 16.51 19.69	15.03	5.62 8.17 3.32	5.70
AL1 -7	22.11.2022	162	104	57	4.84 7.03 3.96	5.28	14.61 5.72 23.50	14.61	13.02 8.68 5.62	9.10
AL1-8	25.11.2022	237	138	97	6.59 3.96 2.64	4.40	9.53 14.61 21.60	15.24	7.91 5.62 10.47	8.00
AL1-9	28.11.2022	203	112	87	3.96 2.20 4.84	3.66	6.99 14.61 19.69	13.76	5.62 7.91 4.60	6.04
Monthly Average		191	114	74		4.85		15.08		6.68
Standard Deviation		28	12	17		0.96		3.34		1.28

Table 8 : Results of Air Pollutant Concentration at Admin Building Vadinar					
Sampling Period	**Date**	**C_6H_6 [µg/m^3]**	***NMHC**	**CO [mg/m^3]**	**CO_2 [ppm]**
		8 hr		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL7 -1	01.11.2022	1.08	BQL	1.43	225
AL7 -2	04.11.2022	1.13	BQL	1.54	236
AL7 -3	08.11.2022	1.17	1.81	1.53	455
AL7 -4	11.10.2022	1.14	BQL	1.61	443
AL7 -5	15.10.2022	1.03	BQL	1.1	347
AL7 -6	18.10.2022	1.06	BQL	1.57	416
AL7 -7	22.10.2022	1.10	BQL	1.05	372
AL7 -8	25.10.2022	1.20	BQL	1.79	464
AL7 -9	28.10.2022	1.13	BQL	1.42	487
Monthly Average		**1.12**	**-**	**1.46**	**388**
Standard Deviation		**0.06**	**-**	**0.25**	**75**

*NMHC- Non- Methane Hydrocarbons
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

At Admin Building, Vadinar the mean TSPM value was 191 µg/m^3, the mean PM_{10} value was 114 µg/m^{3}and the mean $PM_{2.5}$ value was 74 µg/m^3 which was slightly exceed the standard limit. The average values of SO_2, NO_2 and NH_3 concentrations were 4.85 µg/m^3, 15.08 µg/m^3 and 6.68 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Vadinar Port. The mean Benzene concentration was 1.12 µg/m^3, well below the permissible limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.46 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

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

Table 9 : Results of Air Pollutant Concentration at Signal Building, Vadinar										
	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS Limit			100 µg/m3	60 µg/m3		80 µg/m3		80 µg/m3		400 µg/m3
AL8 -1	01.11.2022	113	74	38	3.96	4.40	6.99	13.34	2.30	7.15
					6.59		19.05		8.68	
					2.64		13.97		10.47	
AL8 -2	04.11.2022	146	93	49	2.64	4.40	14.61	15.88	5.36	6.13
					4.84		22.23		8.42	
					5.71		10.80		4.60	
AL8 -3	08.11.2022	124	82	42	3.08	3.52	14.61	16.73	5.62	5.62
					5.28		26.04		7.91	
					2.20		9.53		3.32	
AL8 -4	11.11.2022	175	105	67	2.20	4.40	8.26	13.76	8.93	9.02
					7.03		19.05		12.76	
					3.96		13.97		5.36	
AL8 -5	15.11.2022	152	97	52	3.52	4.98	5.72	13.13	6.89	7.57
					4.84		13.34		10.98	
					6.59		20.33		4.85	
AL8 -6	18.11.2022	176	111	61	3.08	3.81	15.24	17.57	7.15	8.42
					3.96		26.04		7.91	
					4.40		11.43		10.21	
AL8 -7	22.11.2022	214	118	93	3.52	5.71	5.72	12.91	7.91	8.25
					5.28		13.34		6.38	
					8.35		19.69		10.47	
AL8-8	25.11.2022	219	125	92	3.08	4.54	9.53	11.01	5.36	6.04
					4.84		17.78		8.17	
					5.71		5.72		4.60	
AL8-9	28.11.2022	154	97	57	5.71	3.81	10.80	16.94	7.15	8.76
					3.96		22.23		8.93	
					1.76		17.78		10.21	
Monthly Average		164	100	61		4.40		14.59		7.44
Standard Deviation		36	16	20		0.67		2.25		1.27

Table 9 : Results of Air Pollutant Concentration at Signal Building Vadinar					
	Date	C_6H_6 [µg/m^3]	*NMHC	CO [mg/m^3]	CO_2 [ppm]
Sampling Period		**8 hr**		**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m3**		**4.0 mg/m3**	**-**
AL8 -1	01.11.2022	1.06	BQL	1.5	467
AL8 -2	04.11.2022	1.05	BQL	1.46	501
AL8 -3	08.11.2022	1.14	1.81	1.31	489
AL8 -4	11.11.2022	1.16	BQL	1.38	439
AL8 -5	15.11.2022	1.17	BQL	1.29	231
AL8 -6	18.11.2022	1.10	BQL	1.31	244
AL8 -7	22.11.2022	1.00	BQL	1.34	227
AL8 -8	25.11.2022	1.05	BQL	1.37	261
AL8 -9	28.11.2022	1.02	BQL	1.29	234
Monthly Average		**1.16**	**-**	**1.46**	**442**
Standard Deviation		**0.05**	**-**	**0.27**	**63**

* NMHC- Non- Methane Hydrocarbon
BQL- Below Quantification Limit (Quantification Limit – NMHC: 0.5 ppm)

At Signal Building, Vadinar the mean TSPM value was 164 µg/m^3, the mean PM_{10} value was 100 µg/m^3 which was boundary line of the permissible limit, the mean $PM_{2.5}$ value was 61 µg/m^3 which was within the permissible limit. The average values of SO_2, NO_2 and NH_3 concentrations were 4.40 µg/m^3, 14.59 µg/m^3 and 7.44 µg/m^3 respectively and were all within the standard limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Vadinar Port. The mean Benzene concentration was 1.16 µg/m^3, well below the standard limit of 5.0 µg/m^3. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.46 mg/m^3, well below the standard limit of 4.0 mg/m^3.

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

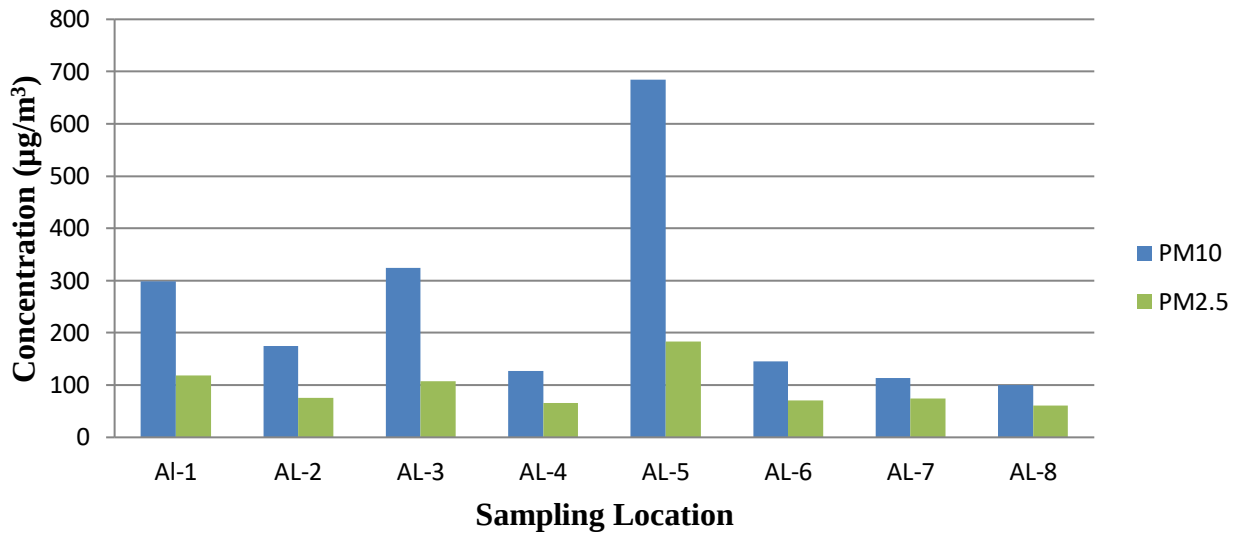


Fig. No:-2. Average ambient air qulaity (Gaseous) month of November-2022 at DPA and Vadinar sampling location

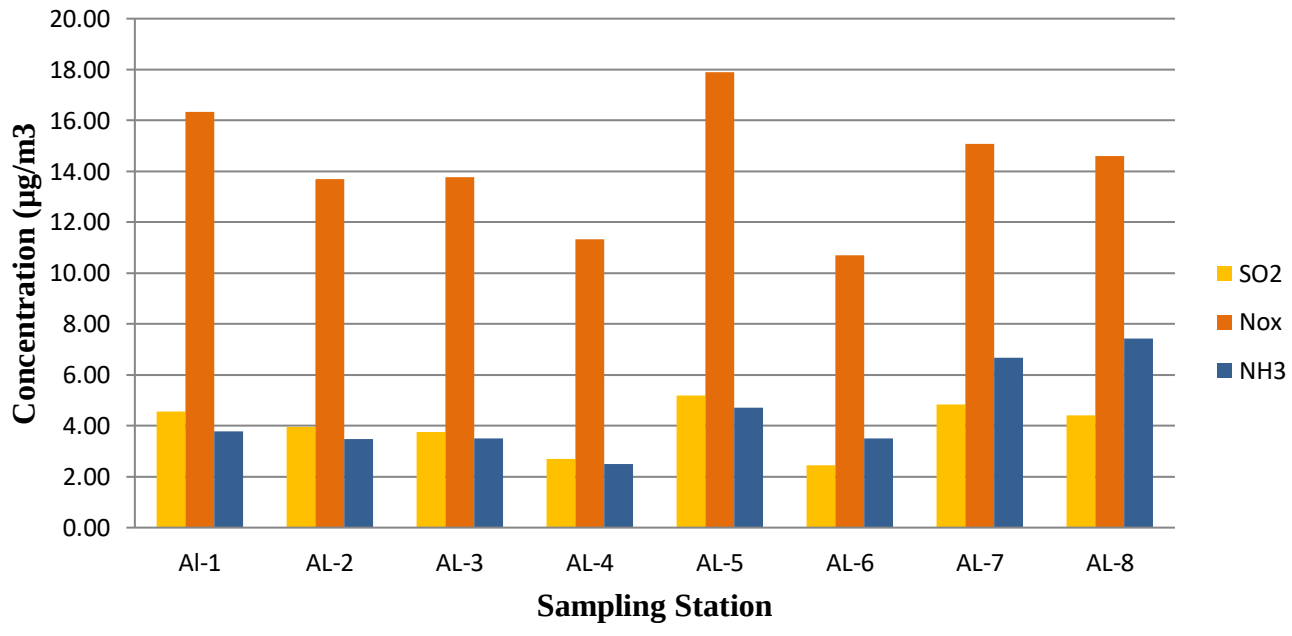


Fig. No:-3. Average ambient air qulaity (Gaseous) month of November-2022 at DPA and Vadinar sampling location

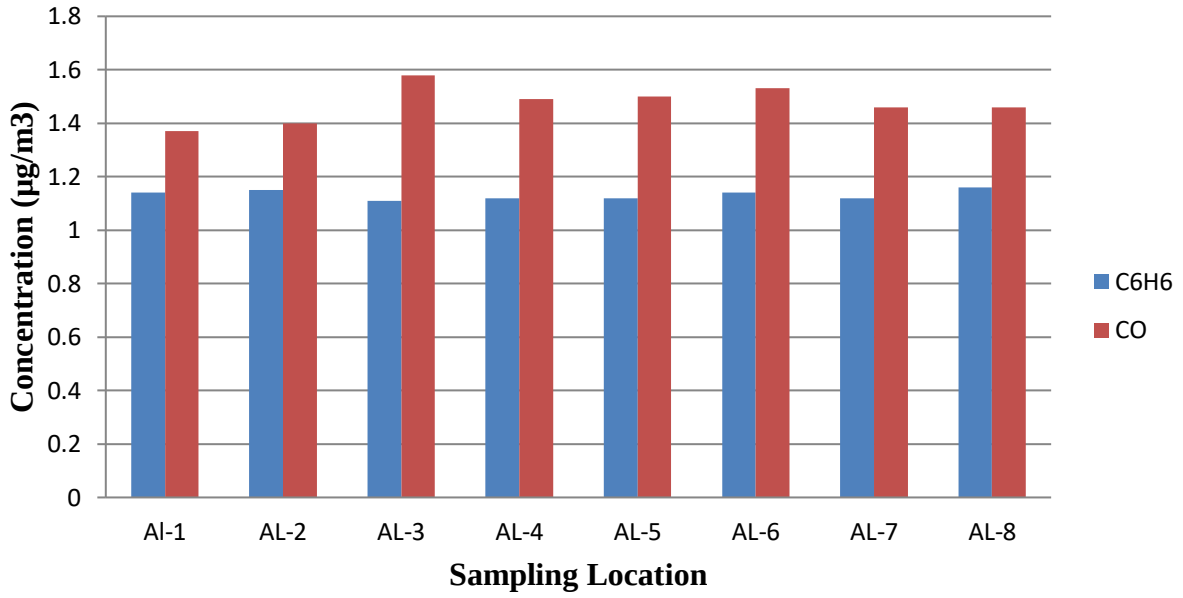
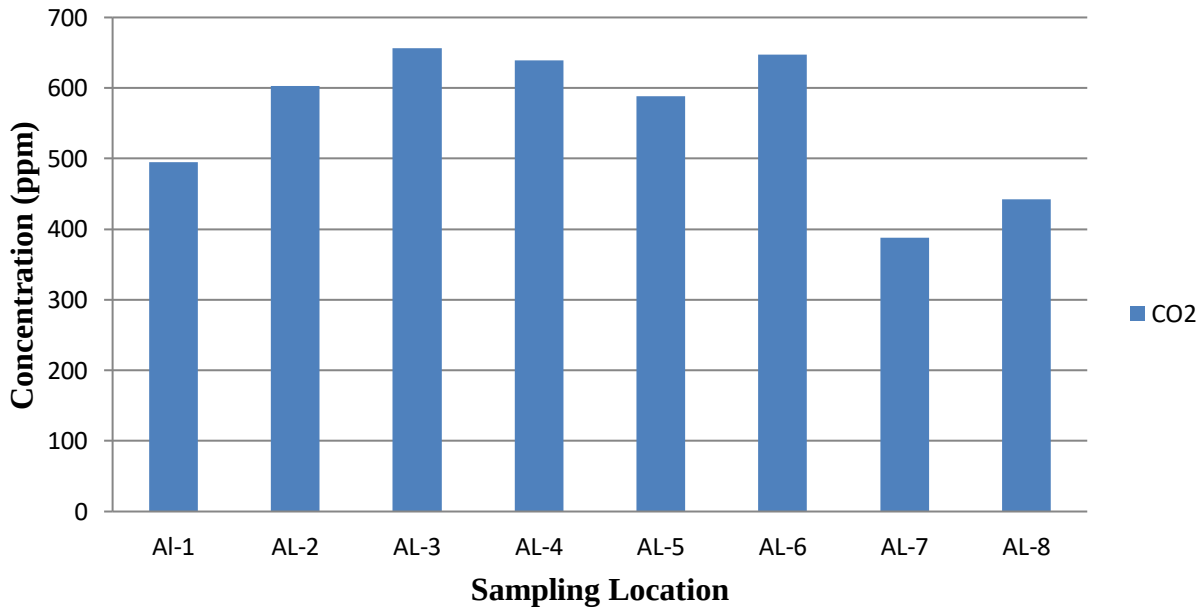


Fig. No:-4. Average ambient air qulaity (Gaseous) month of November-2022 at DPA and Vadinar sampling location



2.3 Observations and Conclusion

During the monitoring period, the overall Ambient Air Quality of the port area was found within permissible levels for various gaseous pollutants. However, Total Suspended Particulate matter as TSPM, Particulate matter as PM_{10} and $PM_{2.5}$ was found to exceed the limits at locations at all ambient air sampling location.

The concentration of PM_{10} and $PM_{2.5}$ were slightly exceeded at Gopalpuri and Tuna Port.

The mean concentration of PM_{10} and $PM_{2.5}$ were slightly exceeded at Admin building Vadinar & at Signal building Vadinar was very close to the standard limit.

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^2) and Rainfall mm.

Meteorological factors play an important role in environmental pollution studies particularly in pollutant transport irrespective of their entry into the environment. The wind speed and direction play a major role in dispersion of environment pollutants. Effects of pollution on receptors animate and inanimate depends on atmospheric condition.

Temperature

At Deendayal Port, the day time temperature was found range 21.1-32.9^{0}C. The average day time temperature was 27.92°C. The night time temperature was range from 20.0-29.7^{0}C. The mean night time temperature recorded was 25.47 °C.

Solar Radiation

The mean Solar Radiation in November month was 167.27 w/m^2. The maximum solar radiation was recorded 759.0 w/m^2 in 4th November, 2022 and the minimum solar radiation was recorded 1.80 w/m^2 in 30th November, 2022.

Rainfall

Rain fall of November month was recorded 0.00 mm.

Relative Humidity

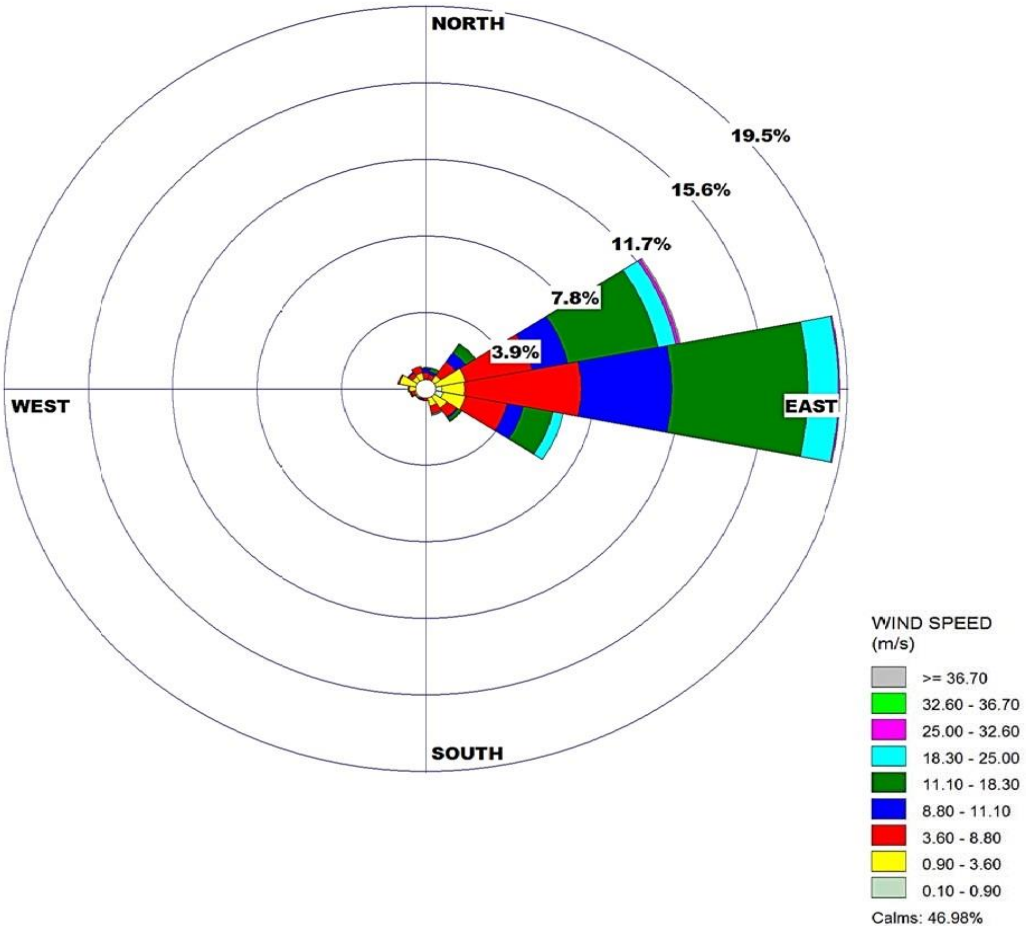
The mean Relative humidity was 69.00 % for the month of November. Maximum Relative humidity was recorded 99.0 % and minimum Relative humidity was recorded 34.0 %.

Wind Velocity and Wind Direction

Velocity and direction of wind have a significant role in the dispersion of air borne materials and therefore determines the air quality of the area. The average wind velocity for the entire month of November was 1.21 m/s. Maximum wind velocity was recorded 10.19 m/s. The wind direction was mostly North-East.

WIND ROSE PLOT:
M/s. Deendayal Port Authority (DPA)
Project Site, Sevasadan-3, Kandla Port.

DISPLAY:
Wind Speed
Direction (blowing from)



COMMENTS:	DATA PERIOD:	COMPANY NAME:	
	Start Date: 01-11-2022 - 00:00 End Date: 30-11-2022 - 23:00	M/s. Deendayal Port Authority (DPA)	
		MODELER: M/s. Eco Chem Sales & Services	
	CALM WINDS: 46.98%	TOTAL COUNT: 1438 hrs.	
	AVG. WIND SPEED: 4.33 m/s	DATE: 09-12-2022	PROJECT NO.:

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_3, NO_2, Mn, Cr-6, Cu, Cd, As, Hg, Pb, Zn, Bacterial Count (CFU) .

4.2 Results

The Drinking Water Quality monitoring data for 20 stations are given in below from table No. 11 to Table No. 17

Table 11: Drinking Water Quality Monitoring Parameters for Nirman Building, P & C Building and Main Gate (North) at Kandla.

Sr. No.	Parameter	Unit	Nirman Building 1	P & C Building	Main Gate North	Acceptable Limits as per IS 10500 :2012 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.35	7.33	7.41	7.35	6.5 to 8.5
2	Total Dissolved Solids	mg/l	690	670	670	690	2000
3	Turbidity	NTU	0	1	1	0	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	1229	1194	1211	NS*	NS*
7	Biochemical Oxygen	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	576.28	355.79	340.76	250	1000
9	Ca as Ca	mg/l	43.29	41.68	39.28	75	200
10	Mg as Mg	mg/l	58.8060	57.3480	56.3760	30	100
11	Total Hardness	mg/l	350	340	330	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.35	0.37	0.31	1	1.5
14	Sulphate as SO_4	mg/l	35.80	30.20	28.30	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	12.70	16.70	15.50	45	No Relaxation
17	Salinity	‰	1.04	0.64	0.62	NS*	NS*
18	Sodium as Na	mg/l	204.00	180.00	192.00	NS*	NS*
19	Potassium as K	mg/l	3.22	3.15	3.18	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Table 12: Drinking Water Quality Monitoring Parameters for Canteen, West Gate – I & Wharf Area at Kandla

Sr. No.	Parameter	Unit	Canteen	West Gate – I	Wharf Area	Acceptable Limits as per IS 10500 :	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.48	7.52	7.36	7.48	6.5 to 8.5
2	Total Dissolved Solids	mg/l	640	650	680	640	2000
3	Turbidity	NTU	0	1	0	0	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	1166	1152	1196	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	335.75	360.80	350.78	250	1000
9	Ca as Ca	mg/l	40.88	38.48	40.08	75	200
10	Mg as Mg	mg/l	62.6940	66.5820	53.4600	30	100
11	Total Hardness	mg/l	360	370	320	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.32	0.30	0.35	1	1.5
14	Sulphate as SO4	mg/l	31.20	28.30	26.00	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	6.60	11.40	5.80	45	No Relaxation
17	Salinity	‰	0.61	0.65	0.63	NS*	NS*
18	Sodium as Na	mg/l	202.00	200.00	-	NS*	NS*
19	Potassium as K	mg/l	3.38	3.48	3.16	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 13: Drinking Water Quality Monitoring Parameters for Sewa sadan–3, Workshop I and Custom Building at Kandla

Sr. No.	Parameter	Unit	Sewa Sadan – 3	Workshop	Custom Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.45	7.38	7.29	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	700	670	910	500	2000
3	Turbidity	NTU	0	1	1	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	1213	1164	1564	NS*	NS*
7	Biochemical	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	365.81	370.82	340.76	250	1000
9	Ca as Ca	mg/l	42.48	37.68	39.28	75	200
10	Mg as Mg	mg/l	59.2920	59.7780	53.9460	30	100
11	Total Hardness	mg/l	350	340	320	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.41	0.30	0.35	1	1.5
14	Sulphate as SO_4	mg/l	24.90	34.20	27.2	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	6.90	3.90	11.00	45	No Relaxation
17	Salinity	‰	0.66	0.67	0.62	NS*	NS*
18	Sodium as Na	mg/l	-	-	-	NS*	NS*
19	Potassium as K	mg/l	3.26	4.03	3.29	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l, Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 14: Drinking Water Quality Monitoring Parameters for Port Colony Kandla, Hospital Kandla and A.O. Building at Gandhidham.

Sr. No.	Parameter	Unit	Port Colony Kandla	Hospital Kandla	A.O. Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 :
1	pH	-	7.39	7.31	7.24	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	760	710	1060	500	2000
3	Turbidity	NTU	1	0	0	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	1328	1251	1821	NS*	NS*
7	Biochemical	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	335.75	345.77	365.81	250	1000
9	Ca as Ca	mg/l	41.68	42.48	40.88	75	200
10	Mg as Mg	mg/l	50.0580	54.4320	62.6940	30	100
11	Total Hardness	mg/l	310	330	360	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.35	0.32	0.46	1	1.5
14	Sulphate as SO_4	mg/l	28.10	24.50	24.50	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	20.20	7.40	15.60	45	No Relaxation
17	Salinity	‰	0.61	0.62	0.66	NS*	NS*
18	Sodium as Na	mg/l	192.80	193.60	194.50	NS*	NS*
19	Potassium as K	mg/l	4.13	4.18	3.26	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified,

BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 15: Drinking Water Quality Monitoring Parameters for School Gopalpuri, Guest House) and E - Type Quarter at Gopalpuri, Gandhidham

Sr. No.	Parameter	Unit	Gopalpuri School	Guest House	E - Type Quarter	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.3	7.24	7.26	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	830	950	1030	500	2000
3	Turbidity	NTU	1	1	0	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	1435	1638	1769	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	355.79	350.78	340.76	250	1000
9	Ca as Ca	mg/l	39.28	43.29	39.28	75	200
10	Mg as Mg	mg/l	61.2360	61.2360	51.5160	30	100
11	Total Hardness	mg/l	350	360	310	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.45	0.42	0.47	1	1.5
14	Sulphate as SO_4	mg/l	24.90	26.00	30.20	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	7.10	8.30	12.60	45	No Relaxation
17	Salinity	‰	0.64	0.63	0.62	NS*	NS*
18	Sodium as Na	mg/l	199.00	193.80	193.00	NS*	NS*
19	Potassium as K	mg/l	3.90	3.26	3.18	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100 ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 16: Drinking Water Quality Monitoring Parameters for F-Type Quarter, Hospital Gopalpuri and Tuna Port.

Sr. No.	Parameter	Unit	F - Type Quarter	Hospital Gopalpuri	Tuna Port	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.28	7.42	7.51	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1050	990	600	500	2000
3	Turbidity	NTU	1	1	-	1	5
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	1796	1700	1044	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	345.77	360.80	380.85	250	1000
9	Ca as Ca	mg/l	38.48	40.88	32.87	75	200
10	Mg as Mg	mg/l	61.7220	62.6940	72.41	30	100
11	Total Hardness	mg/l	350	360	380	200	600
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.42	0.45	0.43	1	1.5
14	Sulphate as SO_4	mg/l	26.00	26.10	24.50	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	10.30	6.80	3.00	45	No Relaxation
17	Salinity	‰	0.62	0.65	0.69	NS*	NS*
18	Sodium as Na	mg/l	201.00	201.00	193.60	NS*	NS*
19	Potassium as K	mg/l	3.15	3.16	3.21	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified, BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6-0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

Table 17: Drinking Water Quality Monitoring Parameters for Vadinar Jetty and Port Colony at Vadinar.

Sr. No.	Parameter	Unit	Vadinar Jetty	Port Colony Vadinar	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	-	7.4	7.43	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	320	300	500	2000
3	Turbidity	NTU	0.00	1.00	1	5
4	Odor	-	Odorless	Odorless	Agreeable	Agreeable
5	Color	-	Colorless	Colorless	5	15
6	Conductivity	µs/cm	570	300	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	160.36	140.31	250	1000
9	Ca as Ca	mg/l	36.87	34.47	75	200
10	Mg as Mg	mg/l	43.25	52.00	30	100
11	Total Hardness	mg/l	270	300	200	600
12	Iron as Fe	mg/l	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.25	0.22	1	1.5
14	Sulphate as SO_4	mg/l	0.75	0.24	200	400
15	Nitrite as NO_2	mg/l	BQL	BQL	NS*	NS*
16	Nitrate as NO_3	mg/l	15.60	12.70	45	No Relaxation
17	Salinity	‰	0.29	0.25	NS*	NS*
18	Sodium as Na	mg/l	191.6	192.0	NS*	NS*
19	Potassium as K	mg/l	BQL	BQL	NS*	NS*
20	Manganese	mg/l	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	0.003	NS*
24	Arsenic	mg/l	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	0.001	NS*
26	Lead	mg/l	BQL	BQL	0.01	NS*
27	Zinc	mg/l	BQL	BQL	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent

*NS: Not Specified,
BQL- Below Quantification Limit, (Nitrite - 0.05 mg/l,BOD-2.0 mg/l, Fe-0.009 mg/l,Mn- 0.01 mg/l, Cr+6- 0.03 mg/l, Cu-0.004 mg/l, Cd-0.003 mg/l, As-0.003mg/l, Hg-0.001 mg/l, Pb-0.006mg/l, Zinc-0.021 mg/l).

4.3 Results & Discussion

The colour of all drinking water samples was found Colourless and odour of the samples also agreeable. All parameters were found within the specified limit as per the Drinking water Standard.

pH

The pH is measure of the intensity of acidity or alkalinity and the concentration of hydrogen ion in water. At DPA Site the pH values for drinking water samples ranged from 7.24-7.52 and mean value was 7.36 while at Vadinar pH ranged from 7.40-7.43 and mean value was 7.42. All the sampling points showed pH values within the prescribed limit by Indian Standards.

Turbidity

The selected drinking water sample location turbidity range from 0-1NTU at all location of DPA and Vadinar in month of November. The Turbidity values were within the permissible limit at all sampling location prescribed limit by Indian standards.

Total Dissolved Solids (TDS)

Water has the ability to dissolve a wide range of inorganic and some organic minerals or salts such as potassium, calcium, sodium, bicarbonates, chlorides, magnesium, sulfates etc.

TDS values at DPA varied between 600-1060 mg/l. The average TDS value was found 792 mg/l. The minimum value for TDS was 600 mg/l at Hospital Gopalpuri and maximum was 980 mg/l at Tuna Port while at Vadinar TDS ranged from 280-300 mg/l and mean was 290.0 mg/l. The TDS values were within the permissible limit at all sampling location prescribed limit by Indian standards.

Conductivity

Electrical Conductivity is the ability of a solution to transfer (conduct) electric current. Conductivity is used to measure the concentration of dissolved solids which have been ionized in a polar solution such as water. The conductivity in the samples collected during the month of November DPA ranged from 1044.0 µs/cm at Tuna Port to1821.0 µs/cm at A.O. Building and mean value was 1381.72 µs/cm while at Vadinar ranged from 300-570 µs/cm and mean was 435 µs/cm.

BOD

BOD value in the studied area of DPA and Vadinar was found Below Quantification Limit (<2.0 mg/l). IS 10500:2012 does not show any standard values for BOD in drinking water.

Chlorides

Excessive chloride concentration increase rates of corrosion of metals in the distribution system. This can lead to increased concentration of metals in the supply. The Chloride value in the studied area of DPA ranged from 335.75-576.28 mg/l. The mean value was 365.53 mg/l. The minimum chloride was 335.75 mg/l at Port colony and maximum was 576.28 mg/l at Nirmal Building while at Vadinar location chloride ranged from 140.31-160.36 mg/l and mean was 150.33 mg/l. The Chloride was found within the Permissible limit of the Drinking Water Standard.

Calcium

Calcium is most abundant element on the earth crust and is very important for human cell physiology and bones. About 95% calcium in human body stored in bones and teeth. The high deficiency of calcium in humans may caused rickets, poor blood clotting, bones fracture etc. and the exceeding limit of calcium produced cardiovascular diseases.

The Calcium value in the studied area of DPA ranged from 32.87-43.29 mg/l. The mean value was 40.12 mg/l. The minimum calcium was 32.87 mg/l at Tuna Port and maximum was 43.29 mg/l at Gopalpuri Hospital while at Vadinar location Calcium ranged from 34.47-36.87 and mean was 35.67 mg/l. All the locations had calcium within the prescribed limits of 75-200 mg/L.

Magnesium

The magnesium value in the studied area of DPA ranged from 50.06-72.41 mg/l. The mean value was 59.24 mg/l. The minimum magnesium was 50.06 mg/l at Port Colony and maximum was 74.41 mg/l at Tuna Port while at Vadinar location magnesium ranged from 43.25-52.00 and mean was 47.61 mg/l. All the locations had magnesium within the prescribed limits of 30-100 mg/L.

Total Hardness

Total Hardness value in the studied area of DPA ranged from 310.0 mg/l at Port Colony to 380.0 mg/l at Tuna Port and mean value was 343.89 mg/l while at Vadinar location total hardness ranged from 270.0-300.00 mg/l and mean was 285.0 mg/l. The values of total

hardness were found within the Permissible limit of the Drinking Water Standard (200-600 mg/L). These results clear, that hardness of water is according to the IS standards and it is not harmful for local inhabitants.

Iron

Iron values in the studied area of DPA & Vadinar were Below Quantification Limit (0.009 mg/l) and hence well below the permissible limit as per Indian Standards are 0.3 mg/L.

Fluoride

Fluoride value in the studied area of DPA varied between 0.3-0.47 mg/l and mean was 0.38 mg/l. The minimum value was 0.3 mg/ at West gate workshop and maximum was 0.47 mg/l at E-Type and mean was 0.38 mg/l while at Vadinar location fluoride ranged from 0.22-0.25 mg/l and mean was 0.24 mg/l. The Fluoride values were well below the permissible limit as per Indian Standards is 1.0-1.5 mg/L. Moderate amounts lead to dental effects, but long-term ingestion of large amounts can lead to potentially severe skeletal problems.

Sulphate

Sulphate value in the studied area of DPA varied between 24.5–35.8 mg/l and mean was 27.83 mg/l. The minimum value was 24.5 mg/ at A.O. Building, Hospital Kandla and Tuna Port and maximum was 35.8 mg/l at Nirmal Building while at Vadinar location Sulphate ranged from 0.24-0.75 mg/l and mean was 0.50 mg/l. All the sampling points showed Sulphate values within the prescribed limits by Indian Standards (200-400 mg/L). Sulphate content in drinking water exceeding the 400 mg/L imparts bitter taste.

Nitrites (NO_2) and Nitrates (NO_3)

The all values of Nitrite were found BQL (<0.05 mg/l) and Nitrate were well within the permissible limit of the Drinking water Standard.

Salinity

Salinity in drinking water in the present samples collected at DPA ranged from 0.61 ‰ at Canteen to 1.04 ‰ at Nirmal Building and average salinity was 0.66 ‰ while at Vadinar sampling location salinity ranged from 0.25-0.29 ‰. There are no prescribed Indian standards for salinity in Drinking water**.**

Sodium and Potassium Salts

Sodium values in the samples collected at DPA ranged from 180 - 204 mg/l and average was 195.74 mg/l while at Vadinar sodium ranged from 191.6- 192.0 mg/l and average was191.8 mg/l . Potassium salts ranged at DPA ranged from 3.15 to 4.18 mg/l while average was 3.42 mg/l while at Vadinar sampling locations potassium were BQL (<2.0 mg/l). There are no prescribed limits of Sodium and Potassium in Indian standards for Drinking water.

Heavy Metals in Drinking Water

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

Bacteriological Study

Analysis of the bacteriological parameter (E-coli and total coliform) at all location shows that Bacteria were not detectable. This shows that drinking water samples were safe for human consumption as per tested parameters.

4.4 Conclusions

These results were compared with permissible limits as prescribed in IS 10500:2012 – Drinking Water Specification. It was seen from the analysis data that during the study period at selected sampling location the water was safe for human consumption as per analyzed parameters at all drinking water monitoring stations.

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
Vadinar Port			
11	Entrance Gate of Vadinar Port	55.0	53.5
12	Nr. Port Colony, Vadinar	60.6	57.6
13	Nr. Vadinar Jetty	52.5	51.0

5.3 Conclusions

Transportation systems are the main source of noise pollution in urban areas. Construction of buildings, highways, and roads cause a lot of noise, due to the usage of air compressors, bulldozers, loaders, dump trucks, and pavement breakers. Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships.

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. The Day Time Noise Level (SPL) in all 10 locations at Deendayal Port Authority ranged from 53.2 dB(A) to 70.4 dB(A) while at Vadinar port 3 location ranged from 52.5 dB(A) to 60.6 dB(A) which was within the permissible limits of 75 dB(A) for the industrial area for the daytime. The Night Time Average Noise Level (SPL) in all locations of Deendayal Port Authority ranged from 45.4 dB to 61.7 dB(A) while at Vadinar port ranged from 52.5 dB (A) to 60.6 dB(A) which was within the permissible limits of 70 dB(A) for the industrial area for the night time.

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 µs/cm at Nakti Creek (Sand from creek after tide) to 36100 µs/cm at IIFCO Plant and mean was 27655 µs/cm while Vadinar soil sampling location conductivity were 155 µs/cm at DPA Admin Site and 594 µs/cm at DPA Colony site.
- Total organic Carbon of DPA Kandla soil sample ranged from 1.7 % at IFFCO Plant to 7.80 % at Nakti Creek (Sand from creek after tide) and mean was 4.30 % while Vadinar soil sample were 2.0 % at DPA Colony and 2.30 % at DPA admin Site.
- The concentration of Phosphorus in the soil samples of DPA Kandla varies from 8.49 mg/kg at Nakti Creek (Sand from creek after tide) and 10.5 mg/kg at IIFCO Plant and mean was 9.62 mg/kg while the Vadinar soil sample for Phosphorus were 4.80 mg/kg at DPA Colony and 6.00 mg/kg at DPA Admin Site.
- Chloride in soil sample of DPA ranged from 2950.00 mg/kg at Nakti Creek (Sand from creek after tide) to 15598 mg/kg at Tuna Port and mean was11356 mg/kg while Vadinar soil sample were 140 mg/kg at DPA admin and 525 mg/kg at DPA Colony.
- The Concentration of Potassium in the soil samples of DPA Kandla ranged from 437 mg/kg at Nakti creek and 708 mg/kg at Khori Creek and mean was 597.75 mg/kg while the Vadinar soil sample for Potassium were 44.52 mg/kg at DPA Colony Site and 44.60 mg/kg at DPA Admin Site.
- The concentration of Sodium in the soil samples of DPA Kandla ranged from 4675.0 mg/kg at Nakti creek and 7649.0 mg/kg at Khori Creek and mean was 6279 mg/kg while the Vadinar soil sample for Sodium were 33.00 mg/kg at DPA Admin Site and 117 mg/kg at DPA Colony.

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

Heavy Metals in the Soil

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

6.4 Conclusion

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

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 (1st Week)

Date of Sampling	03.11.2022

Sr. No.	**Parameters**	**Unit**	**Results**		**GPCB Prescribed Limit**
			DPA STP I/L	**DPA STP O/L**	
1	pH	-	7.55	7.42	6.5 - 8.5
2	Total Suspended Solids	mg/l	100.6	46.8	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	80.8	30.3	100
5	BOD @ 27 °C	mg/l	22	11	30
Aeration Tank					
6	MLSS	mg/l	14.0		
7	MLVSS	%	99.73		

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

Date of Sampling	10.11.2022

Sr. No.	**Parameters**	**Unit**	**Results**		**GPCB Prescribed Limit**
			DPA STP I/L	**DPA STP O/L**	
1	pH	-	7.41	7.36	6.5 - 8.5
2	Total Suspended Solids	mg/l	127	52.6	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	90.9	40.4	100
5	BOD @ 27 °C	mg/l	23	11	30
Aeration Tank					
6	MLSS	mg/l	18.0		
7	MLVSS	%	85.00		

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

Date of Sampling	17.11.2022

Sr. No.	**Parameters**	**Unit**	**Results**		**CPCB Prescribed Limit**
			DPA STP I/L	**DPA STP O/L**	
1	pH	-	7.48	7.29	6.5 - 8.5
2	Total Suspended Solids	mg/l	86.4	22.9	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	101	50.5	100
5	BOD @ 27 °C	mg/l	26	14	30
Aeration Tank					
6	MLSS	mg/l	20.0		
7	MLVSS	%	98.0		

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

Date of Sampling	24.10.2022

Sr. No.	**Parameters**	**Unit**	**Results**		**GPCB Prescribed Limit**
			DPA STP I/L	**DPA STP O/L**	
1	pH	-	7.41	7.29	6.5 - 8.5
2	Total Suspended Solids	mg/l	164.2	58.7	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	171.7	30.3	100
5	BOD @ 27 °C	mg/l	43	10	30
Aeration Tank					
6	MLSS	mg/l	20.0		
7	MLVSS	%	89.0		

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

Date of Sampling	03.11.2022

Sr. No.	**Parameters**	**Unit**	**Results**		**GPCB Prescribed Limit**
			DPA STP I/L	**DPA STP O/L**	
1	pH	-	7.47	7.31	6.5 - 8.5
2	Total Suspended Solids	mg/l	121.2	61	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	111.1	60.6	100
5	BOD @ 27 °C	mg/l	32	13	30
Aeration Tank					
6	MLSS	mg/l	22.0		
7	MLVSS	%	97.16		

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

Date of Sampling	10.11.2022

Sr. No.	**Parameters**	**Unit**	**Results**		**GPCB Prescribed Limit**
			DPA STP I/L	**DPA STP O/L**	
1	pH	-	7.35	7.27	6.5 - 8.5
2	Total Suspended Solids	mg/l	189	67.9	100
3	Residual Chlorine	mg/l			-
4	COD	mg/l	141.4	60.6	100
5	BOD @ 27 °C	mg/l	37	15	30
Aeration Tank					
6	MLSS	mg/l	16.0		
7	MLVSS	%	89.6		

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

Date of Sampling	17.11.2022

Sr. No.	**Parameters**	**Unit**	**Results**		**GPCB Prescribed Limit**
			Gopalpuri STP I/L	**Gopalpuri STP O/L**	
1	pH	-	7.41	7.36	6.5 - 8.5
2	Total Suspended Solids	mg/l	127	52.6	100
3	Residual Chlorine	mg/l			-
4	COD	mg/l	90.9	40.4	100
5	BOD @ 27 °C	mg/l	23	11	30
Aeration Tank					
6	MLSS	mg/l	08.0		
7	MLVSS	%	98.0		

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

Date of Sampling	24.11.2022

Sr. No.	**Parameters**	**Unit**	**Results**		**GPCB Prescribed Limit**
			Gopalpuri STP I/L	**Gopalpuri STP O/L**	
1	pH	-	7.48	7.28	6.5 - 8.5
2	Total Suspended Solids	mg/l	110.2	42.1	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	78	40	100
5	BOD @ 27 °C	mg/l	24.0	12.0	30
Aeration Tank					
6	MLSS	mg/l	18.0		
7	MLVSS	%	90.0		

Table 30: Sewage Water Monitoring at Vadinar STP (1st Week)

Date of Sampling	03.11.2022

Sr. No.	**Parameters**	**Unit**	**Results**		**GPCB Prescribed Limit**
			Vadinar STP I/L	**Vadinar STP O/L**	
1	pH	-	7.35	7.25	6.5 - 8.5
2	Total Suspended Solids	mg/l	74.9	39.5	100
3	Residual Chlorine	mg/	-	<0.5	-
4	COD	mg/l	101	40.4	100
5	BOD @ 27 °C	mg/l	26.0	10.0	30

Table 31: Sewage Water Monitoring at Vadinar STP (2nd Week)

Date of Sampling	10.11.2022

Sr. No.	**Parameters**	**Unit**	**Results**		**GPCB Prescribed Limit**
			Vadinar STP I/L	**Vadinar STP O/L**	
1	pH	-	7.38	7.21	6.5 - 8.5
2	Total Suspended Solids	mg/l	69.6	40.3	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	131.3	50.5	100
5	BOD @ 27 °C	mg/l	32.0	7.0	30

Table 32: Sewage Water Monitoring at Vadinar STP (3rd Week)

Date of Sampling	17.11.2022

Sr. No.	**Parameters**	**Unit**	**Results**		**GPCB Prescribed Limit**
			Vadinar STP I/L	**Vadinar O/L**	
1	pH	-	7.51	7.42	6.5 - 8.5
2	Total Suspended Solids	mg/l	38.6	16.9	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	80.8	20.2	100
5	BOD @ 27 °C	mg/l	24.0	12.0	30

Table 33: Sewage Water Monitoring at Vadinar STP (4th Week)

Date of Sampling	24.11.2022

Sr. No.	**Parameters**	**Unit**	**Results**		**GPCB Prescribed Limit**
			Vadinar STP I/L	**Vadinar STP O/L**	
1	pH	-	7.61	7.42	6.5 - 8.5
2	Total Suspended Solids	mg/l	76.9	33.3	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	131.3	20.2	100
5	BOD @ 27 °C	mg/l	20.0	8.0	30

Table No. 34. General Standards for discharge of Environmental Pollutant Part-A

Sr. No.	Parameter	Inland Surface Water	Land Irrigation	Marine Coastal Areas
1.	pH	5.5-9.0	5.5-9.0	5.5-9.0
2.	Total Suspended Solids (mg/l)	100	200	100
3.	Residual Chlorine (mg/l)	1.0	-	1.0
4.	BOD (mg/l)	30	100	100
5.	COD (mg/l)	250	-	250

Sources:-CPCB

7.3 Results & Discussion

The STP Sample carried out to evaluate the efficiency and performance of the wastewater treatment plant at Gopalpuri, Kandla and Vadinar STP. The performance of these plants is an essential parameter to monitor because the treated sewage water is discharged for irrigation purposes and discharge into marine. Wastewater samples were collected from different unit operations of the plant i.e, the inlet, aeration tank and the final treated outlet. These samples were analyzed for various physico-chemical characteristics such as pH, TSS, Residual Chlorine, COD, BOD, MLSS and MLVS.

The final treated outlet observed pH values were within the allowed range at STP Gopalpuri, STP Kandla & STP Vadinar ranged from 7.22 -7.35, 7.29-7.42 & 7.21-7.42 respectively. The wastewater treatment makes it suitable for irrigation. These values are below the allowed limit of the GPCB.

- The final treated outlet observed Total suspended solid values at Gopalpuri, DPA Kandla & Vadinar ranged from 27.10-67.90 mg/l, 22.90-58.70 mg/l & 16.60-40.30 mg/l respectively. These values are below the allowed limit of the GPCB.
- The final treated outlet observed Residual Chlorine values were <0.5 at Gopalpuri, DPA Kandla & Vadinar. These values are below the allowed limit of the CPCB.
- The final treated outlet observed COD values were at Gopalpuri, DPA Kandla & Vadinar ranged from 40.40-60.60 mg/l, 30.30-50.50 mg/l & 20.20-50.50 mg/l respectively. These values are below the allowed limit of the CPCB.

- The main focus of wastewater treatment plants is supposed to reduce the BOD in the effluent discharged to natural waters. Wastewater treatment plants are designed to function as bacteria farms, where bacteria are fed oxygen and organic waste. The final treated outlet observed BOD values were at Gopalpuri, DPA Kandla & Vadinar ranged from 12.0-16.0 mg/l, 10.0-14.0 mg/l & 7.0-12.0 mg/l respectively. These values are below the allowed limit of the GPCB.

7.4 Conclusions:

All parameters for STP outlet are within limit prescribed by CPCB. After the final treatment, it is found that the treated water is satisfactory.

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 01st & 02nd November-2022 in harbor regions of DPA & Vadinar during Neap tide period of New moon phase of Lunar Cycle. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 8th & 9th November-2022 in harbor regions of DPA & Vadinar during Spring tide period first quarter of Lunar Cycle.

Plankton samples from sub surface layer was collected both during high tide period and low tide period from 3 water quality monitoring stations of DPA harbor area and two stations in Nakti creek and one station in Khori creek. The same sampling schedule was repeated during consecutive spring tide and neap tide in same month. Plankton samples from sub surface layer was collected both during high tide period and low tide period from 1 water quality monitoring stations near Vadinar jetty area during spring tide and neap tide in this month. Collected water samples were processed for estimation

of Chlorophyll- a, Pheophytin- a, qualitative & quantitative evaluation of phytoplankton, qualitative & quantitative evaluation zooplanktons (density and their population).

Sampling Locations

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

8.1 Marine Water Quality and Results

Marine water quality of marine waters of Deendayal Port Harbor waters, Khori & Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each month. The results of marine water quality from table no 35 to 42. *During low tide DPA-6 Nakti-II location monitoring was not possible due to non-availability of marine water.*

Table 35: Marine Water Quality Monitoring Parameters for Location Near DPA Colony

Sr. No.	Parameters	Unit	Kandla Creek Near DPA Colony (1)			
			23°0'58"N 70°13'22."E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.61	7.58	7.55	7.46
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	19.0	19.9	20.4	19.0
5	Turbidity	NTU	38	35	42	35
6	Total Dissolved Solids	mg/l	34152.0	30868.0	30941.0	31974.0
7	Total Suspended Solids	mg/l	639.6	600.6	646.4	595.6
8	Total Solids	mg/l	34791.6	31468.6	31587.4	32569.6
9	DO	mg/l	5.8	5.6	5.7	5.5
10	COD	mg/l	88.0	79.0	82.0	86.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	1.06	0.82	0.99	0.91
13	Phosphate	mg/l	0.48	0.31	0.09	0.04
14	Sulphate	mg/l	3580	3407	3708.0	3658
15	Nitrate	mg/l	4.70	0.50	0.75	0.42
16	Nitrite	mg/l	<0.05	<0.05	BQL	BQL
17	Calcium	mg/l	521.04	440.88	561.12	480.96
18	Magnesium	mg/l	1773.9	1749.6	1701	1773.9
19	Sodium	mg/l	8011.0	8399.0	8396.0	8699.0
20	Potassium	mg/l	299.0	385.0	391.0	395.0
21	Iron	mg/l	BQL	BQL	0.88	0.57
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

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

Table 36: Marine Water Quality Monitoring Parameters for Location Near Passenger Jetty One at Kandla

Sr. No.	Parameters	Unit	Near passenger Jetty One (2)			
			23° 0'18 "N 70°13'31"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.43	7.28	7.33	7.41
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	20.8	20.4	19.9	18.6
5	Turbidity	NTU	43	48	36	41
6	Total Dissolved Solids	mg/l	35468.0	37102.0	34662.0	33398.0
7	Total Suspended Solids	mg/l	679.7	665.5	703.7	663.8
8	Total Solids	mg/l	36147.7	37767.5	35365.7	34061.8
9	DO	mg/l	5.9	6.2	5.6	5.2
10	COD	mg/l	86.0	94.0	90.0	92.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	1.26	0.86	1.33	0.85
13	Phosphate	mg/l	0.29	0.13	0.33	0.19
14	Sulphate	mg/l	3571	3470	4072	3407
15	Nitrate	mg/l	3.40	2.70	1.17	4.36
16	Nitrite	mg/l	<0.05	<0.05	BQL	BQL
17	Calcium	mg/l	561.12	601.20	601.2	521.04
18	Magnesium	mg/l	1701	1603.8	1749.6	1701
19	Sodium	mg/l	9142.0	9345.0	9247.0	9219.0
20	Potassium	mg/l	370.0	385.0	370.0	380.0
21	Iron	mg/l	0.47	BQL	1.76	0.30
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

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

Table 37: Marine Water Quality Monitoring Parameters for location Near Coal Berth

Sr. No.	Parameters	Unit	Near Coal Berth			
			22°59'12"N 70°13'40"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.37	7.51	7.53	7.25
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	18.6	18.1	19.5	20.8
5	Turbidity	NTU	33	42	38	45
6	Total Dissolved Solids	mg/l	39222.0	37586.0	37123.0	36668.0
7	Total Suspended Solids	mg/l	540.2	638.4	620.6	580.2
8	Total Solids	mg/l	39762.2	38224.4	37743.6	37248.2
9	DO	mg/l	7.3	6.4	7.1	6.5
10	COD	mg/l	81.0	874.0	88.0	84.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.56	0.98	0.69	1.76
13	Phosphate	mg/l	0.06	0.56	0.12	0.61
14	Sulphate	mg/l	4222	3458	2981	3758
15	Nitrate	mg/l	2.20	4.60	2.68	4.70
16	Nitrite	mg/l	<0.05	<0.05	BQL	BQL
17	Calcium	mg/l	480.96	641.28	641.28	721.44
18	Magnesium	mg/l	1628.1	1628.1	1676.7	1603.8
19	Sodium	mg/l	8346.0	9380.0	9245.0	9814.0
20	Potassium	mg/l	391.0	300.0	392.0	384.0
21	Iron	mg/l	BQL	BQL	BQL	1.34
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

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

Table 38: Marine Water Quality Monitoring Parameters for location Khori creek at Kandla

Sr. No.	Parameters	Unit	Khori creek			
			Near 15/16 Berth			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.48	7.27	7.34	7.21
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	20.4	19.5	18.6	17.7
5	Turbidity	NTU	35	31	43	39
6	Total Dissolved Solids	mg/l	32557.0	34294.0	30473.0	33329.0
7	Total Suspended Solids	mg/l	641.2	616.3	594.7	731.2
8	Total Solids	mg/l	33198.2	34910.3	31067.7	34060.2
9	DO	mg/l	7.6	6.3	7.3	6.8
10	COD	mg/l	85.0	96.0	92.0	96.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.78	1.04	1.39	1.18
13	Phosphate	mg/l	0.44	0.67	0.35	0.42
14	Sulphate	mg/l	4047	3646	3157	3170
15	Nitrate	mg/l	3.70	1.10	1.34	5.20
16	Nitrite	mg/l	<0.05	<0.05	BQL	BQL
17	Calcium	mg/l	561.12	480.96	480.96	561.12
18	Magnesium	mg/l	1725.3	1676.7	1701	1628.1
19	Sodium	mg/l	9112.0	8436.0	7966.0	8696.0
20	Potassium	mg/l	299.0	385.0	382.0	377.0
21	Iron	mg/l	0.44	BQL	0.17	0.31
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	0.02
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

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

Table 39: Marine Water Quality Monitoring Parameters for location Nakti Creek near Tuna Port

Sr. No.	Parameters	Unit	Nakti Creek Near Tuna Port			
			22°57'49."N 70° 7'0.67"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.41	7.36	7.48	7.23
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	19.0	18.6	19.0	19.5
5	Turbidity	NTU	45	36	40	42
6	Total Dissolved Solids	mg/l	30214.0	28996.0	31047.0	31957.0
7	Total Suspended Solids	mg/l	642.7	526.2	682.5	606.8
8	Total Solids	mg/l	30856.7	29522.2	31729.5	32563.8
9	DO	mg/l	8.1	7.5	6.4	7.2
10	COD	mg/l	94.0	112.0	98.0	100.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	1.12	1.20	1.42	1.22
13	Phosphate	mg/l	0.71	0.37	0.46	0.12
14	Sulphate	mg/l	4172	3846	3445	3433
15	Nitrate	mg/l	1.50	1.70	5.12	1.69
16	Nitrite	mg/l	<0.05	<0.05	BQL	BQL
17	Calcium	mg/l	440.88	641.28	601.2	521.04
18	Magnesium	mg/l	1725.3	1555.2	1701	1773.9
19	Sodium	mg/l	8639.0	9143.0	8655.0	7939.0
20	Potassium	mg/l	395.0	386.0	384.0	386.0
21	Iron	mg/l	BQL	0.33	0.34	0.18
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	BQL	BQL	BQL	BQL

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

Table 40: Marine Water Quality Monitoring Parameters for location Nakti Creek Near NH-8A at Kandla

Sr. No.	Parameters	Unit	Nakti Creek Near NH-8A			
			23° 02'01"N 70° 09'31"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.45	Sampling not possible during Low Tide	7.45	Sampling not possible during Low Tide
2	Color	-	Agreeable		Agreeable	
3	Odor	-	Agreeable		Agreeable	
4	Salinity	‰	19.9		20.8	
5	Turbidity	NTU	45		44	
6	Total Dissolved Solids	mg/l	30288.0		32796.0	
7	Total Suspended Solids	mg/l	529.6		595.7	
8	Total Solids	mg/l	30817.6		33391.7	
9	DO	mg/l	7.4		6.9	
10	COD	mg/l	118.0		110.0	
11	BOD	mg/l	BQL		BQL	
12	Silica	mg/l	1.02		0.16	
13	Phosphate	mg/l	0.75		0.46	
14	Sulphate	mg/l	4109		4961	
15	Nitrate	mg/l	2.70		3.52	
16	Nitrite	mg/l	<0.05		BQL	
17	Calcium	mg/l	681.36		641.28	
18	Magnesium	mg/l	1506.6		1628.1	
19	Sodium	mg/l	9280.0		8528.0	
20	Potassium	mg/l	427.0		427.0	
21	Iron	mg/l	BQL		0.54	
22	Chromium	mg/l	BQL		BQL	
23	Copper	mg/l	BQL		BQL	
24	Arsenic	mg/l	BQL		BQL	
25	Cadmium	mg/l	BQL		0.01	
26	Mercury	mg/l	BQL		BQL	
27	Lead	mg/l	BQL		BQL	
28	Zinc	mg/l	BQL		BQL	

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

Table 41: Marine Water Quality Monitoring Parameters for locations Nr. Vadinar Jetty

Sr. No.	Parameters	Unit	Nr.Vadinar Jetty			
			22°26'25.26"N 69°40'20.41"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.43	7.26	7.36	7.29
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	20.4	20.8	19.0	19.9
5	Turbidity	NTU	39	42	38	42
6	Total Dissolved Solids	mg/l	35265.0	37685.0	36325.0	36681.0
7	Total Suspended Solids	mg/l	585.3	590.8	681.4	657.6
8	Total Solids	mg/l	35850.3	38275.8	37006.4	37338.6
9	DO	mg/l	5.7	5.4	6.3	5.8
10	COD	mg/l	87.0	89.0	96.0	92.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.55	0.45	0.36	0.28
13	Phosphate	mg/l	0.18	0.42	0.33	0.19
14	Sulphate	mg/l	3608	3558	3683	3645
15	Nitrate	mg/l	2.35	1.09	1.00	2.43
16	Nitrite	mg/l	<0.05	<0.05	BQL	BQL
17	Calcium	mg/l	480.96	601.20	521.04	480.96
18	Magnesium	mg/l	1603.8	1652.4	1676.7	1749.6
19	Sodium	mg/l	9448.0	7368.0	7810.0	8912.0
20	Potassium	mg/l	371.0	354.0	452.0	456.0
21	Iron	mg/l	BQL	BQL	0.31	BQL
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	0.29	BQL	0.77	0.35

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

Table 42: Marine Water Quality Monitoring Parameters for locations Nr. Vadinar SPM

Sr. No.	Parameters	Unit	Nr. Vadinar SPM			
			22°30'56.15"N 69°42'12.07"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	-	7.37	7.22	7.41	7.35
2	Color	-	Agreeable	Agreeable	Agreeable	Agreeable
3	Odor	-	Agreeable	Agreeable	Agreeable	Agreeable
4	Salinity	‰	19.0	17.7	19.5	18.6
5	Turbidity	NTU	37	40	37	39
6	Total Dissolved Solids	mg/l	39961.0	39198.0	42642.0	40730.0
7	Total Suspended Solids	mg/l	545.5	493.6	714.3	657.9
8	Total Solids	mg/l	40506.5	39691.6	43356.3	41387.9
9	DO	mg/l	6.1	5.5	5.6	6.1
10	COD	mg/l	95.0	98.0	96.0	94.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.47	0.37	0.34	0.30
13	Phosphate	mg/l	1.08	0.19	0.46	0.28
14	Sulphate	mg/l	3495	3796	3745	4008
15	Nitrate	mg/l	3.86	2.18	4.95	2.10
16	Nitrite	mg/l	<0.05	<0.05	BQL	BQL
17	Calcium	mg/l	561.12	400.80	681.36	641.28
18	Magnesium	mg/l	1628.1	1676.7	1555.2	1628.1
19	Sodium	mg/l	8473.0	10386.0	9131.0	8526.0
20	Potassium	mg/l	452.0	406.0	413.0	441.0
21	Iron	mg/l	BQL	BQL	0.24	BQL
22	Chromium	mg/l	BQL	BQL	BQL	BQL
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	BQL	BQL	BQL	BQL
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	BQL	BQL	BQL	BQL
28	Zinc	mg/l	0.28	BQL	0.40	BQL

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

8.2 Results & Discussion for Marine water samples

Marine water quality of Deendayal Port Harbor waters, Khori and Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each month. The Heavy metal analyzed and mostly found below quantification limit.

pH

During spring tide the pH values was ranged from 7.27-7.61 at DPA Kandla and 7.22-7.43 at Vadinar while during Neap Tide pH values was ranged from 7.21-7.55 at DPA Kandla and 7.29-7.41 at Vadinar.

Color and Odor

All marine samples for Odor and Color were found agreeable at all sampling locations.

Turbidity

During spring tide the Turbidity values was ranged from 31-48 NTU at DPA Kandla and 37-42 NTU at Vadinar while during Neap Tide Turbidity values was ranged from 35-45 NTU at DPA Kandla and 37-42 NTU at Vadinar. Turbidity is the amount of particulate matter that is suspended in water. Turbidity measures the scattering effect that suspended solids have on light: the higher the intensity of scattered light, the higher the turbidity (Yap et al, 2011). Materials that cause water to be turbid include clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, plankton and microscopic organisms (Lawler, 2004). The turbidity affects the amount of light penetrating to the plants for photosynthesis.

Total Dissolved Solids (TDS)

TDS values in the studied area during Spring Tide varied between 28966- 39222 mg/l at DPA Kandla and 35265-39961 mg/l at Vadinar while during Neap Tide TDS values was varied 30473-37123 mg/l at DPA Kandla and 36325-42642 mg/l at Near Vadinar.

Calcium

Calcium value in the studied area during Spring Tide varied between 440.9-681.4 mg/l at DPA Kandla and 400.8-601.2 mg/l at Vadinar while during Neap Tide calcium values between 481.0-721.4 mg/l at DPA Kandla and 481.0-681.4 mg/l at Vadinar.

Magnesium

Magnesium value in the studied area during Spring Tide varied between 1506.6-1773.9 mg/l at DPA Kandla and 1603.8-1676.7 mg/l at Vadinar while during Neap Tide magnesium values between 1603.80-173.9 mg/l at DPA Kandla and 1555.2 -1749.60 at Vadinar. Calcium and magnesium both play an important role in antagonizing the toxic effects of various ions and neutralizing the excess acid produced (Narayan R. et. al., 2007)

Nitrate

Nitrate value in the studied area during Spring Tide varied between 0.5-4.7 mg/l at DPA Kandla and 1.09-3.86 mg/l at Vadinar while during Neap Tide Nitrate values between 0.42-5.2 mg/l at DPA Kandla and 1.0-4.95 at Vadinar.

The variations were observed due to variation in phytoplankton excretion, oxidation of ammonia, reduction of nitrate and by recycling of nitrogen and bacterial decomposition of planktonic detritus (Asha and Diwakar, 2007).

Iron

Iron values in the studied area during Spring Tide ranged from 0.33-0.47 mg/l at DPA Kandla and at Vadinar were BQL (<0.10) while during Neap Tide Iron values ranged from 0.17-1.76 mg/l at DPA Kandla and 0.24-0.31 mg/l at Vadinar.

Sulphates

Sulphate values in the studied area during Spring Tide ranged from 3407-4222 mg/l at DPA Kandla and 3495-3796 mg/l at Vadinar while during Neap Tide the Sulphate values was varied 2981-4961 mg/l at DPA Kandla and 3645-4008mg/l at Vadinar.

Salinity

Salinity values in the studied area during Spring Tide varied ranged 18.11 to 20.82 ‰ at DPA Kandla and 17.65 to 20.82 ‰ at Vadinar while during Neap Tide the Salinity values was varied 17.65 to 20.82 ‰ at DPA Kandla and 18.55 to 19.92 ‰ at Vadinar.

Sodium and Potassium Salts

During Spring Tide the Sodium values ranged from 8011-9380 mg/l at DPA Kandla & 7368-10386 mg/l at Vadinar and Potassium salts ranged from 299-427 mg/l at DPA Kandla & 354-452 mg/l at Vadinar while during Neap Tide the Sodium values was ranges from 7939-

9814 mg/l at DPA Kandla & 7810-9131 mg/l at Vadinar and Potassium salts ranged from 370-427 mg/l at DPA Kandla & 413-456 mg/l at Vadinar.

DO

The DO refers to the amount of oxygen dissolved in the water and it is particularly important in limnology {(aquatic ecology) (Weiss 1970)}. The fate and behavior of DO is of critical importance to marine organisms in determining the severity of adverse impacts (Best et al. 2007). The major factor controlling dissolved oxygen concentration is biological activity: photosynthesis producing oxygen while respiration and nitrification consume oxygen (Best et al. 2007). From the studied samples, DO in marine water during Spring Tide was found in ranges from 5.6-8.1 mg/l at DPA Kandla and 5.4-6.1 mg/l at Vadinar while during Neap Tide 5.2-7.3 mg/l at DPA Kandla and 5.6-6.3 mg/l at Vadinar.

BOD

BOD in marine water at all sampling location in the studied samples were found BQL (<2.0 mg/l).

Heavy Metals in Marine Water

In the present study period marine water samples were analyzed for Cr, Cu, Cd, As, Hg, Pb and Zn. Maximum heavy metals parameters were well Below the Quantification limits.

9.3 Conclusion

In the present study period marine water samples were analyzed and found inline as per Primary Water Quality criteria for class-IV WATERS (For Harbour Waters).

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 (NO3:10.0mg/kg, Cd: 1.0mg/kg, Hg: 1.0mg/kg, As: 1.0mg/kg).

Table 44 : Results of Analysis of Sediment of Kandla & Vadinar Port (Spring Tide)

Sr. No.	Parameters	Unit	DPA – 1	DPA - 2	DPA - 3	DPA - 4	DPA - 5	Jetty	SPM
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	0.91	0.50	1.52	0.37	0.27	1.45	1.68
3	Organic Carbon	mg/kg	0.52	0.29	0.87	0.21	0.15	0.83	0.97
4	Inorganic Phosphate	mg/kg	98.00	90.00	80.00	78.00	100.00	88.00	90.00
5	Moisture	%	17.00	8.70	15.00	6.60	4.80	14.24	13.14
6	Aluminum	mg/kg	ND	ND	ND	ND	ND	ND	ND
7	Silica	mg/kg	7.20	8.26	9.02	5.50	7.80	9.20	10.02
8	Phosphate	mg/kg	7.87	9.29	6.16	5.75	9.49	11.61	10.80
9	Sulphate	mg/kg	745.00	862.00	585.00	490.00	510.00	590.00	396.00
10	Nitrite	mg/kg	0.11	0.12	0.12	0.11	0.10	0.10	0.11
11	Nitrate	mg/kg	BQL	BQL	12.00	16.6	26.2	BQL	BQL
12	Calcium	mg/kg	1723.00	1057.00	1320.00	1220.00	1390.00	1907.00	1643.00
13	Magnesium	mg/kg	1044.00	716.00	1090.00	690.00	896.00	1563.00	2320.00
14	Sodium	mg/kg	2733.00	2720.00	2578.00	2107.00	1558.00	1042.00	952.00
15	Potassium	mg/kg	302.00	332.00	378.0	357.0	87.8	384.00	325.00
16	Chromium	mg/kg	38.00	24.40	51.70	16.10	60.00	48.90	69.20
17	Nickel	mg/kg	15.60	9.50	21.70	6.00	24.70	19.70	28.30
18	Copper	mg/kg	7.80	BQL	11.30	31.40	16.40	12.10	19.90
19	Zinc	mg/kg	30.10	21.90	35.70	13.70	44.90	31.50	51.90
20	Cadmium	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
21	Lead	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
22	Mercury	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
23	Arsenic	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL

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

9.2 Discussion of Marine Sediment samples

Marine Sediments of Deendayal Port Harbor waters, Khori and Nakti Creeks and two locations of Vadinar are monitored for various physico-chemical parameters during spring and neap tide of each month. The Heavy metal analyzed and found below quantification limit.

9.3 Conclusion

The sediment types are majority Sandy loamy. Also maximum heavy metals parameters found below Quantification limit wise, Pb, Cd, Hg , As, Al was not Detected and Nitrate for some locations.

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 01st November 2022 in harbour region of DPA at Kandla Creek, and on 02nd November 2022 in creeks near by the port during Neap tide. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 08th November, 2022 in harbour region of DPA at Kandla Creek and on 09th November, 2022 in creeks near by the port during spring tidal condition.

Plankton samples from sub surface layer was collected both during high tide period and low tide period from 3 water quality monitoring stations of DPA harbour area and two stations in Nakti creek and one station in Khori creek. Sampling at second sampling station of Nakti creek was possible only during high tide period.

Plankton samples from sub surface layer were collected during high tide period and low tide period from monitoring station near Vadinar Jetty at Path Finder Creek during Neap tide on 01/11/2022 and Spring tide period on 08/11/2022.Collected water samples were processed for estimation of Chlorophyll- a, Pheophytin- a, qualitative and quantitative evaluation of phytoplankton, qualitative and quantitative evaluation of zoo plankton density and their population.

TABLE 43. SAMPLING LOCATIONS

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

Sampling methodology adopted:

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

50 litres of the water sample were collected from Sub surface by using bucket. From the collected water sample 1 litres of water sample was taken in an opaque plastic bottle for chlorophyll estimation, thereafter plankton samples were collected by using filtration assembly with Nylobolt cloth of 20µm mesh size. . During low tide DPA-6 Nakti-II location monitoring was not possible due to non-availability of marine water.

Samples Processing for chlorophyll estimation:

Samples for chlorophyll estimation were preserved in ice box on board in darkness to avoid degradation in opaque container covered with aluminium foil. Immediately after reaching the shore after sampling, 1 litre of collected water sample was filtered through GF/F filters (pore size 0.45 µm) by using vacuum filtration assembly. After vacuum filtration the glass micro fiber filter paper was grunted in tissue grinder, macerating of glass fiber filter paper along with the filtrate was done in 90% aqueous Acetone in the glass tissue grinder with glass grinding tube. Glass fiber filter paper will assist breaking the cell during grinding and chlorophyll content was extracted with 10 ml of 90% Acetone, under cold dark conditions along with saturated magnesium carbonate solution in glass screw cap tubes. After an extraction period of 24 hours, the samples were transferred to calibrated centrifuge tubes and adjusted the volume to original volume with 90% aqueous acetone solution to make up the evaporation loss. The extract was clarified by using centrifuge in closed tubes. The clarified extracts were then decanted in clean cuvette and optical density was observed at wavelength 664, 665 nm. By using corrected optical density, Chlorophyll-a value was calculated as given in (APHA, 2017).

PLANKTON:

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

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

Pelagic zone, represents the entire ocean water column from the surface to the deepest depths, is home to a diverse community of organisms. Differences in their locomotive ability categorize the organisms in the pelagic realm into two, ***plankton*** and ***nekton*** (Lalli and Parsons, 1997). ***Plankton*** consists of all organisms drifting in the water and is unable to swim against water currents, whereas ***Nekton*** includes organisms having strong locomotive power. Ecological studies on the plankton community, which form the base of the aquatic food chain, help in the better understanding of the dynamics and

functioning of the marine ecosystem. The term 'Plankton' first coined by Victor Hensen (1887), Plankton, (Greek word: *planktos*meaning "passively drifting or wandering") is defined as drifting or free-floating organisms that inhabit the pelagic zone of water. Based on their mode of nutrition planktonic organisms are categorised into phytoplankton (organisms having an autotrophic mode of nutrition) and zooplankton (organisms having a heterotrophic mode of nutrition).

Phytoplankton in the marine environment:

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

The phytoplankton includes a wide range of photosynthetic and phototrophic organisms. Marine phytoplankton is mostly microscopic and unicellular floating flora, which are the primary producers that support the pelagic food-chain. The two most prominent groups of phytoplankton are Diatoms (Bacillariophyceae) and Dinoflagellates (Dinophyceae).The phytoplankton those normally captured in the net from the Gulf of Kutch is normally dominated by these two major groups; Diatoms and Dinoflagellates. Phytoplankton also include numerous and diverse collection of extremely small, motile algae which are termed micro flagellates (naked flagellates) as well as and Cyanophytes (Blue-green algae).

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

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

Zooplankton in the marine environment:

Zooplankton includes a taxonomically and morphologically diverse community of heterotrophic organisms that drift in the waters of the world's oceans. Qualitative and quantitative studies on zooplankton community are a prerequisite to delineate the ecological processes active in the marine ecosystem. Zooplankton community plays a pivotal role in the pelagic food web as the primary consumers of phytoplankton and act as the food source for organisms in the higher trophic levels, particularly the economically essential groups such as fish larvae and fishes. They also function in the cycling of elements in the marine ecosystem. The dynamics of the zooplankton community, their reproduction, and growth and survival rate are all significant factors determining the recruitment and

abundance of fish stocks as they form an essential food for larval, juvenile and adult fishes (Beaugrand et al., 2004). Zooplankton grazing in the marine environment controls the primary Production and helps in determining the pelagic ecosystem (Banse, 1995). Through grazing in surface waters and following the production of sinking faecal matters and also by the active transportation of dissolved and particulate matter to deeper waters via vertical migration, they help in the transport of organic carbon to deep ocean layers and thus act as key drivers of 'biological pump' in the marine ecosystem. Zooplankton grazing and metabolism also, transform particulate organic matter into dissolved forms, promoting primary producer community, microbial demineralization, and particle export to the ocean's interior.

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

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

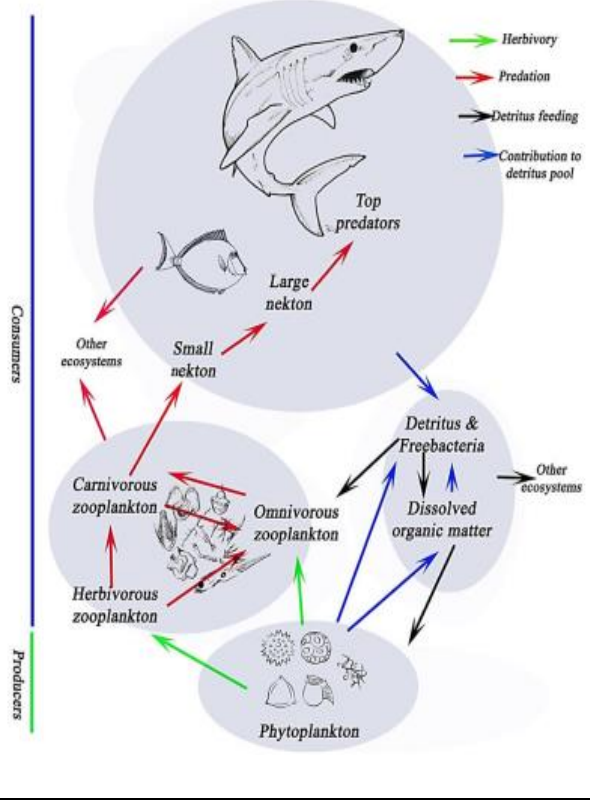
Zooplankton can be subdivided into holoplankton, i.e., permanent members of the plankton (e.g., Calanoid copepods), and meroplankton, i.e., temporary members in the plankton e.g., larvae of fish, shrimp, and crab). The meroplankton group consists of larval and young stages of animals that will adopt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

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

As their community structure and function are highly susceptible to changes in the environmental conditions regular monitoring of their distribution as well as their interactions with various physicochemical parameters is inevitable for the sustainable management of the ecosystem (Kusum et al., 2014). Of all the marine zooplankton groups, copepods mainly Calanoid copepods are the

dominant groups in marine subtropical and tropical waters and exhibit considerable diversity in morphology and habitats they occupy (Madhupratap, 1991 ;)

It has been well established that potential of pelagic fishes viz. finfishes, crustaceans, molluscs and marine mammals either directly or indirectly depend on zooplankton. The herbivorous zooplanktons are efficient grazers of the phytoplankton and are referred to as living machines transforming plant material into animal tissue. Hence they play an essential role as the intermediaries for nutrients/energy transfer between primary and tertiary trophic levels. Due to their large density, shorter lifespan, drifting nature, high group/species diversity and different tolerance to the stress, they used as the indicator organisms for the physical, chemical and biological processes in the aquatic ecosystem (Ghajbhiye, 2002).



Simplified marine food web

Spatial distribution of Plankton:

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

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

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

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

Methodology adopted for Plankton sampling:

Preservation and storage:

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

Sample concentration:

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

Taxonomic evaluation:

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

Cell counts by drop count method:

The common glass slide mounted with a 1ml of concentrated phytoplankton/zooplankton sample in glycerol and covered with cover slip 22 mm x 60 mm was placed under the compound microscope provided with a mechanical stage. The plankton was then counted from the microscopic field of the left top corner of the slide. Then slide is moved horizontally along the right side and plankton in each microscopic field was thus counted. When first microscopic field row was finished the next consecutive row was adjusted using the mechanical device of the stage. In this way all the plankton present in entire microscopic field are counted. From this total number in 1ml of the concentrated plankton, total amount of phytoplankton in the original volume of sample filtered was calculated as units/L and Zooplankton as N/m^3.

BENTHIC ORGANISMS:

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

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

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

SAMPLING METHODOLOGY ADOPTED FOR SUB TIDAL REGION:

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

Sample sieving:

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

Sample staining:

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

DIVERSITY INDICES:

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

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

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

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

Simpson's diversity index

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

The formula for calculating D is presented as:

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

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

N = the total number of organisms of all species

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

Low species diversity suggests:

- relatively few successful species in the habitat
- the environment is quite stressful with relatively few ecological niches and only a few organisms are really well adapted to that environment

- food webs which are relatively simple
- change in the environment would probably have quite serious effects

High species diversity suggests:

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

Species richness indices

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

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

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

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

Shannon-Wiener's index:

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

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

of polluted and unpolluted ecosystems, Wilham and Dorris (1968) concluded that the values of the index greater than

3 indicate clean water, values in the range of 1 to 3 are characterized by moderate pollution and values less than 1 are characterized as heavily polluted

10.2:- RESULTS:

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^3 with an average value 0.645 mg/m^3 in harbour region of DPA in Kandla Creek during sampling done in spring tide period of November 2022. In the nearby creeks chlorophyll-a was varying from 0.359-0.717 mg/m^3 with an average value 0.552 mg/m^3 Pheophytin –a level was below detectable limit- the all the sampling stations during springtide. Even though the plankton diversity and abundance were more during the spring tide sampling,the chlorophyll-content was detected lesser than expected because, the phytoplankton communities were mainly represented by diatoms *Skeletonema* sp. *Coscinodiscus sp.* and *Chaetoceros* sp.

In the sub surface water chlorophyll-a was varying from 0.338-0.547 mg/m^3 with an average value 0.437 mg/m^3 in harbour region of DPA in Kandla Creek during sampling done in Neap tide period of November2022. In the nearby creeks chlorophyll-a was varying from 0.205- 0.440mg/m^3 with an average value 0.370 mg/m^3. Pheophytin–a level was below detectable limit- the all the sampling stations. During neap tide sampling phytoplankton communities were mainly represented by *Coscinodiscus sp. and Ditylum sp.*

In the sub surface water chlorophyll-a was varying from 0.598-0.968 mg/m^3 in harbour region of DPA OOT in path finder Creek during sampling done in spring tide period of November 2022. In the sub surface water chlorophyll-a was varying from 0.709 - 0.987mg/m^3 in harbour region of DPA OOT in path finder Creek during sampling done in Neap Tide period of November 2022

TABLE:-45 VARIATIONS IN CHLOROPHYLL–a PHEOPHYTIN-a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPA HARBOUR AREA IN KANDLA CREEK ,NEAR BY CREEKS AND DPA OOT JETTY IN PATH FINDER CREEK AND SPM NEAR VADINARDURING SPRING TIDE IN NOVEMBER 2022

Sr. No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPA HARBOUR AREA KANDLA CREEK					
1	KPT1	High tide	0.969	BDL	64.92
		Low tide	0.647	BDL	43.35
2	KPT 2	High tide	0.511	BDL	34.24
		Low tide	0.521	BDL	34.91
3	KPT 3	High tide	0.749	BDL	50.18
		Low tide	0.472	BDL	31.62
CREEKS					
4	KPT-4 Khori-I	High tide	0.638	BDL	42.75
		Low tide	0.359	BDL	24.05
5	KPT-5 Nakti-I	High tide	0.717	BDL	48.04
		Low tide	0.493	BDL	33.03
6	KPT-6 Nakti-II	High tide	ND	ND	ND
PATHFINDER CREEK VADINAR					
7	VADINAR-I jetty	High tide	0.968	BDL	64.86
8		Low tide	0.732	BDL	49.04
9	SPM	High tide	0.953	BDL	63.85
10		Low tide	0.598	BDL	

BDL: Below Detectable Limit., ND: Not detected

TABLE:-46. VARIATIONS IN CHLOROPHYLL–a PHEOPHYTIN-a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPA HARBOUR AREA, NEAR BY CREEKS AND DPA OOT JETTY IN PATH FINDER CREEK AND SPM NEAR VADINARDURING NEAP TIDE IN NOVEMBER 2022

Sr.No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPA HARBOUR AREA KANDLA CREEK					
1	KPT1	High tide	0.547	BDL	
		Low tide	0.450	BDL	
2	KPT 2	High tide	0.338	BDL	
		Low tide	0.409	BDL	
3	KPT 3	High tide	0.354	BDL	
		Low tide	0.523	BDL	
CREEKS					
4	KPT-4 Khori-I	High tide	0.440	BDL	
		Low tide	0.408	BDL	
5	KPT-5 Nakti-I	High tide	0.205	BDL	
		Low tide	0.426	BDL	
6	KPT-6 Nakti-II	High tide	ND	ND	ND
PATHFINDER CREEK VADINAR					
7	VADINAR-I jetty	High tide	0.799	BDL	
8		Low tide	0.709	BDL	
9	SPM	High tide	0.857	BDL	
10		Low tide	0.987	BDL	

BDL: Below Detectable Limit.ND: Not detected

PHYTOPLANKTON POPULATION:

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

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by, Diatoms, blue green algae and Dinoflagellates during spring tide period. Diatoms were represented by 26 genera, Blue green algae were represented by 2 genera and Dinoflagellates were represented by 6 genera during the sampling conducted in spring tide in November, 2022. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 39-243units/ L during high tide period and115-199 units/L during low tide of Spring Tide. During spring tide sampling phytoplankton communities were dominated by *Skeletonema* sp almost forming a bloom in the Kandla creek and other nearby creek area and abundant population of *Coscinodiscus sp.* and *Chaetoceros* sp.

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by Diatoms, Blue green algae and DinoflagellatesduringNeap tide period. Diatoms were represented by 24 genera, Blue green algae were represented 2 genera and Dinoflagellates with 5 genera during the sampling conducted in Neap tide in November, 2022. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 43-299 units/ L during high tide period and 143-193 units/L during low tide of Neap Tide. During Neap tide sampling phytoplankton communities were dominated by, *Ditylum sp and Coscinodiscus sp.*

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

The phytoplankton community of the sub surface water in the path finder creeks was represented by Diatoms, Blue green algae and Dinoflagellates during spring tide period. Diatoms were represented by 25 genera, Blue Green algae by 5 genera and Dinoflagellates by 6 genera during the sampling conducted in spring tide in November, 2022. Phytoplankton of the sampling stations at sub surface path finder creek near OOT Jetty area was 209 units/L during high tide period and 177 units/L during low tide of Spring Tide. Phytoplankton of the sampling stations at sub surface layer in the SPM area was varying from 206 units/ L during high tide period and 131 units/ L during low tide of Spring Tide.

The phytoplankton community of the sub surface water in the path finder creeks was represented by Diatoms, Blue green and Dinoflagellates during Neap tide period. Diatoms were represented by 32 genera and Blue green algae by 4 genera and Dinoflagellates by 6 genera during the sampling conducted in Neap tide in November, 2022. Phytoplankton of the sampling stations at sub surface path finder creek near OOT Jetty was varying from 244units/ L during high tide period and 200

units/L during low tide of Neap Tide. Phytoplankton of the sampling stations at sub surface path finder creek near SPM area was varying from 259 units/L during high tide period and 294 units/L during low tide of Neap Tide.

Species Richness Indices and Diversity Indices:

Margalef's diversity index (Species Richness)

Margalef's diversity index (Species Richness) of phytoplankton communities in the Kandla creek and nearby creeks sampling stations was varying from 2.184- 4.688 with an average of 3.346 during the sampling conducted in High tide period of spring tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek region and nearby creeks was varying from1.963- 3.589 with an average of 2.835during the consecutive low tide period.

Margalef's diversity index (Species Richness) of phytoplankton communities in the stations in Kandla creek and nearby creeks was varying from 2.393-4.279 with an average of 3.586during the sampling conducted in High tide period of Neap tide. While Margalef's diversity index (Species Richness) of phytoplankton communities in the Kandla creek region and nearby creeks was varying from 2.821-3.86 with an average of 3.357during consecutive low tide.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations was 4.867 at OOT jetty area and 4.129 at SPM area during the sampling conducted in High tide period of spring tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the path finder creek near OOT jetty was 4.443 and 3.692 at SPM during the consecutive low tide period.

Margalef's diversity index (Species Richness) of phytoplankton communities in the stations was 4.73 at OOT jetty area and 4.139 at SPM area during the sampling conducted in High tide period of Neap tide. While Margalef's diversity index (Species Richness) of phytoplankton communities in the path finder creek near OOT jetty was 4.152 and SPM area was 5.454 during the consecutive low tide period.

Shannon-Wiener's index:

Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.786- 1.034 between selected sampling stations with an average value of 0.925 during high tide period of spring tideat Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.790-0.915 between selected sampling stations with an average value of 0.855 during consecutive low tide at Kandla creek and nearby creeks.

Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.867–1.022 between selected sampling stations with an average value of 0.932 during high tide period of neap tide at Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton

communities in the sampling stations was in the range of 0.926- 1.001 between selected sampling stations with an average value of 0.951during consecutive low tide at Kandla creek and nearby creeks.

Shannon-Wiener's Index (H) of phytoplankton communities in the stations was1.037 at OOT jetty area and 0.946 at SPM area during the sampling conducted in High tide period of spring tide. While Shannon-Wiener's Index (H) of phytoplankton communities in the path finder creek near OOT jetty was 1.043 and 0.982 at SPM during the consecutive low tide period of spring tide.

Shannon-Wiener's Index (H) of phytoplankton communities in the stations was 0.998 at OOT jetty area and1.035 at SPM area during the sampling conducted in High tide period of Neap tide. While Shannon-Wiener's Index (H) of phytoplankton communities in the path finder creek near OOT jetty was 0.942 and at SPM area was1.036 during the consecutive low tide period.

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

Simpson's diversity index:

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks, which was varying from 0.778-0.851 between selected sampling stations with an average of 0.823 during high tide period of spring tide. Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks except few, which was varying from 0.787-0.842 between selected sampling stations with an average of 0.814 during consecutive low tide.

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations except few in Kandla Harbour region and nearby creeks, during high tide period and low tide period during Neap tide also, which was varying from 0.813-0.874 with an average value of 0.847 between selected sampling stations during high tide period and 0.840-0.871 varying from with an average value of 0.858 between selected sampling stations during consecutive low tide period Low species diversity suggests a relatively few successful species in this habitat.

Simpson diversity index (1-D) of phytoplankton communities in the stations was0.863 at OOT jetty area and 0.820 at SPM area during the sampling conducted in High tide period of spring tide at Path finder creek. While Simpson diversity index (1-D) of phytoplankton communities in the path finder creek near OOT jetty was 0.876 and 0.867 at SPM during the consecutive low tide period in the path finder creek.

Simpson diversity index (1-D) of phytoplankton communities in the stations was 0.838 at OOT jetty area and 0.881 at SPM area during the sampling conducted in High tide period of Neap tide at Path

finder Creek. While Simpson diversity index (1-D) of phytoplankton communities in the path finder creek near OOT jetty was 0.832 and at SPM area was 0.867 during the consecutive low tide period.

Table:-47 4PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND , NEAR BY CREEKS DURING SPRING TIDE IN NOVEMBER 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% Of diversity	Margalef's diversity index (Species Richness)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	207	26/34	76.47	4.688	1.034	0.8511
	2	183	22/34	64.71	4.031	1.005	0.8437
	3	193	13/34	38.24	2.28	0.811	0.7778
	4	243	18/34	52.94	3.095	0.9391	0.8192
	5	193	21/34	61.76	3.8	0.9777	0.8281
	6	39	9/34	26.47	2.184	0.786	0.8178
LOW TIDE	1	178	14/34	41.18	2.509	0.8042	0.787
	2	199	20/34	58.82	3.589	0.8982	0.8075
	3	115	14/34	41.18	2.74	0.8696	0.8365
	4	154	18/34	52.94	3.375	0.915	0.8416
	5	163	11/34	32.35	1.963	0.7895	0.7957

Table:-48 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND NEAR BY CREEKS DURING NEAP TIDE IN NOVEMBER 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	216	24/31	77.42	4.279	0.98	0.8568
	2	229	22/31	70.97	3.865	0.958	0.853
	3	228	22/31	70.97	3.868	1.022	0.8743
	4	299	23/31	74.19	3.859	0.8667	0.8127
	5	254	19/31	61.29	3.251	0.8929	0.8307
	6	43	10/31	32.26	2.393	0.8712	0.8571
LOW TIDE	1	183	18/31	58.06	3.263	0.9504	0.8636
	2	143	15/31	48.39	2.821	0.946	0.8666
	3	178	21/31	67.74	3.86	1.001	0.8708
	4	193	19/31	61.29	3.42	0.931	0.84
	5	193	19/31	61.29	3.42	0.9259	0.8469

Table:-49 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND, NEAR BY CREEKS DURING SPRING TIDE IN NOVEMBER2022

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Species Composition % (Group level)
HIGH TIDE	Sub surface	6	BLUE GREEN ALGAE	0-8	2/34	5.88
			DIATOMS	38-238	26/34	76.47
			DINOFLAGELLATES	0-11	6/34	17.65
			TOTAL PHYTO PLANKTON	**39-243**	**34**	
LOW TIDE	Sub surface	5	BLUE GREEN ALGAE	1-6	2/34	5.88
			DIATOMS	110-190	26/34	76.47
			DINOFLAGELLATES	1-7	6/34	17.65
			TOTAL PHYTO PLANKTON	**115-199**	**34**	

TABLE:-50 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND, NEAR BY CREEKS DURING NEAP TIDE IN NOVEMBER 2022

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Species Composition % (Group level)
HIGH TIDE	Sub surface	6	BLUE GREEN ALGAE	0-6	2/31	6.45
			DIATOMS	43-293	24/31	77.42
			DINOFLAGELLATES	0-9	5/31	16.13
			TOTAL PHYTO PLANKTON	**43-299**	**31**	
LOW TIDE	Sub surface	5	BLUE GREEN ALGAE	2-6	2/31	6.45
			DIATOMS	133-186	24/31	77.42
			DINOFLAGELLATES	3-8	5/31	16.13
			TOTAL PHYTO PLANKTON	**143-193**	**31**	

TABLE:-51 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA OOT AT PATH FINDER CREEK , VADINAR &NEAR BY SPM, DURING SPRING TIDE IN NOVEMBER 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	209	27/36	75.00	4.867	1.037	0.863
	SPM	206	23/36	63.89	4.129	0.946	0.820
LOW TIDE	Jetty	177	24/36	66.67	4.443	1.043	0.876
	SPM	131	19/36	52.78	3.692	0.982	0.867

TABLE:-52 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING NEAP TIDE IN NOVEMBER 2022

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	244	27/42	64.29	4.73	0.998	0.838
	SPM	259	24/42	57.14	4.139	1.035	0.881
LOW TIDE	Jetty	200	23/42	54.76	4.152	0.942	0.832
	SPM	294	32/42	76.19	5.454	1.036	0.867

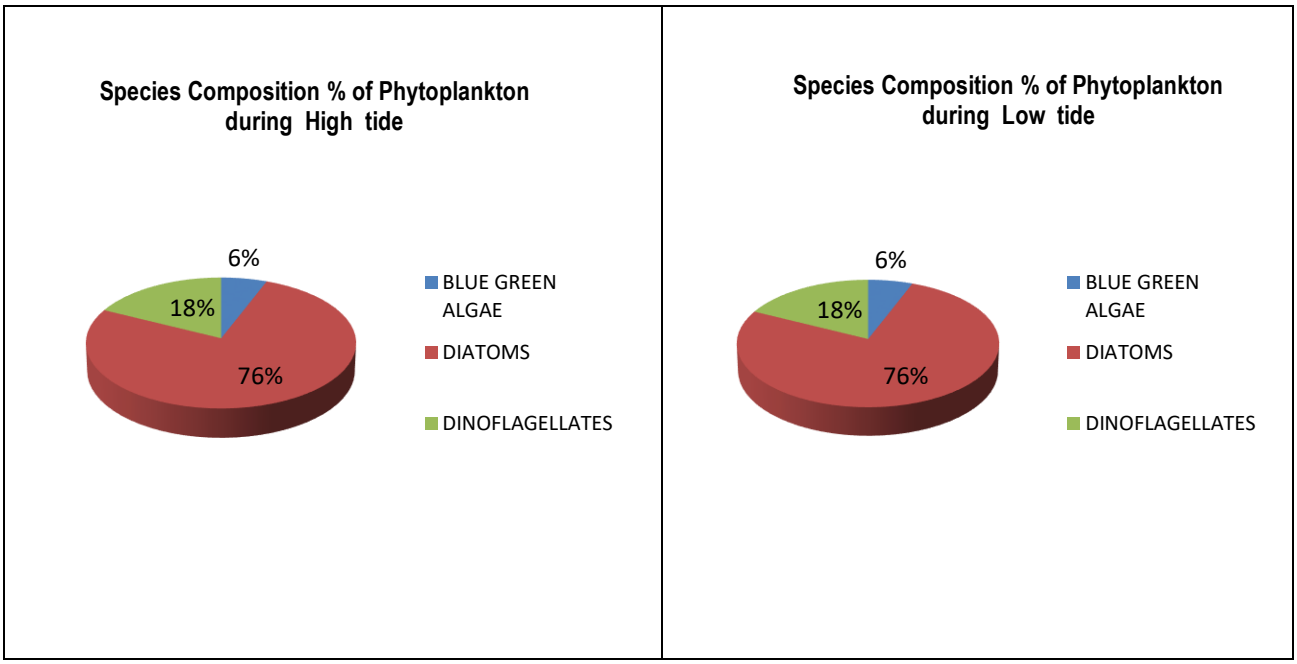
TABLE:-53 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPAOOT AT PATH FINDER CREEK, VADINAR & NEAR BY SPM, DURING SPRING TIDE IN NOVEMBER 2022

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	BLUE GREEN ALGAE	14-20	5/36	13.89
			DIATOMS	180-192	25/36	69.44
			DINOFLAGELLATES	3-6	6/36	16.67
			TOTAL PHYTO PLANKTON	**206-209**	**36**	
LOW TIDE	Sub surface	2	BLUE GREEN ALGAE	12-19	5/36	13.89
			DIATOMS	118-156	25/36	69.44
			DINOFLAGELLATES	1-2	6/36	16.67
			TOTAL PHYTO PLANKTON	**131-177**	**36**	

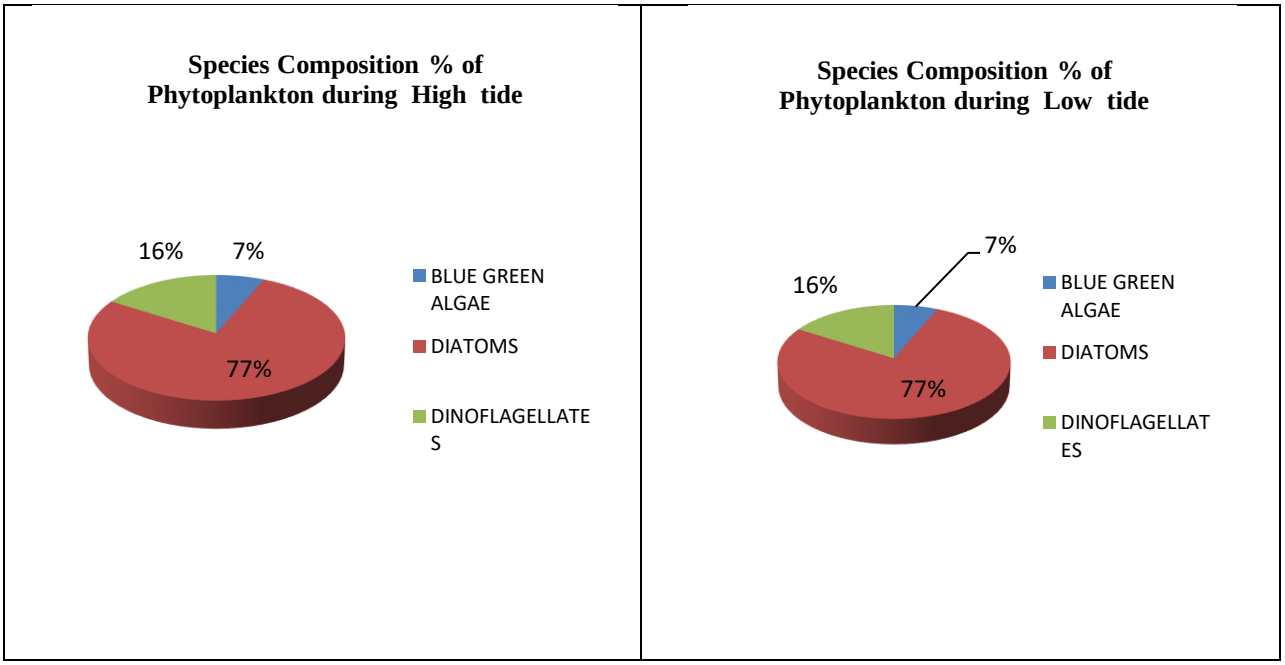
Table:- 54 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPA OOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING NEAP TIDE IN NOVEMBER 2022

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Species Composition % (Group level)
HIGH TIDE	Sub surface	2	BLUE GREEN ALGAE	5-7	4/42	9.52
			DIATOMS	238-248	32/42	76.19
			DINOFLAGELLATES	1-4	6/42	14.29
			TOTAL PHYTO PLANKTON	**244-259**		
LOW TIDE	Sub surface	2	BLUE GREEN ALGAE	4-8	4/42	9.52
			DIATOMS	194-282	32/42	76.19
			DINOFLAGELLATES	2-4	6/42	14.29
			TOTAL PHYTO PLANKTON	**200-294**		

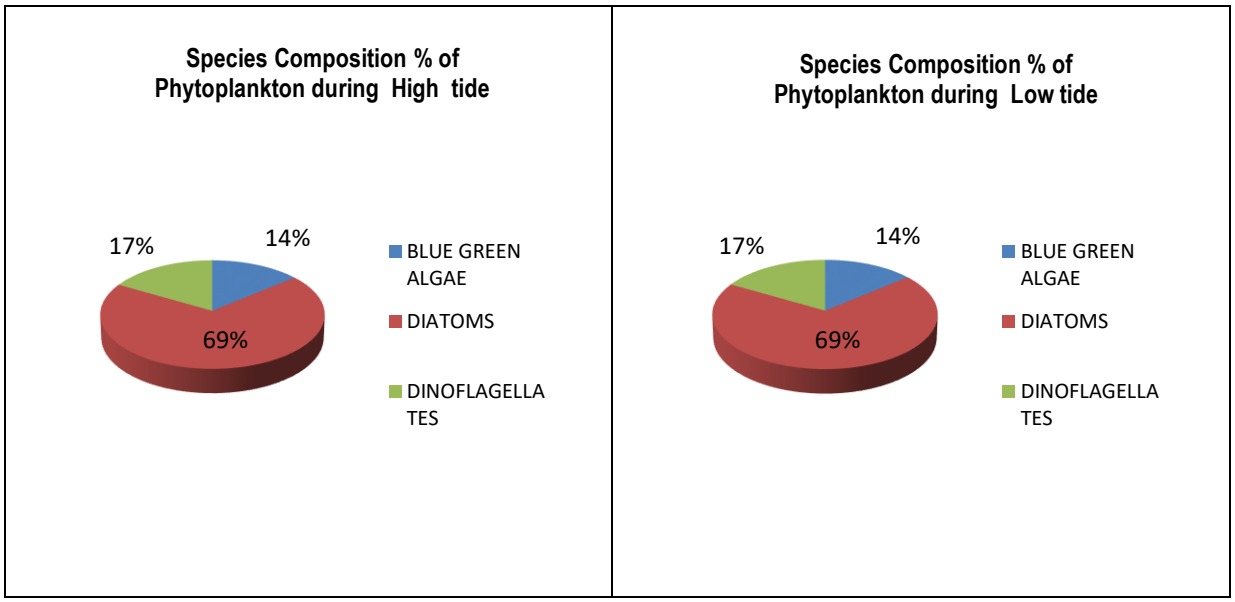
Species Composition % of Phytoplankton during High tide and Low tide period during spring tide in Kandla creek and nearby creeks



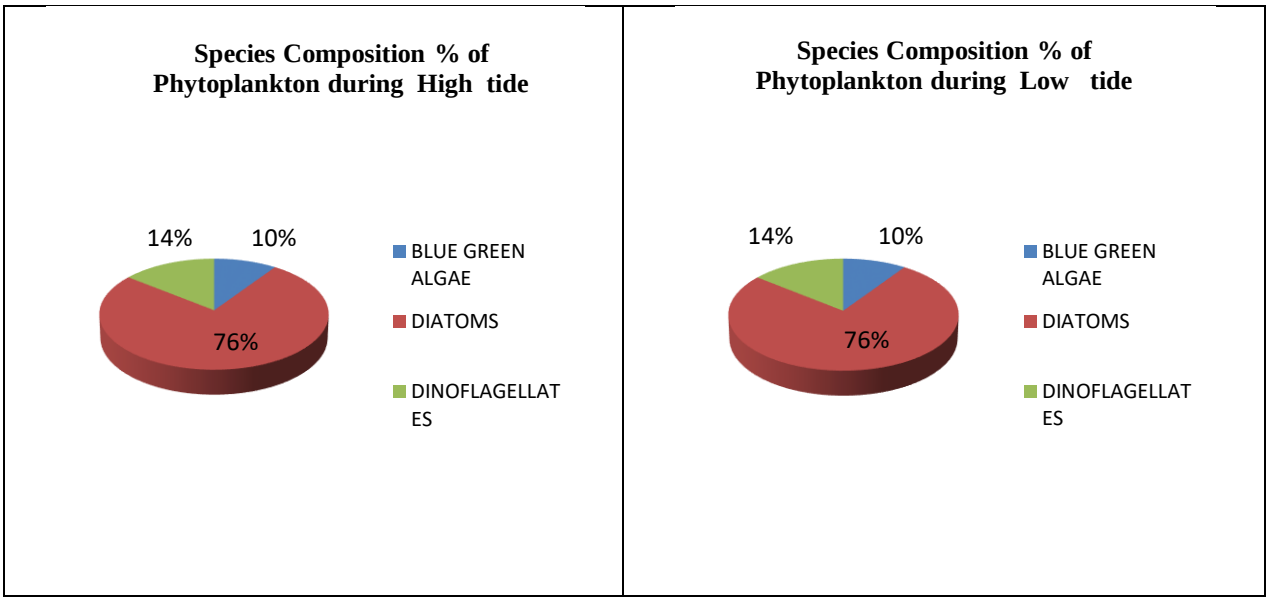
Species Composition % of Phytoplankton during High tide and Low tide period during Neap tide in Kandla creek and nearby creeks



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



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



ZOOPLANKTON POPULATION:

For the evaluation of the Zooplankton population in DPA harbour area and within the immediate surroundings of the port sampling was conducted from 6 sampling locations (3 in harbour area and two in Nakti creek and one in Khoricreek) during high tide period and low tide period of spring tide and Neap tide in November, 2022. The Zooplankton community of the sub surface water in the harbour and nearby creeks during spring tide was representedby mainly six groups;Tintinnids, Copepods,Arrow worms,Mysids, Urochordata,Ciliates and 8 larval forms.The Zooplankton community of the sub surface water in the harbour and nearby creeks during neap tide was represented by mainly six groups;Tintinnids, Copepods,Arrow worms, Mysids, Urochordata, Ciliatesand 6 larval forms.

Zooplankton of the sampling stations at sub surface layer in the DPA harbour area and nearby creek was varying from 25-128 $x10^3$ N/m^3 during high tide and 103-144$x10^3$ N/m^3 during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPA harbour area and nearby creek was varying from 19-114$x10^3$ N/m^3 during high tide and 76-106$x10^3$ N/ m^3 during low tide of Neap Tide period.

For the evaluation of the Zooplankton population in DPA OOT jetty area in Path Finder creek and SPM in Vadinar selected 2 sampling locations (1 in jetty area and one near SPM).

During spring tide sampling plankton sample were collected at Jetty area and near SPM during consecutive high tide period and low tide period. During Neap tide sampling Plankton samples were collected from jetty area and SPM during consecutive high tide period and low tide period.

The Zooplankton community of the sub surface water in the path finder creek during spring tide was represented by mainly four groups Tintinnids, Copepods, Urochordata, Ciliatesand 4 larval forms. While the Zooplankton community of the sub surface water in the path Finder creeks at Jetty region and SPM during neap tide was represented by four groups, Tintinnids, Copepods, Arrow worms, Urochordataand 5 larval forms.

Zooplankton of the sampling stations at sub surface layer in the DPA OOT Jetty area of path finder creek was 91$x10^3$ N/m^3 during high tide and 86$x10^3$ N/m^3 during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPA SPM area of path finder creek was 101$x10^3$ N/m^3 during high tide and 70$x10^3$ N/ m^3 during low tide of spring Tide period.

Zooplankton of the sampling stations at sub surface layer in the DPA OOT jetty area in path finder creek was recorded 87$x10^3$ N/m^3 during high tide and 65$x10^3$ N/ m^3 during consecutive low tide period of Neap tide. Zooplankton of the sampling stations at sub surface layer in the DPASPM area in path finder creek was recorded 64$x10^3$ N/m^3during high tide and 87$x10^3$ N/ m^3 during consecutive low tide period of Neap Tide.

Species Richness Indices and Diversity Indices:

Margalef's diversity index (Species Richness)

Margalef's diversity index (Species Richness) of Zooplankton communities in the stations Kandla creek region and nearby creeks was varying from 2.175- 5.186 with an average of 3.450 during the sampling conducted in High tide period. Margalef's diversity index (Species Richness) of Zooplankton communities varying from 2.373-3.823 with an average of 3.261 during the sampling conducted in low tide period during Spring tide.

Margalef's diversity index (Species Richness) of Zooplankton communities in the Kandla creek region and nearby creeks sampling stations were varying from1.358-3.858 with an average of 2.930 during the sampling conducted in high tide and varying from 2.289- 4.618 with an average of 3.513 during the sampling conducted in low tide during Neap tide period.

Margalef's diversity index (Species Richness) of Zooplankton communities in the sampling stationnear jettyat Path Finder Creek, Vadinar during the sampling conducted inconsecutive high tide period and low tide of spring tide was recorded as 1.995 and 1.796 respectively. Margalef's diversity index (Species Richness) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive high tide period and low tide of spring tide was recorded as 2.600 and 2.118 respectively.

Margalef's diversity index (Species Richness) of Zooplankton communities near Jetty at Path finder creek were varying from 3.807 and 2.396 respectivelyduring the sampling conducted in consecutive high tide period and Low tide period of Neap tide. While Margalef's diversity index (Species Richness) of Zooplankton communities near SPM at Path finder creek were varying from 2.645-3.135 respectively during the consecutive high tide and low tide period.

Shannon-Wiener's index:

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.778-1.164 between selected sampling stations with an average value of0.939 during high tide period of spring tide. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.795-1.015 between selected sampling stations with an average value of0.938 during consecutive low tide period.

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.490-0.914 between selected sampling stations with an average value of 0.805 during high tide period of Neap tide. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range 0.797-1.041 of between selected sampling stations with an average value of 0.928 during consecutive low tide period.

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.816-0.793 respectively. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.834-0.808 respectively.

Shannon-Wiener's Index (H) of Zooplankton communities near jetty at Path finder creek was varying from 0.956-0.755 respectively during the sampling conducted consecutive high tide period and low tide period of Neap tide. While Shannon-Wiener's Index (H) of Zooplankton communities near SPM at Path finder creek was varying from 0.775-0.751during the consecutive high tide and low tide period.

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

Simpson's diversity index:

Simpson diversity index (1-D) of Zooplankton communities was below 0.9 most of sampling stations in the Kandla Harbour region and nearby creeks during high tide and low tide of spring tide period except few stations, which was varying from 0.780-0.909 between selected sampling stations with an average of 0.837 during high tide period and was varying from 0.785- 0.864 with an average value of 0.837 between selected sampling stations during low tide.

Simpson diversity index (1-D) of Zooplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks during high tide and low tide period of Neap tide except few, which was varying from 0.591-0.827 between selected sampling stations with an average of 0.753 during high tide period and was varying from 0.793-0.852 with an average value of 0.820 between selected sampling stations during consecutive low tide. This species diversity suggests a relatively few successful species in this habitat during November, 2022 sampling.

Simpson diversity index (1-D) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.821 and 0.815 respectively. Simpson diversity index (1-D) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.812 and 0.828 respectively.

Simpson diversity index (1-D) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of Neap tide was recorded as 0.836- 0.766 respectively. Simpson diversity index (1-D) of Zooplankton communities in the sampling station near SPM at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.768 and 0.719 respectively.

TABLE:-55 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA HARBOUR AREA AT KANDLA CREEK AND NEAR BY CREEKS DURING SPRING TIDEIN NOVEMBER 2022

Tide	Sampling Station	Abundance In $Nx10^3/m^3$	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	124	26/33	78.79	5.186	1.164	0.9089
	2	114	18/33	54.55	3.589	0.8655	0.7802
	3	102	16/33	48.48	3.243	0.9207	0.8189
	4	128	17/33	51.52	3.298	0.9062	0.8124
	5	107	16/33	48.48	3.21	0.997	0.8686
	6	25	8/33	24.24	2.175	0.7777	0.83
LOW TIDE	1	117	16/33	48.48	3.15	0.9709	0.8609
	2	144	20/33	60.61	3.823	0.9468	0.8238
	3	121	19/33	57.58	3.753	1.015	0.8639
	4	108	16/33	48.48	3.204	0.9609	0.8505
	5	103	12/33	36.36	2.373	0.7949	0.7853

TABLE:-56 ZOOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA HARBOUR AREAAT KANDLA CREEK AND NEAR BY CREEKS DURING NEAP TIDE INNOVEMBER 2022

Tide	Sampling Station	Abundance In No $x10^3/m^3$	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	82	18/32	56.25	3.858	0.9017	0.7814
	2	99	16/32	50.00	3.264	0.9138	0.8273
	3	89	13/32	40.63	2.673	0.8264	0.7763
	4	114	18/32	56.25	3.589	0.8478	0.7645
	5	98	14/32	43.75	2.835	0.8503	0.7766
	6	19	5/32	15.63	1.358	0.4901	0.5906
LOW TIDE	1	79	11/32	34.38	2.289	0.797	0.7932
	2	76	21/32	65.63	4.618	1.041	0.8516
	3	106	21/32	65.63	4.289	1.026	0.8446
	4	90	15/32	46.88	3.111	0.9087	0.8177
	5	100	16/32	50.00	3.257	0.865	0.7939

Table:-57 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA HARBOUR AREAATKANDLA CREEK AND NEAR BY CREEKS DURING SPRING TIDE IN NOVEMBER 2022

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^3/ m^3$ Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	tintinnids	9-26	11/33	33.33
			Copepods	11-51	9/33	27.27
			Arrow worms	0-1	1/33	3.03
			Mysids	0-2	1/33	3.03
			Urochordata	1-6	2/33	6.06
			Ciliates	0-2	1/33	3.03
			Larval forms	4-50	8/33	24.25
			TOTAL ZOOPLANKTON N/ M^3	**25-128**	**33**	
LOW TIDE	Sub surface	5	Tintinnids	18-33	11/33	33.33
			Copepods	37-49	9/33	27.27
			Arrow worms	0-4	1/33	3.03
			Mysids	0-2	1/33	3.03
			Urochordata	0-2	2/33	6.06
			Ciliates	0-2	1/33	3.03
			Larval forms	41-65	8/33	24.25
			TOTAL ZOOPLANKTON N/M^3	**103-144**	**33**	

TABLE:-58 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA HARBOUR AREA IN KANDLA CREEK AND, NEAR BY CREEKS DURING NEAP TIDE IN NOVEMBER 2022

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^{3}/ m^{3}$ Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinnids	0-14	10/32	31.25
			Copepods	6-49	10/32	31.25
			Arrow worms	0	1/32	3.13
			Mysids	0-6	2/32	6.25
			Urochordata	0-4	2/32	6.25
			Ciliates	0-2	1/32	3.13
			Larval forms	13-50	6/32	18.74
			TOTAL ZOOPLANKTON N/M^3	**19-114**	**32**	
LOW TIDE	Sub surface	5	tintinnids	4-17	10/32	31.25
			Copepods	25-45	10/32	31.25
			Arrow worms	0-2	1/32	3.13
			Mysids	0-6	2/32	6.25
			Urochordata	0-5	2/32	6.25
			Ciliates	0-1	1/32	3.13
			Larval forms	27-47	6/32	18.74
			TOTAL ZOOPLANKTON N/M^3	**76-106**	**32**	

Table:-59 ZOOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING SPRING TIDE IN NOVEMBER 2022

Tide	Sampling Station	Abundance In $x10^{3}N / m^{3}$	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	91	10/20	50.00	1.995	0.816	0.821
	SPM	101	13/20	65.00	2.6	0.834	0.812
LOW TIDE	Jetty	86	9/20	45.00	1.796	0.793	0.815
	SPM	70	10/20	50.00	2.118	0.808	0.828

TABLE:-60 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPA OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURINGNEAP TIDE IN NOVEMBER 2022

Tide	Sampling Station	Abundance In N$x10^3/m^3$	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	87	18/21	85.71	3.807	0.956	0.836
	SPM	64	12/21	57.14	2.645	0.775	0.768
LOW TIDE	Jetty	65	11/21	52.38	2.396	0.755	0.766
	SPM	87	15/21	71.43	3.135	0.751	0.719

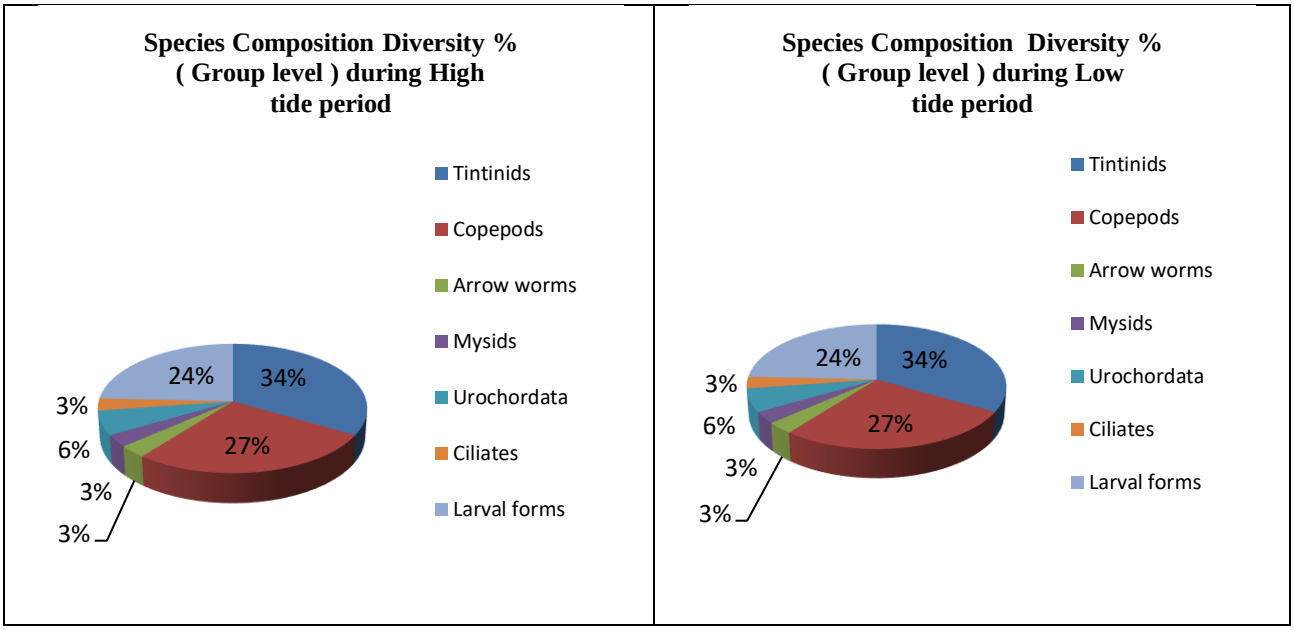
Table:-61 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA OOT AREAAND PATH FINDER CREEK AND NEAR BY SPM DURING SPRING TIDE IN NOVEMBER 2022

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^3/m^3$ Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	Tintinnids	24-32	5/20	25.00
			Copepods	28-38	8/20	40.00
			Urochordata	1-2	2/20	10.00
			Ciliates	0-1	1/20	5.00
			Larval forms	30-36	4/20	20.00
			TOTAL ZOOPLANKTON	**91-101**	**20**	
LOW TIDE	Sub surface	2	Tintinnids	17-21	5/20	25.00
			Copepods	30-37	8/20	40.00
			Urochordata	0	2/20	10.00
			Ciliates	0	1/20	5.00
			Larval forms	19-32	4/20	20.00
			TOTAL ZOOPLANKTON	**70-86**	**20**	

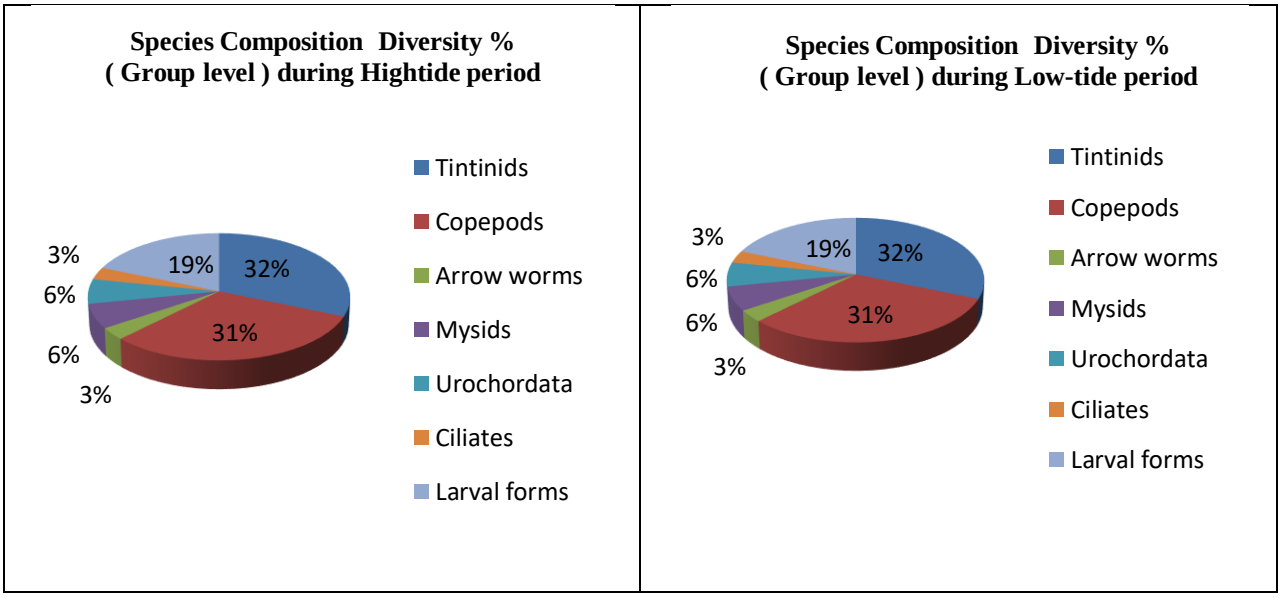
TABLE:-62 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING NEAP TIDE IN NOVEMBER 2022

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^3/ m^3$ Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	tintinnids	9-16	7/21	33.33
			Copepods	23-34	6/21	28.57
			Arrow worms	0	1/21	4.76
			Urochordata	0-2	2/21	9.52
			Larval forms	32-35	5/21	23.82
			TOTAL ZOOPLANKTON	**64-87**	**21**	
LOW TIDE	Sub surface	2	tintinnids	6-9	7/21	33.33
			Copepods	29	6/21	28.57
			Arrow worms	0-1	1/21	4.76
			Urochordata	0-3	2/21	9.52
			Larval forms	27-48	5/21	23.82
			TOTAL ZOOPLANKTON	**65-87**	**21**	

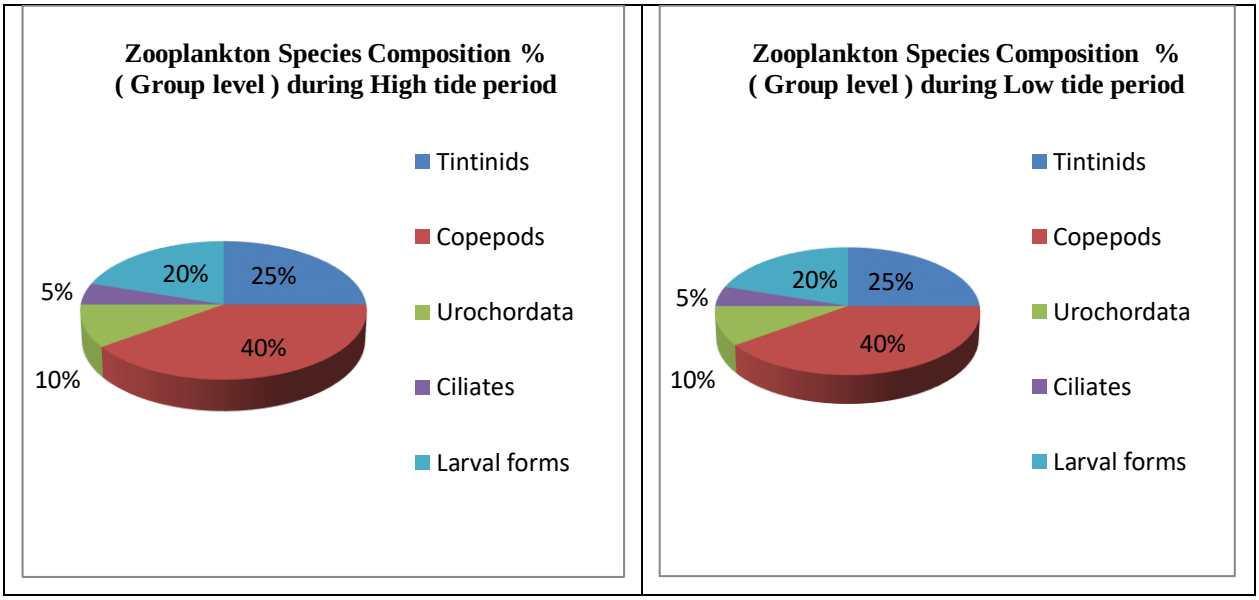
Species Composition % of Zooplankton during High tide and Low tide period of spring tide In Kandla Creek and nearby Creeks



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



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



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

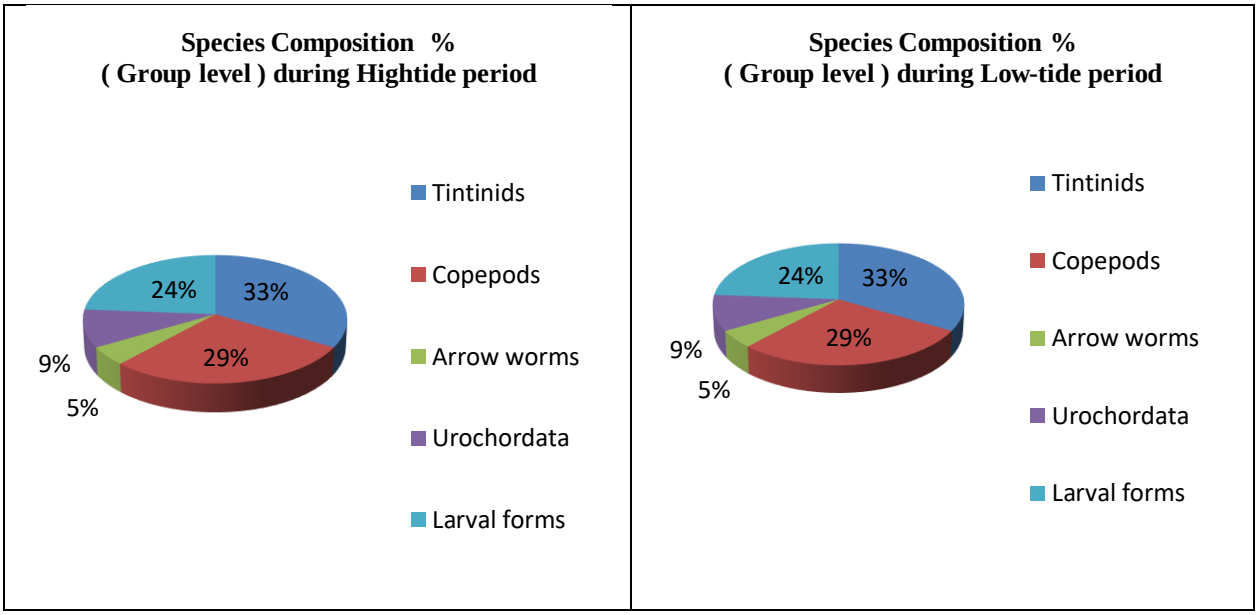


TABLE:-63 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS OF DPA HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING NEAP TIDE OF NOVEMBER 2022

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
Cyanophyceae	Nostocales	Oscillatoriaceae	*Oscillatoria sp.*	B1	Very sparse
	Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B2	Very sparse
Coscinodiscophyceae	Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D1	Abundant
	Chaetocerotales	Chaetocerotaceae	*Bacteriastrum sp*	D2	Very sparse
			Chaetoceros sp.	D3	Scattered
	Corethrales	Corethraceae	*Corethron* sp	D4	Very sparse
	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D5	Dominant
	Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D6	Very sparse
		Streptothecaceae	*Helicotheca sp*	D7	Very sparse
	Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D8	Sparse
	Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D9	Dominant
	Thalassiosirales	Thalassiosiraceae	*Planktoniella*sp	D10	Very sparse
		Skeletonemataceae	*Skeletonema*sp	D11	Abundant
	Triceratiales	Triceratiaceae	*Odontella* sp.	D12	Very sparse
			Triceratium sp.	D13	Very sparse
Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria* sp.	D14	Very sparse
			Nitzschia sp	D15	Sparse
			Pseudo-nitzschia sp.	D16	Very sparse
	Naviculales	Pleurosigmataceae	*Pleurosigma* sp.	D17	Very sparse
	Surirellales	Entomoneidaceae	*Entomoneis sp.*	D18	Very sparse
Fragilariophyceae	Fragilariales	Fragilariaceae	*Asterionellopsis sp*	D19	Scattered
			*Fragilaria*sp	D20	Very sparse
			*Synedra*sp	D21	Very sparse

	Striatellales	Striatellaceae	*Grammatophora sp*	D22	Very sparse
	Thalassionematales	Thalassionemataceae	*Thalassionema sp.*	D23	Sparse
			Thalassiothrix sp.	D24	Very sparse
Noctilucea / Noctiluciphyceae (Dinokaryota)	Noctilucales	Noctilucaceae	*Noctiluca* sp.	DF1	Sparse
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF2	Very sparse
	Gonyaulacales	Pyrophacaceae	*Pyrophacus sp.*	DF3	Very sparse
		Ceratiaceae	*Ceratium furca*	DF4	Very sparse
			Ceratium tripos	DF5	Very sparse

TABLE:-64 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPA HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING SPRING TIDE OF NOVEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
Cyanophyceae	Nostocales	Oscillatoriaceae	*Oscillatoria sp.*	B1	Very sparse
	Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B2	Very sparse
Coscinodiscophyceae	Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D1	Sparse
	Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp.	D2	Abundant
	Corethrales	Corethraceae	*Corethron* sp	D3	Very sparse
	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D4	Abundant
	Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D5	Sparse
	Leptocylindrales	Leptocylindraceae	*Leptocylindrus sp*	D6	Very sparse
	Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D7	Scattered
	Thalassiosirales	Thalassiosiraceae	*Planktoniella*sp	D8	Very sparse
		Lauderiaceae	*Lauderia* sp	D9	Very sparse
		Skeletonemataceae	*Skeletonema*sp	D10	Dominant
	Triceratiales	Triceratiaceae	*Odontella* sp.	D11	Very sparse
			Triceratium sp.	D12	Very sparse
Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria* sp.	D13	Very sparse
			Nitzschia sp	D14	Very sparse
			Pseudo-nitzschia sp.	D15	Very sparse
	Naviculales	Naviculaceae	*Navicula* sp.	D16	Very sparse
		Plagiotropidaceae	*Plagiotropis sp*	D17	Very sparse
		Pleurosigmataceae	*Pleurosigma* sp.	D18	Sparse
	Surirellales	Entomoneidaceae	*Entomoneis sp.*	D19	Very sparse
		Surirellaceae	*Surirella sp.*	D20	Very sparse
Fragilariophyceae	Fragilariales	Fragilariaceae	*Asterionellopsis sp*	D21	Sparse

			*Fragilaria*sp	D22	Very sparse
			*Synedra*sp	D23	Sparse
	Striatellales	Striatellaceae	*Grammatophora sp*	D24	Very sparse
	Thalassionematales	Thalassionemataceae	*Thalassionema sp.*	D25	Scattered
			Thalassiothrix sp.	D26	Sparse
Noctilucea / Noctiluciphyceae (Dinokaryota)	Noctilucales	Noctilucaceae	*Noctiluca* sp.	DF1	Sparse
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF2	Very sparse
	Gonyaulacales	Ceratiaceae	*Ceratium breve*	DF3	Very sparse
			Ceratium furca	DF4	Very sparse
			Ceratium fusus	DF5	Very sparse
			Ceratium tripos	DF6	Very sparse

TABLE:-65 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPA OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINARDURING NEAP TIDE OF NOVEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
Cyanophyceae	Nostocales	Oscillatoriaceae	*Lyngbya sp.*	B1	Very sparse
			Oscillatoria sp.	B2	Very sparse
			Spirulina sp.	B3	Very sparse
	Oscillatoriales	Phormidiaceae	*Planktothrix sp.*	B4	Very sparse
Coscinodiscophyceae	Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D1	Scattered
	Chaetocerotales	Chaetocerotaceae	*Chaetoceros*sp	D2	Scattered
	Corethrales	Corethraceae	*Corethron* sp	D3	Very sparse
	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D4	Dominant
	Hemiaulales	Bellerocheaceae	*Bellerochea*sp	D5	Very sparse
		Hemiaulaceae	*Cerataulina sp.*	D6	Very sparse
			Eucampia sp	D7	Very sparse
		Streptothecaceae	*Helicotheca sp*	D8	Very sparse
	Leptocylindrales	Leptocylindraceae	*Leptocylindrus sp*	D9	Very sparse
	Lithodesmiales	Lithodesmiaceae	*Ditylumsp*	D10	Abundant
	Rhizosoleniales	Rhizosoleniaceae	*Dactyliosolen sp.*	D11	Very sparse
			Rhizosolenia sp.	D12	Sparse
	Thalassiosirales	Skeletonemataceae	*Skeletonema sp.*	D13	Abundant
		Lauderiaceae	*Lauderia sp*	D14	Very sparse
		Thalassiosiraceae	*Planktoniella*sp	D15	Very sparse
	Triceratiales	Triceratiaceae	*Odontellasp*	D16	Very sparse
			*Triceratium*sp	D17	Very sparse
Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria*sp.	D18	Abundant
			Nitzschia sp	D19	Very sparse

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

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

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

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

TABLE:-67 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPA HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKSDURING NEAP TIDE OF NOVEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnussp.*	T1	Very sparse
		Codonellidae	*Tintinnopsis dadayi*	T2	Very sparse
			Tintinnopsisfailakkaensis	T3	Very sparse
			Tintinnopsis gracilis	T4	Very sparse
			Tintinnopsis mortensenii	T5	Very sparse
			Tintinnopsis radix	T6	Very sparse
			Tintinnopsis tocantinensis	T7	Very sparse
		Tintinnidae	*Amphorellopsis sp.*	T8	Very sparse
			Eutintinnus sp.	T9	Very sparse
		Xystonellidae	*Favella sp.*	T10	Very sparse
Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Sparse
			Parvocalanus sp.	C2	Very sparse
		Acartiidae	*Acartia sp.*	C3	Very sparse
		Clausocalanidae	*Clausocalanus sp.*	C4	Very sparse
		Centropagidae	*Centropages sp.*	C5	Very sparse
		Temoridae	*Temora sp.*	C6	Very sparse
	Cyclopoida	Oithonidae	*Oithona sp.*	C7	Abundant
	Harpacticoida	Ectinosomatidae	*Microsetella*sp.	C8	Scattered
		Euterpinidae	*Euterpina sp.*	C9	Sparse
	Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C10	Very sparse
Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse
Malacostraca	Mysida, Decapoda	Penaeidae	*Metapenaeussp.*	M1	Very sparse
		Solenoceridae	*Solenocera sp.*	M2	Very sparse

Appendicularia		Fritillariidae	*Fritillaria sp.*	U1	Very sparse
		Oikopleuridae	*Oikopleura sp.*	U2	Very sparse
Oligohymenophorea	Sessilida	Zoothamniidae	*Zoothamnium sp.*	CI1	Very sparse
Copepoda			Nauplius larvae of copepods	L1	Dominant
Malacostraca Decapoda			Brachyuran zoea	L2	Very sparse
Maxillopoda Thecostraca			Cirripede larvae	L3	Very sparse
			Cyphonautes larvae	L4	Very sparse
			Ophiopluteus larvae	L5	Very sparse
Polychaeta			Trochophore larvae	L6	Very sparse

TABLE:-68 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING OF DPA HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKSDURING SPRING TIDE OF NOVEMBER 2022:

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

Appendicularia		Fritillariidae	*Fritillaria sp.*	U1	Very sparse
		Oikopleuridae	*Oikopleura sp.*	U2	Very sparse
Oligohymenophorea	Sessilida	Zoothamniidae	*Zoothamnium sp.*	CI1	Very sparse
Copepoda			Nauplius larvae of copepods	L1	Dominant
Malacostraca Decapoda			Brachyuran zoea	L2	Sparse
Maxillopoda Thecostraca			Cirripede larvae	L3	Very sparse
			Cyphonautes larvae	L4	Very sparse
			Ophiopluteus larvae	L5	Very sparse
Gastropoda Streptoneura			Opisthobranchia larvae	L6	Very sparse
Polychaeta			Trochophore larvae	L7	Sparse
Pelecypoda			Veliger larvae of bivalves	L8	Very sparse

TABLE:-69 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPA OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINARDURING NEAP TIDE OF NOVEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnussp.*	T1	Sparse
		Codonellidae	*Tintinnopsisfailakkaensis*	T2	Very sparse
			Tintinnopsis gracilis	T3	Very sparse
			Tintinnopsis radix	T4	Very sparse
			Tintinnopsis tocantinensis	T5	Very sparse
		Tintinnidae	*Amphorellopsis sp.*	T6	Very sparse
		Xystonellidae	*Favella sp.*	T7	Very sparse
Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Scattered
			Parvocalanus sp.	C2	Very sparse
	Cyclopoida	Oithonidae	*Oithona sp.*	C3	Abundant
	Harpacticoida	Euterpinidae	*Euterpina sp.*	C4	Very sparse
		Ectinosomatidae	*Microsetella*sp.	C5	Very sparse
	Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C6	Very sparse
Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Very sparse
Appendicularia		Fritillariidae	*Fritillaria sp.*	U1	Very sparse
		Oikopleuridae	*Oikopleura sp.*	U2	Very sparse
Copepoda			Nauplius larvae of copepods	L1	Dominant
Maxillopoda Thecostraca			Cirripede larvae	L2	Very sparse
Gastropoda Streptoneura			Opisthobranchia larvae	L3	Very sparse
Polychaeta			Trochophore larvae	L4	Very sparse
Pelecypoda			Veliger larvae of bivalves	L5	Very sparse

TABLE:-70 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPA OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING SPRING TIDE OF NOVEMBER 2022:

CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnussp.*	T1	Abundant
		Codonellidae	*Tintinnopsisgracilis*	T2	Very sparse
			Tintinnopsis mortensenii	T3	Very sparse
			Tintinnopsis radix	T4	Very sparse
		Xystonellidae	*Favella sp.*	T5	Scattered
Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Sparse
			Parvocalanus sp.	C2	Very sparse
		Centropagidae	*Centropages sp.*	C3	Very sparse
		Tortanidae	*Tortanus sp.*	C4	Very sparse
	Cyclopoida	Oithonidae	*Oithona sp.*	C5	Abundant
		Euterpinidae	*Euterpina sp.*	C6	Very sparse
	Harpacticoida	Ectinosomatidae	*Microsetella*sp.	C7	Scattered
	Poicilostomatatoida	Corycaeidae	*Corycaeus sp.*	C8	Very sparse
Appendicularia		Fritillariidae	*Fritillaria sp.*	U1	Very sparse
		Oikopleuridae	*Oikopleura sp.*	U2	Very sparse
Oligohymenophorea	Sessilida	Zoothamniidae	*Zoothamnium sp.*	CI1	Very sparse
Copepoda			Nauplius larvae of copepods	L1	Dominant
Malacostraca Decapoda			Brachyuran zoea	L2	Very sparse
Gastropoda Streptoneura			Opisthobranchia larvae	L3	Very sparse
Pelecypoda			Veliger larvae of bivalves	L4	Very sparse

BENTHIC ORGANISMS:

Few Benthic organisms were observed in the collected sediments by using the Van-Veen grabs during the sampling conducted during spring tide period and Neap tide period from DPA harbour region and nearby creek. The Meio-benthic organisms during spring tide were represented by Polychaetes *Tharyx sp*and *Nereis sp.*, during Neap tide *by Neries sp.* and few Amphipods. Population of benthic fauna was varying from 10-60- N/m^2 during spring tide and 0-80 N/m^2 during Neap tide. The benthic communities at path finder Creek were represented by Polychaetes *Glycera* sp. *Cirratulus* sp. *Nereis sp*. and few Amphipods. Their population was varying as 60 N/m^2 at OOT jetty premises and 80 $N/m^{2\ near}$ the SPM area during spring tide and 50 N/m^2 at OOT jetty premises and 50 N/m^2 near the SPM area during Neap tide period.

Table:-71 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPA HARBOUR AREA CREEKS DURING SPRING TIDE IN NOVEMBER 2022

ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS						
REPRESENTATION BY GROUP	DPA HARBOUR			CREEKS		
Benthic fauna						
POLYCHAETES	DPA-1	DPA-2	DPA-3	DPA-4	DPA-5	DPA-6
Family : CIRRATULIDAE *Tharyxsp.*	20	10	10	0	0	NS
Family :NEREIDAE *Nereis sp.*	0	0	0	20	40	NS
AMPHIPODA	0	0	0		20	NS
TOTAL Benthic Fauna NUMBER/ M^2	20	10	10	20	60	NS

NS: No sample

Table:-72 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPA HARBOUR AREA CREEKS DURING NEAP TIDE IN NOVEMBER 2022

ABUNDANCE IN NO/M^2 DIFFERENT SAMPLING STATIONS						
REPRESENTATION BY GROUP	DPA HARBOUR			CREEKS		
Benthic fauna						
POLYCHAETES	DPA-1	DPA-2	DPA-3	DPA-4	DPA-5	DPA-6
Family :NEREIDAE *Nereis sp.*	0	0	0	40	60	NS
Amphipoda	0	20	10	10	20	NS
TOTAL Benthic Fauna NUMBER/M^2	0	20	10	50	80	NS

Table:-73 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPA OOT JETTY AREA, VADINAR DURING SPRING TIDE IN NOVEMBER 2022

ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS		
REPRESENTATION BY GROUP	OOT Jetty Area	SPM area
POLYCHAETES		
Family : Glyceride *Glycera*sp.	20	40
Family : CIRRATULIDAE *Cirratulus*sp.	0	20
Family: *NEREIDAE* *Nereis sp.*	30	10
Amphipoda	10	20
TOTAL Benthic Fauna NUMBER/ M^2	60	80

Table:-74 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPA OOT JETTY AREA, VADINAR DURING NEAP TIDE IN NOVEMBER 2022

ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS		
REPRESENTATION BY GROUP	OOT Jetty Area	SPM area
POLYCHAETES		
Family : Glyceridase *Glycera* sp.	20	40
Family: *NEREIDAE* *Nereis sp.*	30	10
TOTAL Benthic Fauna NUMBER/ M^2	50	50

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 (standards100 µg/m^3, 60 µg/m^3). The higher concentration of Particulate matter at Marine Bhavan may be due to vehicles emissions during loading-unloading of food grains and timbers; at Estate office due to construction work, vehicles emission produced from trucks, heavy duty vehicles that pass through the road outside Kandla port and Oil jetty area; while at Coal Storage area lifting of coal from grab yard and other coal handling processes. Moreover, the transportation of coal produces pollution from heavy vehicles. At Tuna Port location, concentration of PM_{10} varied from 88-175 µg/m^3 and mean value was observed 145 µg/m^3 which was exceed the prescribed standard limit (100 µg/m^3), concentration of $PM_{2.5}$ was ranged from 47-87 µg/m^3 and mean was found 71 µg/m^3 which was exceed the standard limit (60 µg/m^3). At Gopalpuri PM_{10} concentration ranged from 67-168 µg/m3 and mean was 127 µg/m3 while $PM_{2.5}$ concentration ranged from 34-94 µg/m3 and mean was 66 µg/m3 were found exceed standard limit prescribed by NAAQS.
- At Vadinar, the average concentration of PM_{10} was 114 µg/m^3 and $PM_{2.5}$ was 74 µg/m^3 at Admin Colony which was slightly exceed the standard limit while at Signal building the mean concentration PM_{10} was 100 µg/m3 and $PM_{2.5}$ was 61 µg/m^3 which were very close to standard limit.
- During winter, the concentration of PM_{10} and $PM_{2.5}$ has been slowly augmented and reached a peak in the evening due to surface inversion of temperature after sunset. Thus, the pollutants are subsequently trapped in the lower layer of the atmosphere due to high atmospheric air pressure.
- Further, precautionary measures and management strategies to minimize the effect of particulate as well as gaseous pollutants have also been suggested for achieving its ambient levels in and around Kandla Port and Vadinar Port, Gujarat, India.

- Drinking water at all the twenty locations was found potable and it was found within in line of BIS standards (IS: 10500-2012).
- Transportation systems are the main source of noise pollution in project areas. Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading

containers and ships. All sampling location were within the permissible limit day time 75 dB (A) and night time 70 dB (A) for the industrial area.

- The treated sewage water of Kandla STP, Deendayal Port Colony (Gopalpuri) STP and Vadinar were in line with the standards set by the Central Pollution Control Board.
- It was suggested to monitor the STP performance on regular basis to avoid flow of contamination / Polluted water into the sea.
- Good species diversity suggests a relatively successful species in this habitat. A greater number of successful species and a more stable ecosystem. More ecological niches are available and the environment is less likely to be hostile complex food webs environmental change is less likely to be damaging to the ecosystem as a whole.
- The results obtained from the study for biological and ecological parameters in marine water for Arabian Sea at surrounding area of Deendayal Port Authority (DPA) Kandla and Vadinar were not affected by Port activities.
- The mean day time temperature at Deendayal Port was 27.92 °C. The day-time maximum temperature was 32.9°C and minimum was 21.1 °C. The mean night time temperature recorded was 25.47 °C. The night-time maximum temperature was 29.7°C and minimum was 20.0 °C. The mean Solar Radiation in November month was 167.27 w/m^2. The maximum solar radiation was recorded 759 w/m^2 in 4th November, 2022 and the minimum solar radiation was recorded 1.80 w/m^2 in 30th November, 2022. The mean Relative humidity was 69.00 % for the month of November. Maximum Relative humidity was recorded 99.0 % and minimum Relative humidity was recorded 34.0 %. The average wind velocity for the entire month of November was 1.21 m/s. Maximum wind velocity was recorded 10.19 m/s. The wind direction was mostly North-East.
- The results obtained from the study for the month of November 2022 for biological and ecological parameters in marine water for Arabian Sea at surrounding area of Deendayal Port Authority (DPA) Kandla and Vadinar were not affected by Port activities.

Reasons for higher Values of PM_{10}

- The unloading of coal directly in the truck, using grabs cause coal to spread in air as well as coal dust to fall on ground. This settled coal dust again mixes with the air while trucks travel through it.

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

Remedial Measures

The values of PM_{10} & $PM_{2.5}$ during the month of November, 2022 were beyond the standard limit at all locations (Coal Storage, Marine Bhavan, Oil Jetty and Estate office, Tuna Port) except Gopalpuri the concentration of particulate matter was slightly exceed. Given below are the remedial measures suggest to minimize the Air pollution.

- During November, 2022 overall ambient air quality of the DPA was within CPCB permissible limits except TSPM, PM_{10}, $PM_{2.5}$ at Coal storage area, Marine Bhavan, Oil Jetty and Estate Office. To improve air quality the port was using number of precautionary measures, such as maintained a wide expanse of Green zone, initiated Inter-Terminal Transfer (ITT) of tractor-trailers, Centralized Parking Plaza, providing shore power supply to tugs and port crafts, the use of LED lights at DPA area helps in lower energy consumption and decreases the carbon foot prints in the environment, time to time cleaning of paved and un paved roads, use of tarpaulin sheets to cover dumpers at project sites etc. are helping to achieve the cleaner and green future at port.

Solution towards the Green port:

Today, it is increasingly recognized that air pollution hurts human health. Consequently, efficient mitigation strategies need to be implementation for substantial environmental and health co-benefits.

The guidelines can be considered a basis for governments for the implementation of a strategic plan focused on the reduction of multi pollutant emission, as well as of the overall air pollution related risk.

- The plantation should be all along the periphery of the port and inside and outside the port along with the road. Trees having high dust trapping efficiency (*Azadirachta indica, Cassia fistula, Delonix regia, Ficus religiosa, Pterocarpus marsupium*) are to be grown alongside the roads.
- The water sprinkling should be use at each and every stage of transporting coal up the loading of truck to avoid generation of coal dust.

- The vehicles should be covered during transportation and the vehicle carrying the coal should not be overloaded by raising the height of carriage.
- The water sprinklers should be use during transportation of loaded heavy vehicles on raw road.
- It should be ensure that regular sweeping of coal internal, main road and space a free circulation.
- Practice should be initiated for using mask as preventative measure, to avoid Inhalation of dust particle- Mask advised in sensitive areas.
- Department for use maintenance should have a routine checkup noise level by replacing bearings, tights of all loose parts that can vibrate.
- Speed control is also an effective way to mitigate noise pollution, the lowest sound emission arise from vehicles moving smoothly.
- Use of renewable energy like solar energy should be optimal and ensure to work continuously.
- Keep neat and clean public transport and all basic items at public interaction places as much as possible.
- Technology like Electric cart, Inter-Terminal Transfer (ITT) are worthy selection to reduce Port operation efficiency and fuel cost.
- Conventional RTGCs should be altered as E-RTGCs counting inside the port completely.
- Initiate Natural Gas (CNG) as fuel by all buses and trucks.

Green Ports Initiative

- Deendayal Port is committed to sustainable development and adequate measures are being taken to maintain the Environmental well-being of the Port and its surrounding environs. Weighing in the environmental perspective for sustained growth, the Ministry of Shipping had started “Project Green Ports” which will help in making the Major Ports across India cleaner and greener. “Project Green Ports” will have two verticals - one is “Green Ports Initiatives” related to environmental issues and second is “Swachh Bharat Abhiyaan”.

- The Green Port Initiatives include twelve initiatives such as preparation and monitoring plan, acquiring equipments required for monitoring environmental pollution, acquiring dust suppression system, setting up of waste water treatment plants/ garbage disposal plant, setting up Green Cover area, projects for energy generation from renewable

energy sources, completion of shortfalls of Oil Spill Response (OSR) facilities (Tier-I), prohibition of disposal of almost all kind of garbage at sea, improving the quality of harbour wastes etc.

- Deendayal port has also appointed GEMI as an Advisor for "Making Deendayal Port a Green Port - Intended Sustainable Development under the Green Port Initiatives.
- Deendayal Port has also signed MOU with Gujarat Forest Department in August 2019 for Green Belt Development in an area of 31.942 Ha of land owned by Deendayal Port Trust. The plantation is being carried out by the Social Forestry division of Kachchh.

CHAPTER-12

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Annexure -C

DEENDAYAL PORT AUTHORITY

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www.deendayalport.gov.in

NO.EG/WK/4751/Part (Greenbelt-GUIDE) 196 Dated : 31/5/2022

M/S Gujarat Institute of Desert Ecology,
P.O.Box No. 83,
Opp. Changleshwar Temple, Mundra Road,
Bhuj (Kachchh)- 370 001,Gujarat (India).
Tel.: 02832-329408, 235025.
Tele/Fax: 02832-235027
Email: desert_ecology@yahoo.com

Kind Attn.: Dr.V.Vijay Kumar, Director, M/s GUIDE, Bhuj.

Sub: Greenbelt Development in Deendayal Port Authority and its Surrounding Areas Charcoal site (Phase-I).

Ref.: M/s GUIDE, Bhuj offer vide letter no. M/s GUIDE, Bhuj vide communication no. GUIDE/DPA/GRN/080/2022-23 dated 24/5/2022.

Sir,

Your offer for the subject work submitted vide above referred letter dated 24/5/2022 amounting to Rs. 38,22,900.00 + applicable GST (Rupees Thirty-Eight Lakhs Twenty-Two Thousand and Nine Hundred Only Plus Eighteen Percent GST), with all terms & conditions mentioned in the offer letter, has been accepted **(Copy of offer letter M/s GUIDE attached)**.

2. Scope of work:

Development of Greenbelt in Charcoal site – Kandla, DPA and its surrounding areas. The activities under the Greenbelt Development include; inventory of suitable sites for greenbelt development in DPA, soil & Moisture conservation and management at Plantation sites, selection of suitable species of Plants for plantation, Procurement and plantation of plant saplings and seeds (5000 plants), along with management and monitoring of plantation, including drip/tanker water supply for a period 1 year.

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3. Obligation of Deendayal Port Authority :

- Assistance regarding the statutory clearance from authorities concerned to be rendered by DPA for field visits/plantation activities.

4. The Terms of Payment:

1. 50% of the project budget to be paid to GUIDE within 15 days from the date of acceptance of Work order by GUIDE.
2. 20% of the project budget to be paid to GUIDE within 15 days from the date of completion of plantation works.
3. 20% of the project budget to be paid to GUIDE within 15 days from the date of submission Progress Report (December 2022).
4. 10% of the project budget to be paid to GUIDE within 15 days from the date of submission of Final Completion Report (May 2023).

5. Time Period : One year (from 5/6/2022 to 4/6/2023).

6. Kindly send the acceptance of this work order & start the work w.e.f. 5/6/2022 .

Thanking you.

Yours faithfully,

Superintending Engineer (PL) & EMC (I/c)
Deendayal Port Authority

Copy To :1) A.O.(W/A) - The proposal has been approved by the Board in its meeting held on 27/5/2022.

The expenditure shall be charged to the scheme Environmental Services & Clearance thereof (Allocation: 841/587/9744 WC – 5-13001).

2) TPA to CE for kind information of the Chief Engineer, please.

3) DA (PL) for further necessary action.

4) M/s Precitech Laboratorie ,Vapi, Environmental Management Cell to coordinate with M/s GUIDE,Bhuj.

5) RAO, DPA

Annexure -D

DEENDAYAL PORT TRUST

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

www.deendayalport.gov.in

NO.EG/WK/4783/V/131 Dated : 05/02/2021

To,
M/s Precitech Laboratories Pvt Ltd,
1st Floor, Bhanujyot Complex,
Plot No C5/27, B/h Panchratna Complex,
Nr. GIDC Char Rasta,
VAPI-396195.

Sub: **Work order** for "STRENGTHENING OF EXISTING ENVIRONMENTAL MANAGEMENT CELL AT DEENDAYAL PORT TRUST: Appointment of environment experts for two years further extendable for one year"-**reg**.

Ref: 1) Tender dated 21.06.2019 submitted by M/s Precitech Laboratories Pvt.Ltd, Vapi.
2) Letter of Acceptance vide no-EG/WK/4783/V/100 dtd 01(04).01.2021
3) Letter from DPT no E/WK/4783/V/103 dtd 06.01.2021
4) Performance Guarantee submitted by M/s Precitech Laboratories Pvt Ltd in the form of Bank Guarantee of Rs. 3,60,000.00 vide Bank Guarantee no. 1102921BG0000016 dated 19.01.2021 issued by State Bank of India, Vapi.

Sir,

Kindly refer above cited Letter of Acceptance dtd 01(04).01.2021.

2) You shall have to provide Key Experts as per tender requirement during the entire contract period. Accordingly, you shall have to submit the qualification and experience certificates of the Key experts to be appointed at DPT, as per tender conditions for verification & approval.

3) Please submit the Agreement of contract as per tender conditions no 1.29.

4) Kindly commence the work on or before 15.02.2021.

……Cont……..

Please note that the time period for providing Consultancy services for the subject work will be initially for two years and further extendable for one year on mutual consent as per tender conditions.

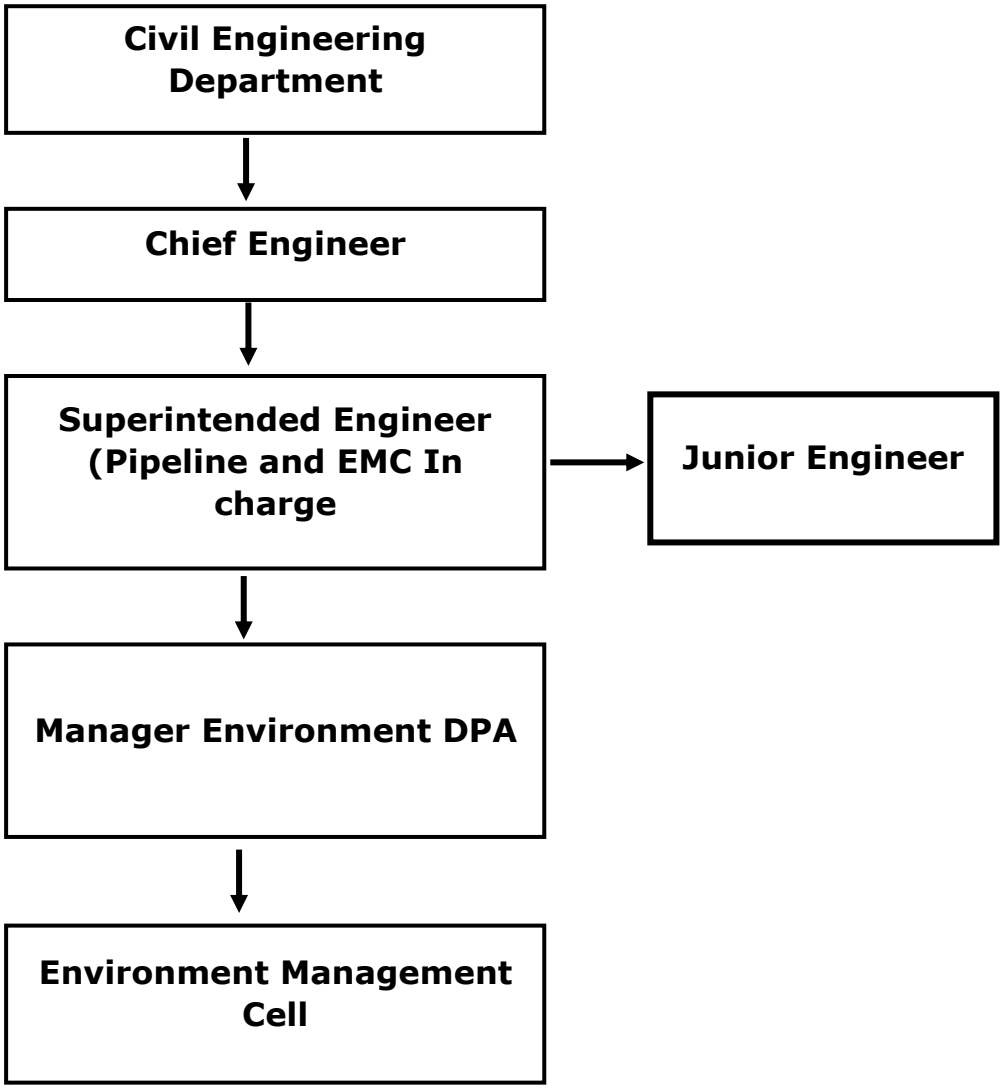
Thanking you.

Yours faithfully,

Superintending Engineer (Design & EMC (i/c))
Deendayal Port Trust

Annexure -E

ORGANIZATION CHART OF EMC



Annexure -F

DEENDAYAL PORT TRUST

ISO 9001 : 2008 ; ISO 14001 : 2004

Ph. : 02836-220167
Fax: 02836-233172
website: deendayalport.gov.in
e-mail : secretary@deendayalportgov.in

General Administration Deptt.
Administrative Office Building,
Post Box No. 50,
Gandhidham (Kutch) 370 201

By Speed Post / E-mail

No. GA/PS/4292/HE(PF)/2017/ 304 Dated, 17 January, 2022

OFFER OF CONTRACTUAL ENGAGEMENT AS MANAGER(ENVIRONMENT), IN DEENDAYAL PORT TRUST.

With Reference to your application for contractual engagement as Manager – Environment, in response to the advertisement, inviting applications for the subject position, on assessment and interview before the Services Selection Committee on 06.01.2022, the Competent authority has been pleased to offer the contractual engagement as Manager (Environment) in Deendayal Port Trust, purely on contractual basis, subject to the following terms and conditions :

a) Roles & Responsibilities

- Develop, implement and manage long term port environmental programmes such as the Green Marine Programme, sustainability plan, air strategies, tenant environment plan and tenant lease management.
- Represent the Port in local, state and federal agency meetings.
- Assist in the development and updating of the Port's comprehensive scheme of Harbour improvements and strategic plan.
- Monitor and conduct regular mock drills to train the employees at different levels.

b) Remuneration :-

Your consolidated remuneration per month will be Rs.1,00,000/- (Rupees One Lakh Only). Suitable increase depending upon the performance and variation in the AICP index may be given after successful completion of yearly service. Applicable taxes will be deducted at the time of payment.

c) Period of Contract :

The contract will be for a period of 3 years, extendable by another two years, subject to satisfactory performance.

d) Duty Hours :

You may be posted at/under any department/authority of Deendayal Port Trust, as per requirement, Duty Hours are from 10.00 AM to 06.00 PM or as may be decided by the Administration from time to time. In case of requirement, you may have to work beyond the normal duty hours, for which no other compensation, monetary or otherwise will be considered.

Contd....

.....

(Mukkannawar Utkarsh Suresh)

You will normally be entitled to a weekly off on Sunday. If situation warrants, the weekly day of rest may be changed with prior intimation. For work on any weekly day off / declared national holiday in exigencies of work, a compensatory day of rest as per the convenience of the Administration, in lieu thereof, will be granted and for which no other compensation, monetary or otherwise will be considered.

Failure to report for duty will entail deduction of wages on pro-rata basis.

e) Medical facility : Only Outdoor Medical treatment facility for self and your spouse will be provided in the Port Trust Hospital. No other medical facilities will be provided to you/ your family.

f) Leave entitlement : 10 days leave in a year and National Holidays will be given. No other leave will be admissible and for any absence beyond the said leave, pro-rata deduction will be made from the consolidated remuneration.

g) Accommodation : Suitable accommodation, if available, may be provided, subject to recovery of charges under FR-45A, and the element of HRA excluded from the lumpsum remuneration.

h) Your engagement on contractual basis is subject to strict adherence to the norms and conduct.

i) The engagement can be terminated by giving one month's notice in writing from either side. However, in case of unsatisfactory performance or for any act considered derogatory/ detrimental to the interest of Deendayal Port Trust, this contractual engagement will be terminated forthwith.

j) If you leave without notice or without acceptance of notice of termination, the amount due i.e., consolidated remuneration payable will be forfeited.

k) You shall not claim any right/title/interest on par with the regular employees of the Port or otherwise.

l) You shall not have any claim/right whatsoever for regular appointment / absorption in Deendayal Port Trust under any circumstances.

m) Your contractual engagement is subject to verification of antecedents by the police. If any adverse report is received from the Police, your contractual services are liable to be terminated forthwith.

n) You will not be permitted to take any other assignment during the period of contract with Deendayal Port Trust.

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(Mukkannawar Utkarsh Suresh)

Contd....

l) On official tour outside Head Quarters, you will be entitled to TA/DA as admissible under the rules.

m) The terms and conditions shall be amended / modified depending upon the requirement of the Port. Any dispute(s)/difference(s) shall be decided solely by the Chairman, Deendayal Port Trust, which shall be final and binding.

n) You are required to submit discharge letter / relieving letter from your present employer at the time of joining Deendayal Port Trust, without you may not be allowed to join.

o) The contractual engagement is subject to your being found medically fit as per the requirements of Deendayal Port Trust.

2. You have to report for medical examination before the Medical Board of DPT at Gopalpuri Hospital on any working day between 10.00 hrs to 12.00 hrs.

3. If you agree to the above terms and conditions, you may convey acceptance by signing the duplicate of the letter in token of your acceptance and submit the same to this office and call at this office with all certificates and two copies of passport size photographs latest by 27th January, 2022 failing which the offer of contractual engagement stands automatically cancelled.

Secretary
Deendayal Port Trust

To
Shri. Mukkanawar Utkarsh Suresh,
21/1, Madhukunj Housing Society,
Near Canara Bank, Panchavati,
Pashan, Pune, Maharashtra – 411008.
Email : utkaish@gmail.com

I accept the above terms and conditions and will report for duty on _____.

Name :

Date :

Copy to: CMO – for conducting Medical Examination.