DEENDAY[illegible] ORT TRUST
(Erstwhile: KANDLA 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/4684(EC)/PartVII/ 141

Date: 08/02/2022

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

Sub: Creation of water front facilities (Oil Jetties 8, 9, 10 & 11) and development of land of area 554 acres for associated facilities for storage at Old Kandla, Gandhidham, Kutch, Gujarat by M/s Deendayal Port Trust- **Compliance of Conditions mentioned in the NoC/CTE reg.**

Ref.: 1) NOC No. 94118 received vide letter no. PC/CCA-Kutch-1524/GPCB ID 56985 Dated 23/07/2018
2) DPT Letter No. EG/WK/4684(EC)/PartVII/29 dated 29/06/2021

Sir,

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

In this connection, it is to state that, vide above referred Letter No- PC/CCA-Kutch-1524/GPCB ID 56985 Dated 23/07/2018 had granted NoC/CTE with validity up to 03/04/2023. DPT vide ref 2 cited letter had submitted the compliance report of condition stipulated in CTE for period upto May, 2021.

Please find enclosed herewith, compliance report of conditions stipulated in CTE order (period **June 2021 to November, 2021**) along with necessary enclosures as **Annexure I,** for your kind perusal & record please.

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

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

Yours faithfully,

4/2/22

SE (PL) & EMC (I//c)
Deendayal Port Trust

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

Annexure -I

Compliance Report June-November, 2021

Subject: Point wise compliance report of stipulated conditions mention in the NOC/CTE for the Creation of water front facilities (Oil Jetties 8, 9, 10 & 11) and development of land of area 554 acres for associated facilities for storage at Old Kandla, Gandhidham, Kutch, Gujarat by M/s Deendayal Port Trust.

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

Sr. No	Conditions	Compliance Status
1	**Specific Conditions**	
1	Proposed jetties shall be handled of 3.5 MMTPA of liquid Cargo of edible oil, Fertilizers & food grains etc.	Point noted for the compliance.
2.	Unit shall strictly adhere to all conditions of TOR issued by MoEF&CC. Delhi dated 04/07/2017 & shall not carry out any construction activities till obtaining EC and CRZ from competent authority	DPT has already received the EC and CRZ clearance from MoEF&CC vide file no. 10-1/2017-1A-111 dated 20/11/2020 and CRZ recommendation from GCZMA vide letter no. ENV-10-2018-24-T cell dated 30/07/2020. (**Copies attached as Annexure A & B**)
3.	No ground water shall be used for the project coming under dark zone without permission of competent authority.	DPT is not using ground water for any of the purpose.
2	**Conditions Under Water Act**	
2.1	There shall be no Industrial water consumption and hence there shall be no generation from manufacturing process and other ancillary industrial operations.	It is here by assured that Water is used only for the domestic purpose and there is no Industrial water consumption and no waste water generation from the Industrial purpose.
2.2	Domestic water Consumption shall not exceed 20 KL/day	Point noted for the compliance.
2.3	The quantity of domestic waste water (sewage) shall not exceed 16 KL/day	Point noted for the compliance.
2.4	The quality of the sewage shall confirm to the following standards <table><tr><td>Parameters</td><td>Permissible Limit</td></tr><tr><td>pH</td><td>6.5-9.0</td></tr><tr><td>BOD (5 days at 20 ^{0}C)</td><td>30 mg/lit</td></tr><tr><td>Suspended Solid</td><td>20 mg/lit</td></tr></table>	DPT appointed M/s Detox Corporation, Surat for Monitoring of environmental parameters since the year 2016. The work is in progress & DPT submitted monitoring data regularly to all the concerned

<table>
<tr><td></td><td><table><tr><td>Fecal Coliform</td><td>1000 MPN/100 ml</td></tr></table></td><td>authorities along with compliance reports submitted. The monitoring reports are attached herewith as <u>Annexure C</u>.</td></tr>
<tr><td>2.5</td><td>The domestic sewage shall be treated in sewage treatment plant and treated sewage confirming to standard mentioned in 2.4 shall be reused in various activities shall not be used for gardening and plantation purpose in premises.</td><td>The domestic sewage is treated in sewage treatment plant of the DPT.</td></tr>
<tr><td>3</td><td colspan="2">Conditions under air act 1981:</td></tr>
<tr><td>3.1</td><td>There shall be no use of fuel; hence there is no flue gas emission from manufacturing activities and other ancillary operations.</td><td>It is hereby assured that no fuel is used and hence there is no flue gas emission from manufacturing activities and other ancillary operations.</td></tr>
<tr><td>3.2</td><td>There shall be no process gas emission from manufacturing and other ancillary activities.</td><td>No manufacturing process is involved and hence there is no no process gas emission from manufacturing and other ancillary activities.</td></tr>
<tr><td>3.3</td><td>The concentration of the following parameters in the ambient air within the premises of the industry shall not exceed the limits specified hereunder as per National Ambient Air Quality Emission Standards issued by Ministry of Environment, Forest and Climate Change dated 16th November 2009.

<table>
<tr><td>Parameters</td><td>Time Weighted Average</td><td>Concentration in Ambient air in µg/m³</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</td><td>Annual
24 Hours</td><td>40
60</td></tr>
</table></td><td>DPT appointed M/s Detox Corporation, Surat for Monitoring of environmental parameters since the year 2016. The work is in progress & DPT submitted monitoring data regularly to all the concerned authorities along with compliance reports submitted. The monitoring reports are attached herewith as <u>Annexure C</u>.</td></tr>
</table>

	2.5µm) or $PM_{2.5}$	
3.4	The level of Noise in ambient air within the premises of industrial unit shall not exceed following levels:; Between 6 A.M and 10 P.M : 75 dB(A) Between 10 A.M and 6 P.M : 70 dB(A)	DPT appointed M/s Detox Corporation, Surat for Monitoring of environmental parameters since the year 2016. The work is in progress & DPT submitted monitoring data regularly to all the concerned authorities along with compliance reports submitted. The monitoring reports are attached herewith as **Annexure C**.
4	**Conditions under Hazardous waste:**	
4.1	The applicant shall provide temporary storage facilities for each type of Hazardous waste as per Hazardous waste (Management, Handling & Transboundary Movement) Rules, 2016 as amended from time to time.	Point Noted for the Compliance. DPT has a contract with the GPCB/CPCB authorized Recycler for disposal of Haz. Waste.
4.2	The applicant shall be obtain membership of common TSDF site for disposal of Hazardous waste as Categorized in Hazardous waste (Management, Handling & Transboundary Movement) Rules, 2016 as amended from time to time	Point Noted for the Compliance. DPT has a contract with the GPCB/CPCB authorized Recycler for disposal of Haz. Waste.
5	**General Conditions**	
5.1	Any change in the personnel, equipment or working conditions as mentioned in the consents form/order should immediately be intimated to this Board.	Point noted for the compliance.
5.2	The waste generator shall be totally responsible for (i.e Collection, Storage, transportation and ultimate disposal) of the wastes generated.	Point noted for the compliance.
5.3	Record of Waste generation, its management and annual return shall be submitted to Gujrat pollution Control Board in Form-4 by 31st January of every year.	Point noted for the compliance. It is relevant to mention here that DPT is regularly submitting the annual return to Gujarat pollution Control Board in Form-4 by 30th June of every year for the DPT area. The Form 4 for the year 2020-21 is attached herewith as **Annexure D**.
5.4	In case of any accident, details of the same shall be submitted in Form-5 to Gujrat pollution Control Board	Point noted for the compliance.
5.5	Applicant shall comply relevant	Point noted for the compliance.

	provision of "Public Liability Insurance Act-91"	
5.6	Unit shall take all concrete measures to show tangible results in waste generation, reduction, avoidance, reuse and recycle. Action taken in this regard shall be submitted within three months and also along with Form-4.	Point noted for the compliance.
5.7	Industry shall have to display on-line data outside the main factory gate with regard to quantity and nature of hazardous chemicals being handled in the plant, including waste water and air emissions and solid hazardous waste generated within the factory premises.	Point noted for the compliance.
5.8	Adequate plantation shall be carried out all the periphery of the industrial premises in such a way that the density of plantation is at least 1000 trees per acre of land and a green belt of 10 meters width shall be developed	Point noted for the compliance.
5.9	The applicant shall have to submit the returns in prescribed form regarding water consumption and shall have to make payment of water cess to the Board under the water (Prevention and Control of Pollution) Cess Act - 1977	Only construction work is in progress (Oil Jetty No.8 -Jetty and allied facilities). In the operation phase, DPT shall regularly submit the returns in prescribed form regarding water consumption.

ANNEXURE A

File No.: 10-1/2017-IA-III
Proposal No. IA/GJ/MIS/61679/2017
Government of India
Ministry of Environment, Forest and Climate Change
(Impact Assessment Division)

Indira Paryavaran Bhawan,
Jor Bagh Road, Ali Ganj
New Delhi – 110 003
Dated: 20th November, 2020

To

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

Subject: Expansion of port by creation of water front facilities (Oil Jetties 8,9,10 & 11) and development of land of area 554 acres for associated facilities for storage at Old Kandla, Gandhidham, Kachchh (Gujarat) by M/s Deendayal Port Trust (formerly known as Kandla Port Trust) - Environmental and CRZ Clearance.

Sir,

This has reference to your online proposal to this Ministry on 5th August, 2020 regarding Environmental and CRZ Clearance for expansion of port by creation of water front facilities (Oil Jetties 8,9,10 & 11) and development of land of area 554 acres for associated facilities for storage at Old Kandla, Gandhidham, Kachchh (Gujarat) by M/s Deendayal Port Trust (formerly known as Kandla Port Trust)

2. The capacity of each jetty is 3.5 MMTPA for handling all types of liquid cargo. Area proposed for development is 554 acres (Mangrove area including 70 m buffer etc., have been excluded from the total area). Dredging quantity for capital dredging and maintenance dredging will be 16,56.058 m^3 and 1,07,500 m^3/annum, respectively. The dredged material will be disposed at designated dumping ground (Latitude 22°51'00" & Longitude 70°10'00"). Total plot for storage will be 11 Nos. Tentative Tank Capacity will be 2.28 Million KL and number of Pipelines on each jetty will be 9 (chemicals, Edible Oil, Fire fighting, water supply, air, etc).

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

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

i. The terrain is flat with elevation from sea level to up to 3m MSL. Topography at the site location is generally flat with average ground level of about 6.5m CD. Topsoil appears marshy. Gulf of Kutch at 11.65km and Sang River at 371.5m. There is no stream or nala is passing through the project site. The area (10 km area) around the project site is drained by Sakar River, Sang River and Churva River. All the rivers in study area are draining towards sea. The entire area is drainage north to south towards sea coast.

ii. Approx. 20 m3/day of water will be required for domestic consumption; the important source of water is the 14.5million m^3 capacity reservoir of Tapar Dam, besides a number of deep tube wells. The project does not lie in Critically Polluted area.

iii. There is no Protected Areas (PA) including National Parks, Sanctuaries and Tiger Reserves etc located within 10 km of the project boundary. Further there is no Eco-Sensitive Zone (ESZ) or Eco-Sensitive Area (ESA) notified by the MoEF&CC within 10 km radius.

iv. There would be approximately 100 persons employed in the oil jetties 8 -11 (maximum number of permanent and contract workers at any given time). Expected waste generation quantity from proposed project is approximately 75kg/day (@0.75kg/capita/day) of non-hazardous domestic waste (food waste, general solid waste and plastic waste) that will need collection and disposal. With the implementation of standard waste handling practices in line with MARPOL requirements, potential impacts resulting from the generation of non-hazardous waste is expected to be of low significance. The waste water will be treated in the existing STP of DPT.

v. No tree cutting is involved in this project. Mangrove plantation is being done by DPT in phased manner. Land clearance will only remove herbs and shrubs of common species. The project is employing renewable energy sources such as day lighting & passive solar panels, using energy efficient electrical appliances, regular maintenance of all powered equipment to ensure appropriate fuel consumption rates.

vi. A provision for storm water collection has been made for harvesting the rainwater and using it for irrigation or fire fighting purpose. The main storm water drains are proposed as trapezoidal drains of 0.95m base width and 1.3m depth to cater for 10ARI rainfall. The storm water storage proposed will also act as a buffer to cater for the risk for flooding due high intensity rainfall coincident with the high tide.

vii. The project involves foreshore facilities. Dredging requirement is 16, 56,058 m^3 (Berth basin + Patches in approach channel) and Maintenance Dredging of 1, 07,500 m^3 per annum is required. The dredged material will be disposed at designated dumping ground (Latitude 22°51'00" & Longitude 70°10'00"). Storage of permissible liquid cargo as permitted. 3.5 MMTPA each (3.5 X 4 =14 MMTPA total Capacity) for handling all types of liquid cargo. No handling of dusty cargo is proposed. Oil spill contingency plan has been prepared.

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

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

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

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

9. The Ministry of Environment, Forest and Climate Change has considered the proposal based on the recommendations of the Expert Appraisal Committee (Infrastructure, CRZ and other Miscellaneous projects) and hereby decided to grant Environmental and CRZ Clearance for the "Expansion of port by creation of water front facilities (Oil Jetties 8,9,10 & 11) and development of land of area 554 acres for associated facilities for storage at Old Kandla, Gandhidham, Kachchh (Gujarat) by M/s Deendayal Port Trust (formerly known as Kandla Port Trust)" under the EIA Notification, 2006 as amended and CRZ Notification 2011, subject to strict compliance of the following specific conditions, in addition to all standard conditions applicable for such projects.

(i) The Environmental and CRZ Clearance to the project is primarily under provisions of EIA Notification, 2006 and CRZ Notification, 2011. It does not tantamount to approvals/consent/permissions etc required to be obtained under any other Act/Rule/regulation. The Project Proponent is under obligation to obtain approvals /clearances under any other Acts/ Regulations or Statutes as applicable to the project.

(ii) The project proponent shall abide by all the commitments and recommendations made in the Form-II, EIA and EMP report and also that have been made during their presentation to EAC.

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

(iv) All the recommendations and conditions specified by the Gujarat Coastal Zone Management Authority (GCZMA) vide letter No. ENV-10-2018-24-T cell dated 30th July, 2020 shall be complied with.

(v) The Project proponent shall ensure that no creeks or rivers are blocked due to any activities at the project site and free flow of water is maintained. Creek water monitoring program shall be implemented during the construction phase

(vi) Dredging shall not be carried out during the fish breeding season. Dredging, etc. shall be carried out in confined manner to reduce the impacts on marine environment. Silt curtains shall be used to minimize spreading of silt plume during dredging using online monitoring system. Turbidity should be monitored during the dredging. No removal of silt curtain unless baseline values are achieved.

(vii) As proposed the dredged material can be used to provide an engineered base for marine terminal i.e., oil jetties 8-11 and construction yard. The impact of dredging on the marine environment should be monitored and necessary measures shall be taken on priority basis if any adverse impact is observed.

(viii) Marine ecological monitoring and its mitigation measures for protection of phytoplankton, zooplanktons, macrobenthos, estuaries, sea-grass, algae, sea weeds, Crustaceans, Fishes, coral reefs and mangroves and migratory birds etc. as given in the EIA-EMP Report shall be complied with in letter and spirit through a reputed university/institute with financial support as desired. Six monthly report of the studies to be provided to the regional office of MoEFCC.

(ix) Continuous online monitoring of air and water covering the total area shall be carried out and the compliance report of the same shall be submitted along with the 6 monthly compliance report to the regional office of MoEF&CC.

(x) The actions shall be in accordance with proposed landscape planning concepts to minimise major landscape changes. The change in land use pattern shall be limited to the proposed port limits and be carried out in such a way as to ensure proper drainage by providing surface drainage systems including storm water network.

(xi) Suitable preventive measures be taken to trap spillage of fuel / engine oil and lubricants from the construction site. Measures should be taken to contain, control and recover the accidental spills of fuel during cargo handling.

(xii) All the mitigation measures submitted in the EIA report shall be prepared in a matrix format and the compliance for each mitigation plan shall be submitted to the RO, MoEF&CC along with half yearly compliance report.

(xiii) The company shall draw up and implement Corporate Social Responsibility Plan as per the Company's Act of 2013.

(xiv) As per the Ministry's Office Memorandum F. No. 22-65/2017-IA.III dated 30th September, 2020, the project proponent, based on the commitments made during the public hearing, shall include all the activities required to be taken to fulfill these commitments in the Environment Management Plan along with cost estimates of these activities, in addition to the activities proposed as per recommendations of EIA Studies and the same shall be submitted to the ministry as part of the EIA Report. The EMP shall be implemented at the project cost or any other funding source available with the project proponent.

(xv) In pursuance of Ministry's OM No stated above the project proponent shall add one annexure in the EIA Report indicating all the commitments made by the PP to the public during public hearing and submit it to the Ministry and the EAC.

B. STANDARD CONDITIONS:

I. Statutory compliance:

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

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

(ii) A certificate of adequacy of available power from the agency supplying power to the project along with the load allowed for the project should be obtained.

(iii) All other statutory clearances such as the approvals for storage of diesel from Chief Controller of Explosives, Fire Department, Coast Guard, Civil Aviation Department shall be obtained, as applicable by project proponents from the respective competent authorities.

II. Air quality monitoring and preservation:

(i) The project proponent shall install system to carryout Ambient Air Quality monitoring for common/criterion parameters relevant to the main pollutants released (e.g. PM_{10} and $PM_{2.5}$ in reference to PM emission, and SO_2 and NOx in reference to SO_2 and NOx emissions) within and outside the project area at least at four locations, covering upwind and downwind directions.

(ii) Appropriate Air Pollution Control (APC) system shall be provided for all the dust generating points including fugitive dust from all vulnerable sources, so as to comply prescribed emission standards.

(iii) Shrouding shall be carried out in the work site enclosing the dock/proposed facility area. This will act as dust curtain as well achieving zero dust discharge from the site. These curtain or shroud will be immensely effective in restricting disturbance from wind in affecting the dry dock operations, preventing waste dispersion, improving working conditions through provision of shade for the workers.

(iv) Dust collectors shall be deployed in all areas where blasting (surface cleaning) and painting operations are to be carried out, supplemented by stacks for effective dispersion.

(v) The Vessels shall comply the emission norms prescribed from time to time.

(vi) Diesel power generating sets proposed as source of backup power should be of enclosed type and conform to rules made under the Environment (Protection) Act, 1986. The height of stack of DG sets should be equal to the height needed for the combined capacity of all proposed DG sets. Use of low sulphur diesel. The location of the DG sets may be decided with in consultation with State Pollution Control Board.

(vii) A detailed traffic management and traffic decongestion plan shall be drawn up to ensure that the current level of service of the roads within a 05 kms radius of the project is maintained and improved upon after the implementation of the project. This plan should be based on cumulative impact of all development and increased habitation being carried out or proposed to be carried out by the project or other agencies in this 05 Kms radius of the site in different scenarios of space and time and the traffic management plan shall be duly validated and certified by the State Urban Development department and the P.W.D./ competent authority for road augmentation and shall also have their consent to the implementation of components of the plan which involve the participation of these departments.

III. Water quality monitoring and preservation:

(i) The Project proponent shall ensure that no creeks or rivers are blocked due to any activities at the project site and free flow of water is maintained.

(ii) Appropriate measures must be taken while undertaking digging activities to avoid any likely degradation of water quality. Silt curtains shall be used to contain the spreading of suspended sediment during dredging within the dredging area.

(iii) No ships docking at the proposed project site will discharge its on-board waste water untreated in to the estuary/ channel. All such wastewater load will be diverted to the proposed Effluent Treatment Plant of the project site.

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

(v) The project proponents will draw up and implement a plan for the management of temperature differences between intake waters and discharge waters.

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

(vii) Total fresh water use shall not exceed the proposed requirement as provided in the project details. Prior permission from competent authority shall be obtained for use of fresh water.

(viii) Sewage Treatment Plant shall be provided to treat the wastewater generated from the project. Treated water shall be reused for horticulture, flushing, backwash, HVAC purposes and dust suppression.

(ix) A certificate from the competent authority for discharging treated effluent/ untreated effluents into the Public sewer/ disposal/drainage systems along with the final disposal point should be obtained.

(x) No diversion of the natural course of the river shall be made without prior permission from the Ministry of Water resources.

(xi) All the erosion control measures shall be taken at water front facilities. Earth protection work shall be carried out to avoid erosion of soil from the shoreline/boundary line from the land area into the marine water body.

IV. Noise monitoring and prevention:

(i) Noise level survey shall be carried as per the prescribed guidelines and report in this regard shall be submitted to Regional Officer of the Ministry as a part of six-monthly compliance report.

(ii) Noise from vehicles, power machinery and equipment on-site should not exceed the prescribed limit. Equipment should be regularly serviced. Attention should also be given to muffler maintenance and enclosure of noisy equipments.

(iii) Acoustic enclosures for DG sets, noise barriers for ground-run bays, ear plugs for operating personnel shall be implemented as mitigation measures for noise impact due to ground sources.

(iv) The ambient noise levels should conform to the standards prescribed under E(P)A Rules, 1986 viz. 75 dB(A) during day time and 70 dB(A) during night time.

V. Energy Conservation measures:

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

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

VI. Waste management:

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

(ii) Shoreline should not be disturbed due to dumping. Periodical study on shore line changes shall be conducted and mitigation carried out, if necessary. The details shall be submitted along with the six monthly monitoring reports.

(iii) Necessary arrangements for the treatment of the effluents and solid wastes must be made and it must be ensured that they conform to the standards laid down by the competent authorities including the Central or State Pollution Control Board and under the Environment (Protection) Act, 1986.

(iv) The solid wastes shall be managed and disposed as per the norms of the Solid Waste Management Rules, 2016.

(v) Any wastes from construction and demolition activities related thereto shall be managed so as to strictly conform to the Construction and Demolition Waste Management Rules, 2016.

(vi) A certificate from the competent authority handling municipal solid wastes should be obtained, indicating the existing civic capacities of handling and their adequacy to cater to the M.S.W. generated from project.

(vii) Used CFLs and TFLs should be properly collected and disposed off/sent for recycling as per the prevailing guidelines/ rules of the regulatory authority to avoid mercury contamination.

(viii) Oil spill contingency plan shall be prepared and part of DMP to tackle emergencies. The equipment and recovery of oil from a spill would be assessed. Guidelines given in MARPOL and Shipping Acts for oil spill management would be followed. Mechanism for integration of terminals oil contingency plan with the overall area contingency plan under the co-ordination of Coast should be covered.

VII. Green Belt:

(i) Green belt shall be developed in area as provided in project details with a native tree species in accordance with CPCB guidelines.

(ii) Top soil shall be separately stored and used in the development of green belt.

VIII. Marine Ecology:

(i) The dredging schedule shall be so planned that the turbidity developed is dispersed soon enough to prevent any stress on the fish population.

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

(iii) A detailed marine biodiversity management plan shall be prepared through the NIO or any other institute of repute on marine, brackish water and fresh water ecology and biodiversity and submitted to and implemented to the satisfaction of the State Biodiversity Board and the CRZ authority. The report shall be based on a study of the impact of the project activities on the intertidal biotopes, corals and coral communities, molluscs, sea grasses, sea weeds, sub-tidal habitats, fishes, other marine and aquatic micro, macro and mega flora and fauna including benthos, plankton, turtles, birds etc. as also the productivity. The data collection and impact assessment shall be as per standards survey methods and include underwater photography.

(iv) Marine ecology shall be monitored regularly also in terms of sea weeds, sea grasses, mudflats, sand dunes, fisheries, echinoderms, shrimps, turtles, corals, coastal vegetation, mangroves and other marine biodiversity components including all micro, macro and mega floral and faunal components of marine biodiversity.

(v) The project proponent shall ensure that water traffic does not impact the aquatic wildlife sanctuaries that fall along the stretch of the river.

IX. Public hearing and human health issues:

(i) The work space shall be maintained as per international standards for occupational health and safety with provision of fresh air respirators, blowers, and fans to prevent any accumulation and inhalation of undesirable levels of pollutants including VOCs.

(ii) Workers shall be strictly enforced to wear personal protective equipments like dust mask, ear muffs or ear plugs, whenever and wherever necessary/ required. Special visco-elastic gloves will be used by labour exposed to hazards from vibration.

(iii) Safety training shall be given to all workers specific to their work area and every worker and employee will be engaged in fire hazard awareness training and mock drills which will be conducted regularly. All standard safety and occupational hazard measures shall be implemented and monitored by the concerned officials to prevent the occurrence of untoward incidents/ accidents.

(iv) Emergency preparedness plan based on the Hazard identification and Risk Assessment (HIRA) and Disaster Management Plan shall be implemented.

(v) Provision shall be made for the housing of construction labour within the site with all necessary infrastructure and facilities such as fuel for cooking, mobile toilets, mobile STP, safe drinking water, medical health care, crèche etc. The housing may be in the form of temporary structures to be removed after the completion of the project.

(vi) Occupational health surveillance of the workers shall be done on a regular basis.

X. Environment Responsibility:

(i) The company shall have a well laid down environmental policy duly approved by the Board of Directors. The environmental policy should prescribe for standard operating procedures to have proper checks and balances and to bring into focus any infringements/deviation/violation of the environmental / forest /wildlife norms/ conditions. The company shall have defined system of reporting infringements / deviation / violation of the environmental / forest / wildlife norms / conditions and / or shareholders / stake holders. The copy of the board resolution in this regard shall be submitted to the MoEF&CC as a part of six-monthly report.

(ii) A separate Environmental Cell both at the project and company head quarter level, with qualified personnel shall be set up under the control of senior Executive, who will directly report to the head of the organization.

(iii) Action plan for implementing EMP and environmental conditions along with responsibility matrix of the company shall be prepared and shall be duly approved by competent authority. The year wise funds earmarked for environmental protection measures shall be kept in separate account and not to be diverted for any other purpose.

AK

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

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

XI. Miscellaneous:

(i) The project proponent shall make public the environmental clearance granted for their project along with the environmental conditions and safeguards at their cost by prominently advertising it at least in two local newspapers of the District or State, of which one shall be in the vernacular language within seven days and in addition this shall also be displayed in the project proponent's website permanently.

(ii) The copies of the environmental clearance shall be submitted by the project proponents to the Heads of local bodies, Panchayats and Municipal Bodies in addition to the relevant offices of the Government who in turn has to display the same for 30 days from the date of receipt.

(iii) The project proponent shall upload the status of compliance of the stipulated environment clearance conditions, including results of monitored data on their website and update the same on half-yearly basis.

(iv) The project proponent shall submit six-monthly reports on the status of the compliance of the stipulated environmental conditions on the website of the ministry of Environment, Forest and Climate Change at environment clearance portal.

(v) The project proponent shall submit the environmental statement for each financial year in Form-V to the concerned State Pollution Control Board as prescribed under the Environment (Protection) Rules, 1986, as amended subsequently and put on the website of the company.

(vi) The criteria pollutant levels namely; $PM_{2.5}$, PM_{10}, SO_2, NOx (ambient levels) or critical sectoral parameters, indicated for the project shall be monitored and displayed at a convenient location near the main gate of the company in the public domain.

(vii) The project proponent shall inform the Regional Office as well as the Ministry, the date of financial closure and final approval of the project by the concerned authorities, commencing the land development work and start of production operation by the project.

(viii) The project authorities must strictly adhere to the stipulations made by the State Pollution Control Board and the State Government.

(ix) The project proponent shall abide by all the commitments and recommendations made in the EIA/EMP report, commitment made during Public Hearing and also that during their presentation to the Expert Appraisal Committee.

(x) No further expansion or modifications in the port area shall be carried out without prior approval of the Ministry of Environment, Forests and Climate Change (MoEF&CC).

(xi) Concealing factual data or submission of false/fabricated data may result in revocation of this environmental clearance and attract action under the provisions of Environment (Protection) Act, 1986.

(xii) The Ministry may revoke or suspend the clearance, if implementation of any of the above conditions is not satisfactory.

(xiii) The Ministry reserves the right to stipulate additional conditions if found necessary. The Company in a time bound manner shall implement these conditions.

(xiv) The Regional Office of this Ministry shall monitor compliance of the stipulated conditions. The project authorities should extend full cooperation to the officer (s) of the Regional Office by furnishing the requisite data / information/monitoring reports.

(xv) The above conditions shall be enforced, inter-alia under the provisions of the Water (Prevention & Control of Pollution) Act, 1974, the Air (Prevention & Control of Pollution) Act, 1981, the Environment (Protection) Act, 1986, Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 and the Public Liability Insurance Act, 1991 along with their amendments and Rules and any other orders passed by the Hon'ble Supreme Court of India / High Courts and any other Court of Law relating to the subject matter.

(xvi) Any appeal against this EC shall lie with the National Green Tribunal, if preferred, within a period of 30 days as prescribed under Section 16 of the National Green Tribunal Act, 2010.

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

(Amardeep Raju)
Scientist-E

Copy to:

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

(Amardeep Raju)
Scientist-E

ANNEXURE B

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

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

Email: direnv@gujarat.gov.in

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

July *30, 2020*

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

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

Dear Sir,

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

Deendayal Port Trust has submitted following documents alongwith application:

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

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

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

I. During construction of the oil jetties, piling of jetty will involve the use of anchored piling barges. The barges/rigs will use diesel generator sets to provide power for the pile hammer and boring equipment. The generators would produce exhaust emissions during the construction period, which could cause temporary and localized adverse impacts on local air quality around these barges. The expected emissions will depend on total diesel combustion, which can vary between 100 to 500 litres per hour.

II. The proposed project will have no major considerable stress/ pressure on the environment to give rise to any significant adverse impacts on environment. The only major impacts on air during construction phase are predicted to be caused due to airborne dust arising from the construction activities as well as gaseous pollutants from vehicles used for transportation of construction materials & emission from equipment used during construction phase. The dust particles in the form of particulate matter will strongly depend on various activities like movement of vehicles, their speed, excavation of earth, back filling etc during the construction phase.

III. Exhaust emissions due to vehicular movement for on land transport of construction material may marginally increase the air pollution load along the road. This impact is temporary and localized.

IV. The probable sources of the dust are the activities of excavation, filling, leveling etc. However it is noticed that, the area of the proposed project is situated close to the creek of Gulf of Kutch; hence the moisture in the soil will not allow the particles to travel to longer distance from the sources.

V. The dredging quantity is 16, 56,058 M3 will be capital dredging for 8-11 oil jetties. It is proposed that the dredged material would be directly disposed of at the CWPRS (Central Water & Power Research Station) approved site.

VI. Beside the texture of soil is mostly sandy, hence the size and density of particles also prevent them from longer travelling. However maximum care will be taken to prevent the particles to be airborne by using water sprinkler system & covering the excavated materials. Hence there will be no significant impacts due to the dust particles.

VII. There is no chemical process or manufacturing activity, hence there will not be any process emission. As the proposed project is only export and import of cargo, increase in vehicular movement and emissions from DG set may affect ambient air quality.

VIII. Noise generation is due to the noise generation by the operation of the machineries, equipments and some mechanical works. The impacts due to noise of these equipments will be local and temporary as well as negligible due to the efficient implementation of proper mitigation measures like provision of Ear Protective Safety Equipment (ear plug or ear muff) for the personnel likely to the exposed to high noise level. The noise level shall be minimized by proper lubrication, modernization, maintenance, muffling and provision of silencers wherever possible.

IX. The day and night noise levels near the pile-driving site reduce to within prescribed limits as per "Noise Rules 2000" at distance of 50m and 100m from the source. There is a potential for underwater noise from piling of the jetty to impact marine fauna. As there are no marine mammals identified in the DPT area, it is expected that the noise impact would be of low significance as the piling activity would be localised and temporary in nature and sensitive receptors are not located in the vicinity of the noise generating area.

X. The major expected source to increase the noise level at the jetty area are arrival of cargo and vehicular movement to transport export and import goods, conveyor system and operation of DG set for emergency power supply. However, this increase in noise level will be lower compared to the construction phase. Proper lubrication, muffling shall be done to reduce the noise, DG set with acoustic enclosure shall be provided.

XI. The workers working in the high noise area shall be provided with ear protected equipments. The propagation of noise way would be prevented by creating barrier in form of greenbelt development all around the project area boundary.

XII. Before commencing any dredging operations the dredging contractor will provide complete details of their vessels and equipment including anticipated noise levels at the source. The noise levels during the activity will also be continuously monitored and mitigated if needed.

XIII. The Gujarat Water Supply and Sewerage Board (GWSSB) is responsible for providing of water during construction and operation phase. It is estimated that approx. 20KLD will be required once all facilities are functional. Hence there would not be any impact on local water sources and its competitive users.

XIV. During construction phase, there would be generation of some sewage due to personnel involved in the construction work. With the implementation of mitigation measures, the potential for contamination of surface and ground water resources resulting from sewage disposal is expected to be insignificant.

XV. During operation phase, the waste water will be treated in a sewage treatment plant. The treated wastewater will be used for flushing, cooling water makeup and landscaping purposes. Disposal of industrial effluent and sewage without proper treatment into water bodies can pollute and degrade the water quality by making it unfit for usage and survival of aquatic life. Hence no waste water should be discharged outside the project premises. This will prevent any direct disposal of waste water in this stream.

XVI. Storm water drainage system will be developed by DPT at project site for collection of storm water. The storm water drain will be covered by a steel gutter grill that is level with the surrounding pavement. This collected water will be recharged into ground through injection wells. Development of storm water drainage system and RWH structures will regulate the run-off from the site & prevent flooding of the area during heavy rains. Injection well will be interlinked to prevent any overflow or waste of harvested water. Thus, no negative impact is anticipated on drainage of the area. Measures propose to prevent impact of project development on surface water bodies.

XVII. Land use patterns of the surrounding area would not changed as it already used for port activity with some open land/back-up area. The proposed project is in the water front of marine water course of Gulf of Kutch. The project requires 554 acres of land for the development of proposed project. The land is generally barren and saline soil having low nutrients. At present, the site is almost devoid of vegetation, so major clearance of vegetation in site for development of proposed project is not required. Hence there would not be any adverse impacts on land cover is envisaged.

XVIII. Some degraded mangrove colonies are noticed in the buffer area of the project. The project area is revised to 554 acres from 1432 acres maintaining 70 m buffer all around the mangrove colonies.

XIX. The proposed jetty site is within the limit of existing port where benthic diversity and abundance in the area is found to be low in comparison with other near-shore areas in the region. This is principally attributed to the fact that the area is surrounded by marine-based development projects related to the extension and development of the Deenadayal Port. Installation of the 210-240 steel piles will take place using a jack up rig, which will need to be repositioned to cover the entire piling operation. Piles shall be driven to the required depth by a suitably sized hydraulic hammer. Based on the geotechnical conditions found at the site no drilling is anticipated as area is known for soft sand.

XX. The disturbance caused by the direct impacts of the rig could cause a temporary loss in benthic habitat in the area occupied by the steel piles and the legs of the jack up rig (4 no. per pile). This habitat is likely to become re-established after end of rigging. There could also be localized, temporary smothering of habitat with finer materials and suspension of fine sediments into the water column. This could reduce light penetration in the vicinity, impacting the marine environment and directly affecting photosynthetic species, and increased sediment loading in the waters could affect filter feeding organisms. The impact on benthic habitat because of the piling is expected to be temporary and localized and is therefore predicted to be of low significance.

XXI. None of the species included in Schedule –I of the Indian Wildlife Act was reported from the core area. The project is not expected to bring about any major irreversible change in the terrestrial area. It can therefore be concluded that the proposed project and its activities will not have any adverse impacts in the terrestrial flora and fauna of the core area or its buffer zone.

XXII. The general water quality, and sediment quality parameters in the Port premises remained within normal limits during study period as ongoing capital and maintenance dredging, and no variations and fluctuations were observed. The phytoplankton, zooplankton, benthic organisms and fish populations in the Kandla did not show any abnormal variations in their quality and quantity during this period. This indicates that the ongoing dredging activities as well as and the port activities have already disturbed the marine environment. The project-specific dredging would cumulatively add to that disturbance though this disturbance will be more localized and for a duration of approximately 18 months. The overall impact of the dredging activities on the marine flora and fauna would be of medium significance, which after the implementation of mitigation measures is expected to be of low significance.

XXIII. The land is designated port land, which is currently not under any permanent use; hence there are no impacts in terms of displacement or livelihood loss.

XXIV. The impact significance during operation phase is expected to be low considering the fact the project will be at onshore and offshore with limited impact on socio-economic environment. However, the project will have positive impacts on socio-economic environment by increasing availability of power, creation of employment opportunities and procuring material locally.

XXV. There would be approximately 100 persons employed in the oil jetties 8 -11 (maximum number of permanent and contract workers at any given time). Expected waste generation quantity from proposed project is approximately 75kg/day (@0.75kg/capita/day) of non-hazardous domestic waste (food waste, general solid waste and plastic waste) that will need collection and disposal. With the implementation of standard waste handling practices in line with MARPOL requirements, potential impacts resulting from the generation of non-hazardous waste is expected to be of low significance.

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

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

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

The Representative of the DPT made a presentation before the Authority and submitted that existing Port is having facilities such as –

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

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

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

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

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

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

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

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

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

The representative of DPT further submitted that the EIA study has determined that the construction and operational activities of the proposed project will have some overall low and medium impacts on the local environment. However, with the implementation of proposed pollution control and environment management measures, it is envisaged that these anticipated impacts will be largely mitigated for land, water, ar and Marine environment. It will not create any harmful impact on the surrounding environment.

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

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

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

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

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

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

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

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

Environment Department and the District Collector / District Development Officer.

26. A six monthly report on compliance of the conditions mentioned in this letter shall have to be furnished by DPT on a regular basis to this Department and MoEF&CC,GoI.

27. The DPT shall ensure that the numbers of the Vessels and machinery deployed during marine construction, which are a source of low level organic and PHC pollution will be optimized to minimize risks of accidents involving these vessels.

28. The noise level during transport and construction of marine facilities shall be kept minimum.

29. The DPT shall regularly conduct the surveys to identify changes in the channel bathymetry to minimize navigation hazards. Proper navigational aids and guidance should be provided to ships navigating the channel and there should be a properly structured vessels traffic management strategy to avoid accidents.

30. The DPT shall carry out separate study for further erosion and deposition pattern in the area after dredging through a reputed agency and shall follow the suggestions of the study done by reputed agency ,for maintenance dredging, the recommendations/suggestions of the reputed agency shall be follow by the DPT.

31. Any other condition that may be stipulated by this Department and MoEF&CC,GoI from time to time for environmental protection / management purpose shall also have to be complied with by DPT.

Thanking You,

O/c
30/7/2020

Yours Sincerely,

(S. M. Saiyad)

Encl: As above

રવાના કર્યું
તા. 30 JUL 2020

Copy to:

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

ANNEXURE C

ENVIRONMENTAL MONITORING REPORT
FOR
DEENDAYAL PORT TRUST

REPORT NO.	:	DCPL/DPT/20-21/14
Month	:	June 2021
Issue No	:	01
Revision No	:	00
Prepared by	:	DETOX CORPORATION PVT. LTD., SURAT

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Introduction

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

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

1. Ambient Air Quality Monitoring

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

1.1 Air Quality Monitoring Methodology

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

The AAQ samples are collected twice a week from all the eight locations as per the EMP.

1.2 Results

The ambient air quality monitoring data for six stations, viz. Marine Bhavan, Oil Jetty, Port Colony,Gopalpuri Hospital,Tuna Port and Nr. Coal Storage Area for the month of June 2021 are given in Tables 1A to 6B. The ambient air quality monitoring data for two stations at Vadinar (Nr. Admin Building &Nr. Signal Building) are given in Tables 7A to 8B.

Location 1: Marine Bhavan (AL1)

Table 1 : Results of Air Pollutant Concentration at Marine Bhavan

Parameter	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period	-	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit	-	**NS**	**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL1 – 1	02-06-2021	447	107	53	14.07	9.23	23.50	24.14	12.51	11.83
					9.23		20.33		10.72	
					4.40		28.58		12.25	
AL1 – 2	04-06-2021	399	135	46	12.75	11.28	20.33	22.87	12.51	11.74
					11.87		24.77		12.00	
					9.23		23.50		10.72	
AL1 – 3	09-06-2021	423	204	172	13.63	14.95	24.77	19.27	7.40	7.06
					18.46		17.15		7.91	
					12.75		15.88		5.87	
AL1 – 4	11-06-2021	223	58	149	5.71	6.59	16.51	13.76	9.19	9.62
					5.71		14.61		8.93	
					8.35		10.16		10.72	
AL1 – 5	16-06-2021	476	103	203	17.14	16.56	18.42	16.51	7.15	6.81
					14.07		16.51		6.89	
					18.46		14.61		6.38	
AL1 - 6	18-06-2021	268	111	116	9.23	10.55	26.68	25.41	12.00	12.42
					9.67		27.95		12.51	
					12.75		21.60		12.76	
AL1 - 7	23-06-2021	415	179	65	5.71	6.74	26.68	26.68	6.89	7.83
					6.15		28.58		5.87	
					8.35		24.77		10.72	
AL1 – 8	25-06-2021	341	141	57	11.87	13.48	17.15	23.29	10.98	10.98
					17.14		20.33		12.00	
					11.43		32.39		9.96	
Monthly Average		374	130	108		11.17		21.49		9.79
Standard Deviation		89	46	61		3.65		4.53		2.28

NS: Not Specified

Table 1B : Results of Air Pollutant Concentration at Marine Bhavan					
Parameter	**Date**	**C_6H_6 [µg/m^3]**	**HC* ppm**	**CO [mg/m^3]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m^3**	**NS**	**4.0 mg/m^3**	**NS**
AL1 – 1	02/06/2021	1.2	BDL	1.46	510
AL1 – 2	04/06/2021	1.23	BDL	1.3	519
AL1 – 3	09/06/2021	1.07	BDL	1.86	495
AL1 – 4	11/06/2021	1.06	BDL	1.84	476
AL1 – 5	16/06/2021	1.06	BDL	1.75	490
AL1 - 6	18/06/2021	1.11	BDL	1.62	489
AL1 – 7	23/06/2021	1	BDL	1.8	480
AL1 – 8	25/06/2021	1.07	BDL	1.71	476
Monthly Average		**1.10**	-	**1.67**	**492**
Standard Deviation		**0.08**	-	**0.20**	**16**

* NMHC- Non- Methane Hydrocarbons

BDL- Below Detection Limit (Detection Limit – NMHC: 0.5ppm)

NS -Not Specified

At Marine Bhavan, the overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_X and NH_3 is attributed mainly by motor vehicle emission produced from various types of automobiles (both diesel and petrol driven). Moreover, the loading and unloading of Food Grains and Timber at Jetty no. 1 and 2 also contributes to the high levels of TSPM and PM_{10}. The mean TSPM value at Marine Bhavan was 374 µg/m^3, The mean PM_{10} values were 130.0 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean = 108 µg/m^3). The average values of SO_2, NO_x and NH_3 were within the permissible limit. The average values of SO_2, NO_x and NH3 were 11.17 µg/ m^3, 21.49 µg/ m^3 & 9.79 µg/ m^3 respectively.These were within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Marine Bhavan. The mean Benzene concentration was 1.10 µg/m^3,well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and CarbonMonoxide concentration was 1.67 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 2: Oil Jetty (AL2)

Table 2 : Results of Air Pollutant Concentration at Oil Jetty										
Parameters	**Date**	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period	-	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit	-	**NS**	**100 µg/m3**	**60 µg/m3**	-	**80 µg/m3**	-	**80 µg/m3**	-	**400 µg/m3**
AL2 - 1	02-06-2021	283	68	120	9.23	11.72	20.33	23.08	13.27	10.47
					13.19		25.41		10.72	
					12.75		23.50		7.40	
AL2 - 2	04-06-2021	353	108	210	9.23	11.14	18.42	17.15	10.72	10.89
					14.07		14.61		11.23	
					10.11		18.42		10.72	
AL2 - 3	09-06-2021	275	42	137	17.58	13.19	17.15	20.54	9.96	8.25
					12.74		24.14		7.91	
					9.23		20.33		6.89	
AL2 - 4	11-06-2021	257	37	145	5.27	5.42	23.50	19.27	3.32	5.87
					5.71		18.42		4.85	
					5.27		15.88		9.45	
AL2 - 5	16-06-2021	532	84	117	12.75	12.02	17.15	18.21	7.15	6.98
					9.23		20.33		7.40	
					14.07		17.15		6.38	
AL2 - 6	18-06-2021	192	111	65	11.87	7.91	26.68	28.58	10.72	11.40
					8.35		27.95		12.51	
					3.52		31.12		10.98	
AL2 - 7	23-06-2021	346	79	80	5.71	6.30	15.88	16.73	9.45	8.85
					7.91		17.15		9.70	
					5.28		17.15		7.40	
AL2 - 8	25-06-2021	256	125	31	11.87	15.09	18.42	18.84	3.83	7.83
					13.63		18.42		8.93	
					19.78		19.69		10.72	
Monthly Average		312	82	113		10.35		20.30		8.82
Standard Deviation		103	32	55		3.43		3.90		1.97

NS: Not Specified

Table 2B : Results of Air Pollutant Concentration at Oil Jetty					
Parameter	**Date**	**C_6H_6 [µg/m^3]**	**HC* ppm**	**CO [mg/m^3]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m^3**	**NS**	**4.0 mg/m^3**	**NS**
AL2 -1	02/06/2021	1.11	BDL	1.78	482
AL2 -2	04/06/2021	1.06	BDL	1.77	496
AL2 -3	09/06/2021	1.22	BDL	1.8	480
AL2 -4	11/06/2021	1.05	BDL	1.75	484
AL2 – 5	16/06/2021	1.02	BDL	1.81	515
AL2 – 6	18/06/2021	1.07	BDL	1.78	496
AL2 -7	23/06/2021	1.09	BDL	1.88	491
AL2 – 8	25/06/2021	1.06	BDL	1.64	470
Monthly Average		**1.09**	**-**	**1.78**	**489**
Standard Deviation		**0.06**	**-**	**0.07**	**14**

* NMHC- Non- Methane Hydrocarbons

BDL- Below Detection Limit (Detection Limit – NMHC : 0.5ppm)

NS- Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Oil Jetty area was mainly by motor vehicle emission produced from various types of vehicles Oil Jetty Area. The mean TSPM values at Oil Jetty were 312 µg/m^3 The mean PM_{10} values were 82 µg/m^3, which is below the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean = 113 µg/m^3).The average values of SO_2, NO_x and NH_3 were within the permissible limit; The mean concentration of SO_2, NO_x and NH3 were 10.35 µg/m^3, 20.30 µg/m^3 and 8.82 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 1.09 µg/m^3 .Well below the permissible limit of 5.0 µg/m^3. , HC's were below the detectable limit and Carbon Monoxide concentration was 1.78 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

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

Table 3 : Results of Air Pollutant Concentration at Estate Office										
Parameters	**Date**	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period	-	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit	-	**NS**	**100 µg/m3**	**60 µg/m3**	-	**80 µg/m3**	-	**80 µg/m3**	-	**400 µg/m3**
AL3 – 1	02-06-2021	151	18	41	3.96	6.01	18.42	16.51	4.85	8.42
					5.28		17.15		6.89	
					8.79		13.97		13.53	
AL3 – 2	04-06-2021	232	63	12	10.11	11.58	17.15	18.00	6.89	9.19
					12.75		19.69		8.17	
					11.87		17.15		12.51	
AL3 – 3	09-06-2021	290	98	55	12.75	10.84	20.33	20.11	10.98	10.47
					9.67		24.77		12.25	
					10.11		15.24		8.17	
AL3 – 4	11-06-2021	235	61	128	1.76	2.34	20.33	20.54	6.89	6.13
					2.20		23.50		5.87	
					3.08		17.78		5.62	
AL3 – 5	16-06-2021	231	66	139	5.71	10.84	26.68	22.02	13.53	9.28
					12.75		20.96		7.40	
					14.07		18.42		6.89	
AL3 – 6	18-06-2021	463	76	37	10.11	11.43	20.33	22.23	7.91	8.00
					13.63		22.87		9.96	
					10.55		23.50		6.13	
AL3 – 7	23-06-2021	382	70	35	11.87	13.33	8.26	13.97	9.96	8.68
					14.07		15.24		10.72	
					14.07		18.42		5.36	
AL3 – 8	25-06-2021	148	99	42	12.75	12.16	19.69	19.69	7.15	7.91
					12.31		22.23		9.19	
					11.43		17.15		7.40	
Monthly Average		267	69	61		9.82		19.13		8.51
Standard Deviation		109	25	46		3.70		2.83		1.27

NS: Not Specified

Table 3B : Results of Air Pollutant Concentration at Kandla Port Colony					
Parameter	**Date**	**C_6H_6 [µg/m^3]**	**HC***	**CO [mg/m^3]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m^3**	**NS**	**4.0 mg/m^3**	**NS**
AL3 -1	02/06/2021	1.07	BDL	1.72	489
AL3 -2	04/06/2021	1.1	BDL	1.82	502
AL3 -3	09/06/2021	1.07	BDL	1.74	482
AL3 -4	11/06/2021	1.16	BDL	1.61	480
AL3 – 5	16/06/2021	1.17	BDL	1.69	475
AL3 – 6	18/06/2021	1.1	BDL	1.7	489
AL3 – 7	23/06/2021	1.04	BDL	1.96	486
AL3 – 8	25/06/2021	1.04	BDL	1.59	464
Monthly Average		**1.09**		**1.73**	**483**
Standard Deviation		**0.05**		**0.12**	**11**

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

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Kandla Port Colony was attributed by vehicle emission produced from trucks and heavy duty vehicles that pass through the road outside Kandla Port Colony. The mean TSPMvalues at Oil Jetty were 267 µg/m^3, The mean PM_{10} values were 69µg/m^3, which is below the permissible limit. $PM_{2.5}$ values were slightly above the permissible limit (mean = 61 µg/m^3). The average values of SO_2, NO_x and NH3 were 9.82 µg/m^3, 19.13 µg/m^3 and 8.51 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Kandla Port Colony. The mean Benzene concentration was 1.09 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.73 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 4: Gopalpuri Hospital (AL-4)

Table 4 : Results of Air Pollutant Concentration at Gopalpuri Hospital										
Parameter	**Date**	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period	-	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit	-	**NS**	**100 µg/m3**	**60 µg/m3**	-	**80 µg/m3**	-	**80 µg/m3**	-	**400 µg/m3**
AL4 -1	02-06-2021	115	40	15	3.96	2.64	13.34	15.46	5.11	5.28
					3.08		14.61		4.85	
					0.88		18.42		5.87	
AL4 -2	04-06-2021	144	43	13	8.79	7.33	14.61	17.57	6.89	7.49
					5.71		19.69		7.40	
					7.47		18.42		8.17	
AL4 -3	09-06-2021	157	49	34	2.64	3.37	14.61	20.96	6.89	7.40
					3.52		29.85		7.40	
					3.96		18.42		7.91	
AL4 -4	11-06-2021	122	29	46	9.23	7.47	5.08	6.99	3.06	4.60
					9.23		7.62		4.85	
					3.96		8.26		5.87	
AL4 – 5	16-06-2021	156	35	21	3.96	3.96	10.80	12.49	10.72	11.40
					3.52		12.07		10.98	
					4.40		14.61		12.51	
AL4 – 6	18-06-2021	207	72	108	9.23	8.65	13.34	18.42	7.40	7.57
					8.79		24.77		9.96	
					7.91		17.15		5.36	
AL4 – 7	23-06-2021	263	36	13	0.88	3.08	11.43	13.97	10.98	10.30
					3.96		13.34		12.00	
					4.40		17.15		7.91	
AL4 – 8	25-06-2021	216	111	14	3.52	4.54	12.70	11.86	7.40	7.06
					4.84		12.07		7.15	
					5.28		10.80		6.64	
Monthly Average		173	52	33		5.13		14.71		7.64
Standard Deviation		51	27	33		2.33		4.39		2.28

NS: Not Specified

Table 4B : Results of Air Pollutant Concentration at Gopalpuri Hospital					
Parameter	Date	C_6H_6 [µg/m^3]	HC*	CO [mg/m^3]	CO_2 [ppm]
Sampling Period		8 hr	Grab Sampling	Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m^3	NS	4.0 mg/m^3	NS
AL4 -1	02/06/2021	1.07	BDL	1.68	482
AL4 -2	04/06/2021	1.06	BDL	1.7	488
AL4 -3	09/06/2021	1.11	BDL	1.9	478
AL4 -4	11/06/2021	1.1	BDL	1.54	470
AL4 – 5	16/06/2021	1.21	BDL	1.58	455
AL4 – 6	18/06/2021	1.2	BDL	1.78	460
AL4 – 7	23/06/2021	1.19	BDL	1.94	481
AL4 – 8	25/06/2021	1.13	BDL	1.91	475
Monthly Average		**1.13**		**1.75**	**474**
Standard Deviation		**0.06**		**0.15**	**11**

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

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Gopalpuri Hospital was attributed by vehicle emission produced from light motor vehicles of the colony residents. The mean TSPMvalues at Oil Jetty were 173 µg/m^3, The mean PM_{10} values were 52 µg/m^3, which is below the permissible limit. $PM_{2.5}$ values were also within the permissible limit (mean= 33 µg/m^3). The average values of SO_2, NO_x and NH_3 were 5.13 µg/m^3, 14.71 µg/m^3 and 7.64 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Gopalpuri Hospital. The mean Benzene concentration was 1.13 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.75 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 5: Coal Storage Area (AL-5)

Table 5 : Results of Air Pollutant Concentration at Coal Storage Area										
Parameters	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period	-	24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit	-	NS	100 µg/m3	60 µg/m3	-	80 µg/m3	-	80 µg/m3	-	400 µg/m3
AL5 – 1	02-06-2021	829	78	60	9.23	9.23	26.04	26.47	13.27	13.96
					12.75		28.58		15.32	
					5.71		24.77		13.27	
AL5 – 2	04-06-2021	332	104	97	5.71	7.77	20.33	21.60	12.51	12.00
					8.79		24.77		12.51	
					8.79		19.69		10.98	
AL5 – 3	09-06-2021	289	185	154	10.11	13.48	18.42	18.84	10.72	11.83
					12.75		17.78		12.51	
					17.58		20.33		12.25	
AL5 – 4	11-06-2021	280	70	162	9.23	13.19	12.07	13.55	10.98	10.64
					13.19		13.34		10.72	
					17.14		15.24		10.21	
AL5 – 5	16-06-2021	944	148	150	3.96	10.99	14.61	18.84	2.30	5.45
					19.78		10.80		6.89	
					9.23		31.12		7.15	
AL5 – 6	18-06-2021	603	145	234	10.11	9.23	26.68	24.56	13.53	13.96
					7.47		22.87		13.27	
					10.11		24.14		15.06	
AL5 – 7	23-06-2021	766	181	152	11.87	12.75	12.70	21.17	12.51	10.47
					14.07		17.15		10.72	
					12.31		33.66		8.17	
AL5 – 8	25-06-2021	728	208	94	13.63	11.72	18.42	15.03	12.51	9.53
					10.55		17.78		9.19	
					10.99		8.89		6.89	
Monthly Average		596	140	138		11.04		20.01		10.98
Standard Deviation		263	51	54		2.11		4.40		2.74

NS: Not Specified

Table 5B : Results of Air Pollutant Concentration at Coal Storage Area					
Parameter	**Date**	**C_6H_6 [µg/m^3]**	**HC***	**CO [mg/m^3]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m^3**	**NS**	**4.0 mg/m^3**	**NS**
AL5 – 1	02/06/2021	1.08	BDL	1.78	482
AL5 – 2	04/06/2021	1.1	BDL	1.68	490
AL5 – 3	09/06/2021	1.24	BDL	1.64	462
AL5 – 4	11/06/2021	1.28	BDL	1.66	464
AL5 – 5	16/06/2021	1.31	BDL	1.66	460
AL5 – 6	18/06/2021	1.2	BDL	1.7	490
AL5 – 7	23/06/2021	1.33	BDL	1.74	464
AL5 – 8	25/06/2021	1.11	BDL	1.91	484
Monthly Average		**1.21**	**-**	**1.72**	**475**
Standard Deviation		**0.10**	**-**	**0.09**	**13**

* NMHC- Non- Methane Hydrocarbons

BDL- Below Detection Limit (Detection Limit – NMHC: 0.5 ppm)

NS-Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Coal Storage Area was comparatively highest among all the locations of Air Quality monitoring in Kandla Port. High values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_X at this location was due to lifting of coal with grab and other coal handling processes near Berth no. 6 & 7. Moreover, the traffic was also heavy around this place for transport of coal thus emissions produced from heavy vehicles. The mean TSPMvalues at Coal storage were 596 µg/m^3. The mean PM_{10} values were 140 µg/m^3, which is well above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean = 138 µg/m^3). The average values of SO_2, NO_x and NH_3 were 11.04 µg/m^3, 20.01 µg/m^3 and 10.98 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Coal Storage Area. The mean Benzene concentration was 1.21 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.72 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 6: Tuna Port (AL-6)

Table 6 : Results of Air Pollutant Concentration at Tuna Port										
Parameters	**Date**	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period	-	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit	-	**NS**	**100 µg/m3**	**60 µg/m3**	-	**80 µg/m3**	-	**80 µg/m3**	-	**400 µg/m3**
AL6 -1	02-06-2021	72	72	37	0.44	1.76	17.15	16.73	4.60	6.72
					1.32		13.34		8.17	
					3.52		19.69		7.40	
AL6 – 2	04-06-2021	80	42	39	4.84	6.01	24.77	18.84	7.40	8.76
					3.96		13.34		9.45	
					9.23		18.42		9.45	
AL6 – 3	09-06-2021	122	38	31	9.23	12.45	17.78	16.94	7.40	8.76
					18.90		14.61		8.17	
					9.23		18.42		10.72	
AL6 – 4	11-06-2021	72	25	44	3.52	2.93	10.80	14.61	3.32	4.25
					1.32		14.61		4.85	
					3.96		18.42		4.60	
AL6 – 5	16-06-2021	86	78	12	8.79	11.72	15.24	19.69	9.45	9.19
					13.63		20.33		9.96	
					12.75		23.50		8.17	
AL6 – 6	18-06-2021	187	32	66	11.87	6.74	19.69	18.00	5.62	6.30
					3.96		17.78		6.13	
					4.40		16.51		7.15	
AL6 – 7	23-06-2021	261	73	8	11.87	12.75	20.33	18.42	8.17	9.87
					12.75		26.68		10.72	
					13.63		8.26		10.72	
AL6 – 8	25-06-2021	123	109	26	8.35	10.26	11.43	10.16	9.96	8.25
					9.23		6.99		9.45	
					13.19		12.07		5.36	
Monthly Average		125	59	33		8.08		16.67		7.76
Standard Deviation		67	29	18		4.33		3.06		1.86

NS: Not Specified

Table 6B : Results of Air Pollutant Concentration at Tuna Port					
Parameter	Date	C_6H_6 [µg/m^3]	HC*	CO [mg/m^3]	CO_2 [ppm]
Sampling Period		8 hr	Grab Sampling	Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m^3	NS	4.0 mg/m^3	NS
AL6 -1	02/06/2021	1.2	BDL	1.72	489
AL6 – 2	04/06/2021	1.12	BDL	1.65	479
AL6 – 3	09/06/2021	1.03	BDL	1.71	466
AL6 – 4	11/06/2021	1.14	BDL	1.74	469
AL6 – 5	16/06/2021	1.05	BDL	1.71	490
AL6 – 6	18/06/2021	1.12	BDL	1.72	472
AL6 – 7	23/06/2021	1.29	BDL	1.7	470
AL6 – 8	25/06/2021	1.27	BDL	1.88	480
Monthly Average		**1.15**	**-**	**1.73**	**477**
Standard Deviation		**0.09**	**-**	**0.07**	**9**

* NMHC- Non- Methane Hydrocarbons

BDL- Below Detection Limit (Detection Limit – NMHC : 0.5 ppm)

NS- Not Specified

The mean TSPM values at Tuna Port were 125 µg/m^3, The mean PM_{10} values were 59 µg/m^3, which is below the permissible limit. $PM_{2.5}$ values were within the permissible limit (mean = 33 µg/m^3 µg/m^3). The average values of SO_2, NO_x and NH_3 were 8.08 µg/m^3, 16.67 µg/m^3 and 7.76 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Tuna Port. The mean Benzene concentration was 1.15 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.73 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

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

Table 7 : Results of Air Pollutant Concentration at Signal Building											
Parameters	**Date**	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**		
Sampling Period	**-**	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	
NAAQMS limit	**-**	**NS**	**100 µg/m3**	**60 µg/m3**	**-**	**80 µg/m3**	**-**	**80 µg/m3**	**-**	**400 µg/m3**	
AL7 -1	02-06-2021	56	27	27	3.517	4.396	10.98	9.96	17.15	17.57	
					5.715		10.47		19.69		
					3.956		8.42		15.88		
AL7 -2	04-06-2021	59	16	29	3.517	2.051	7.91	10.13	10.80	12.70	
					1.319		10.98		12.07		
					1.319		11.49		15.24		
AL7 -3	09-06-2021	51	41	26	2.198	1.905	6.13	6.30	10.80	14.19	
					1.319		3.32		12.70		
					2.198		9.45		19.05		
AL7 -4	11-06-2021	49	38	63	3.956	3.077	7.15	9.53	9.53	10.80	
					3.077		9.96		10.80		
					2.198		11.49		12.07		
AL7 -5	16-06-2021	62	51	24	1.758	3.810	10.98	9.10	10.80	11.43	
					2.198		11.49		11.43		
					7.473		4.85		12.07		
AL7 -6	18-06-2021	68	29	58	11.869	6.447	6.89	13.96	15.88	16.94	
					3.956		21.44		17.78		
					3.517		13.53		17.15		
AL7 -7	23-06-2021	63	41	24	10.110	10.843	3.318611	9.28	8.892276	10.37	
					10.990		11.4875		10.79776		
					11.429		13.01917		11.43293		
AL7 -8	25-06-2021	66	23	55	0.879	1.612	6.8925	7.23	24.77134	22.44	
					1.758		7.913611		23.50102		
					2.198		6.8925		19.05488		
Monthly Average		**59**	**33**	**38**		**4.268**		**9**		**15**	
Standard Deviation		**7**	**11**	**17**		**3.098**		**2**		**4**	

NS: Not Specified

Table 7B : Results of Air Pollutant Concentration at Signal Building					
Parameter	**Date**	**C_6H_6 [µg/m³]**	**HC***	**CO [mg/m³]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m³**	**NS**	**4.0 mg/m³**	**NS**
AL7 -1	02/06/2021	1.06	BDL	1.68	472
AL7 – 2	04/06/2021	1.11	BDL	1.72	468
AL7 – 3	09/06/2021	1.23	BDL	1.55	482
AL7 – 4	11/06/2021	1.07	BDL	1.69	492
AL7 – 5	16/06/2021	1.23	BDL	1.78	466
AL7 – 6	18/06/2021	1.21	BDL	1.92	478
AL7 – 7	23/06/2021	1.18	BDL	1.88	485
AL7 – 8	25/06/2021	1.14	BDL	1.68	488
Monthly Average		**1.15**	**-**	**1.74**	**479**
Standard Deviation		**0.07**	**-**	**0.12**	**10**

* NMHC- Non- Methane Hydrocarbons
BDL- Below Detection Limit (Detection Limit – NMHC : 0.5 ppm)
NS_ Not Specified

The mean TSPM values at Vadinar Port were 59 µg/m³. The mean PM_{10} values were 33 µg/m³, which is below the permissible limit. $PM_{2.5}$ values were also within the permissible limit (mean = 38 µg/m³ µg/m³). The average values of SO_2, NO_x and NH_3 were 4.26 µg/m³, 9 µg/m³ and 15 µg/m³ respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Vadinar Port. The mean Benzene concentration was 1.15 µg/m³, well below the permissible limit of 5.0 µg/m³. HC's were below the detectable limit and Carbon Monoxide concentration was 1.74 mg/m³, well below the permissible limit of 4.0 mg/m³.

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

Table 8 : Results of Air Pollutant Concentration at Admin Building										
Parameters	**Date**	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period	-	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit	-	**NS**	**100 µg/m3**	**60 µg/m3**	-	**80 µg/m3**	-	**80 µg/m3**	-	**400 µg/m3**
AL8 -1	02-06-2021	54	16	27	0.879	1.905	8.257	8.469	6.893	6.637
					1.758		8.257		7.148	
					3.077		8.892		5.871	
AL8 -2	04-06-2021	58	19	23	0.879	1.172	19.690	16.514	5.361	4.850
					1.758		17.149		4.850	
					0.879		12.703		4.340	
AL8 -3	09-06-2021	70	63	23	2.198	1.612	14.609	12.915	1.276	1.106
					1.319		8.257		1.021	
					1.319		15.879		1.021	
AL8 -4	11-06-2021	53	47	28	1.758	2.198	17.149	17.996	2.298	4.340
					2.198		13.338		6.382	
					2.638		23.501		4.340	
AL8 -5	16-06-2021	57	12	14	2.198	2.638	17.149	12.915	3.319	3.234
					2.638		12.703		3.063	
					3.077		8.892		3.319	
AL8 -6	18-06-2021	59	28	19	1.319	1.758	9.527	9.527	4.850	4.340
					1.758		8.257		4.340	
					2.198		10.798		3.829	
AL8 -5	23-06-2021	56	29	15	0.879	1.758	6.352	8.892	3.829	5.191
					1.319		9.527		4.340	
					3.077		10.798		7.403	
AL8-6	25-06-2021	73	51	28	0.440	0.733	13.974	15.667	7.914	8.084
					0.879		15.244		10.466	
					0.879		17.785		5.871	
Monthly Average		60	33	22		1.7217		12.862		4.72
Standard Deviation		7	18	6		0.5848		3.660		2.10

NS: Not Specified

Table 8B : Results of Air Pollutant Concentration at Admin Building					
Parameter	Date	C_6H_6 [µg/m³]	HC*	CO [mg/m³]	CO_2 [ppm]
Sampling Period		8 hr	Grab Sampling	Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m³	NS	4.0 mg/m³	NS
AL8 -1	02/06/2021	1.21	BDL	1.78	496
AL8-2	04/06/2021	1.18	BDL	1.92	477
AL8 -3	09/06/2021	1.23	BDL	1.68	468
AL8-4	11/06/2021	1.16	BDL	1.77	484
AL8 -5	16/06/2021	1.25	BDL	1.84	477
AL8-6	18/06/2021	1.22	BDL	1.68	485
AL8-7	23/06/2021	1.16	BDL	1.62	476
AL8-8	25/06/2021	1.12	BDL	1.77	466
Monthly Average		**1.19**	**-**	**1.76**	**479**
Standard Deviation		**0.04**	**-**	**0.10**	**10**

* NMHC- Non- Methane Hydrocarbons

BDL- Below Detection Limit (Detection Limit – NMHC: 0.5 ppm)

NS-Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Admin Building Vadinar was comparatively low among all the locations of Air Quality monitoring in Kandla Port and Vadinar Port. The mean TSPMvalues at Vadinar Port were 60 µg/m³. The mean PM_{10} values were 33 µg/m³, which is below the permissible limit. $PM_{2.5}$ values were also within the permissible limit (mean = 22.0 µg/m³). The average values of SO_2, NO_x and NH_3 were 1.72 µg/m³, 12.86 µg/m³ and 4.72 µg/m³ respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Admin Building, Vadinar Port. The mean Benzene concentration was 1.19 µg/m³, well below the permissible limit of 5.0 µg/m³. HC's were below the detectable limit and Carbon Monoxide concentration was 1.76 mg/m³, well below the permissible limit of 4.0 mg/m³.

1.4 Observations and Conclusion

During the monitoring period, the overall Ambient Air Quality of the port area was found to be well within the desired levels for various pollutants. However, Near Coal storage area, Marine Bhavan and Oil Jetty area, PM_{10} values was above the permissible standards. All other pollutants were recorded well below the prescribed limits.

2. Drinking Water Quality Monitoring

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

2.1 Drinking Water Monitoring Methodology

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

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

2.2 Results

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

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

Sr. No.	Parameter	Unit	Nirman Building 1	P & C building	Main Gate North	Acceptable Limits as per IS 10500 : 2012	Permissible Limits as per IS 10500 : 2012
1	pH	pH Unit	7.1	7.3	7.8	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	570	590	610	500	2000
3	Turbidity	NTU	1	1	0	1.0	5.0
4	Odor	-	Odourless	Odourless	Odourless	Agreeable	Agreeable
5	Color	Hazen Units	Colourless	Colourless	Colourless	5.0	15.0
6	Conductivity	µs/cm	1243.0	1150.0	1190.0	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2.0	<2.0	<2.0	NS*	NS*
8	Chloride as Cl	mg/l	513.19	457.02	561.25	250.0	1000.0
9	Ca as Ca	mg/l	48.10	44.09	48.10	75.0	200.0
10	Mg as Mg	mg/l	82.62	87.48	89.91	30.0	100.0
11	Total Hardness	mg/l	460.0	470.0	490.0	200.0	600.0
12	Iron as Fe	mg/l	<0.01	<0.01	<0.01	0.3	No Relaxation
13	Fluorides as F	mg/l	0.30	0.47	0.24	1.0	1.5
14	Sulphate as SO4	mg/l	232.8	180	258	200.0	400
15	Nitrite as NO2	mg/l	0.04	0.05	0.05	NS*	NS*
16	Nitrate as NO3	mg/l	0.77	9.15	28.16	45.0	No Relaxation
17	Salinity	%	0.93	0.83	1.01	NS*	NS*
18	Sodium as Na	mg/l	322.0	315.0	342.0	NS*	NS*
19	Potassium as K	mg/l	3.44	3.21	4.08	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Sr. No.	Parameter	Unit	Canteen	West Gate - I	Wharf Area	Acceptable Limits as per IS 10500 : 2012	Permissible Limits as per IS 10500 : 2012
1	pH	pH Unit	7.0	7.6	7.4	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	910.0	960.0	870.0	500	2000
3	Turbidity	NTU	0	1	0	1.0	5.0
4	Odor	-	Odourless	Odourless	Odourless	Agreeable	Agreeable
5	Color	Hazen Units	Colourless	Colourless	Colourless	5.0	15.0
6	Conductivity	µs/cm	1703.0	1753.0	1630.0	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2.0	<2.0	<2.0	NS*	NS*
8	Chloride as Cl	mg/l	613.86	620.88	658.46	250.0	1000.0
9	Ca as Ca	mg/l	52.10	52.10	44.09	75.0	200.0
10	Mg as Mg	mg/l	72.90	80.19	77.76	30.0	100.0
11	Total Hardness	mg/l	430.0	460.0	430.0	200.0	600.0
12	Iron as Fe	mg/l	<0.01	<0.01	<.0.01	0.3	No Relaxation
13	Fluorides as F	mg/l	0.47	0.32	0.42	1.0	1.5
14	Sulphate as SO4	mg/l	156.0	300.0	366.0	200.0	400
15	Nitrite as NO2	mg/l	0.03	<0.01	0.03	NS*	NS*
16	Nitrate as NO3	mg/l	24.64	10.56	12.67	45.0	No Relaxation
17	Salinity	%	1.11	1.12	1.19	NS*	NS*
18	Sodium as Na	mg/l	333.0	362.0	412.0	NS*	NS*
19	Potassium as K	mg/l	3.78	3.99	4.11	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Sr. No.	Parameter	Unit	SewaSadan – 3	Workshop	Custom Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits as per IS 10500 : 2012
1	pH	pH Unit	7.3	7.4	7.8	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1090.0	830.0	935.0	500	2000
3	Turbidity	NTU	1	0	1	1.0	5.0
4	Odor	-	Odourless	Odourless	Odourless	Agreeable	Agreeable
5	Color	Hazen Units	Colourless	Colourless	Colourless	5.0	15.0
6	Conductivity	µs/cm	1910.0	1600.0	1820.0	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2.0	<2.0	<2.0	NS*	NS*
8	Chloride	mg/l	743.65	571.77	550.72	250.0	1000.0
9	Ca as Ca	mg/l	52.10	56.11	48.10	75.0	200.0
10	Mg as Mg	mg/l	82.62	85.05	80.19	30.0	100.0
11	Total Hardness	mg/l	470.0	490.0	450.0	200.0	600.0
12	Iron as Fe	mg/l	<0.01	<0.01	<0.01	0.3	No Relaxation
13	Fluorides	mg/l	0.32	0.93	0.30	1.0	1.5
14	Sulphate	mg/l	190.8	172.8	195.6	200.0	400
15	Nitrite	mg/l	0.01	0.03	0.05	NS*	NS*
16	Nitrate	mg/l	13.37	6.33	12.67	45.0	No Relaxation
17	Salinity	%	1.34	1.03	0.99	NS*	NS*
18	Sodium as Na	mg/l	333.0	342.	392.0	NS*	NS*
19	Potassium as K	mg/l	3.88	3.71	4.12	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Sr. No.	Parameter	Unit	Port Colony Kandla	Hospital Kandla	A.O. Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits as per IS 10500 : 2012
1	pH	pH Unit	7.2	7	7.2	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1200.0	1400.0	1090.0	500	2000
3	Turbidity	NTU	0	0	1	1.0	5.0
4	Odor	-	Odourless	Odourless	Odourless	Agreeable	Agreeable
5	Color	Hazen Units	Colourless	Colourless	Colourless	5.0	15.0
6	Conductivity	µs/cm	2512.0	2830.0	1920.0	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2.0	<2.0	<2.0	NS*	NS*
8	Chloride	mg/l	763.70	794.77	838.86	250.0	1000.0
9	Ca as Ca	mg/l	56.11	48.10	60.12	75.0	200.0
10	Mg as Mg	mg/l	77.76	80.19	77.76	30.0	100.0
11	Total Hardness	mg/l	460.0	450.0	470.0	200.0	600.0
12	Iron as Fe	mg/l	<0.01	<0.01	<0.01	0.3	No Relaxation
13	Fluorides	mg/l	0.77	0.12	0.21	1.0	1.5
14	Sulphate	mg/l	202.8	261.6	372	200.0	400
15	Nitrite	mg/l	0.05	0.05	0.06	NS*	NS*
16	Nitrate	mg/l	5.63	12.67	16.89	45.0	No Relaxation
17	Salinity	%	1.38	1.44	1.52	NS*	NS*
18	Sodium as Na	mg/l	322.0	373.0	432.0	NS*	NS*
19	Potassium as K	mg/l	3.61	3.81	4.45	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Sr. No.	Parameter	Unit	School Gopalpuri	Guest House	E - Type Quarter	Acceptable Limits as per IS 10500 : 2012	Permissible Limits as per IS 10500 : 2012
1	pH	pH Unit	7.1	7.3	7.4	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	970.0	1010.0	1135.0	500	2000
3	Turbidity	NTU	0	1	0	1.0	5.0
4	Odor	-	Odourless	Odourless	Odourless	Agreeable	Agreeable
5	Color	Hazen Units	Colourless	Colourless	Colourless	5.0	15.0
6	Conductivity	µs/cm	1850.0	1920.0	2210.0	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2.0	<2.0	<2.0	NS*	NS*
8	Chloride	mg/l	708.58	615.87	845.88	250.0	1000.0
9	Ca as Ca	mg/l	56.11	52.10	56.11	75.0	200.0
10	Mg as Mg	mg/l	82.62	85.05	85.05	30.0	100.0
11	Total Hardness	mg/l	480.0	480.0	490.0	200.0	600.0
12	Iron as Fe	mg/l	<0.01	<0.01	<0.01	0.3	No Relaxation
13	Fluorides	mg/l	1.37	0.89	0.33	1.0	1.5
14	Sulphate	mg/l	369.6	384	376.8	200.0	400
15	Nitrite	mg/l	0.04	0.06	0.04	NS*	NS*
16	Nitrate	mg/l	7.74	6.33	12.67	45.0	No Relaxation
17	Salinity	%	1.28	1.11	1.53	NS*	NS*
18	Sodium as Na	mg/l	392.0	320.0	332.0	NS*	NS*
19	Potassium as K	mg/l	4.11	3.11	3.29	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Sr. No.	Parameter	Unit	F - Type Quarter	Hospital Gopalpuri	Tuna Port	Acceptable Limits as per IS 10500 : 2012	Permissible Limits as per IS 10500 : 2012
1	pH	pH Unit	7	7.3	7.38	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	890.0	950.0	1030.0	500	2000
3	Turbidity	NTU	1	0	0	1.0	5.0
4	Odor	-	Odourless	Odourless	Odorless	Agreeable	Agreeable
5	Color	Hazen Unit	Colourless	Colourless	Colorless	5.0	15.0
6	Conductivity	µs/cm	1700.0	2030.0	1920.0	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2.0	<2.0	<2	NS*	NS*
8	Chloride	mg/l	706.57	545.21	692.0	250.0	1000.0
9	Ca as Ca	mg/l	52.10	56.11	69.74	75.0	200.0
10	Mg as Mg	mg/l	85.05	85.05	38.39	30.0	100.0
11	Total Hardness	mg/l	480	490	332.0	200.0	600.0
12	Iron as Fe+3	mg/l	<0.01	<0.01	<0.01	0.3	No Relaxation
13	Fluorides	mg/l	0.65	1.00	0.39	1.0	1.5
14	Sulphate	mg/l	358.8	378	112.8	200.0	400
15	Nitrite	mg/l	0.06	0.04	<0.01	NS*	NS*
16	Nitrate	mg/l	9.856	11.264	1.42	45.0	No Relaxation
17	Salinity	%	1.28	0.98	1.23	NS*	NS*
18	Sodium as Na	mg/l	373.0	351.0	344	NS*	NS*
19	Potassium as K	mg/l	4.07	3.87	3.4	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Sr. No.	Parameter	Unit	Vadinar Jetty	Port Colony Vadinar	Acceptable Limits as per IS 10500 : 2012	Permissible Limits as per IS 10500 : 2012
1	pH	pH Unit	7.5	7.3	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	990.0	1010.0	500	2000
3	Turbidity	NTU	0.00	1.00	1.0	5.0
4	Odor	-	Odourless	Odourless	Agreeable	Agreeable
5	Color	Hazen Units	Colourless	Colourless	5.0	15.0
6	Conductivity	µs/cm	1830.0	1990.0	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2.0	<2.0	NS*	NS*
8	Chloride	mg/l	445.99	496.10	250.0	1000.0
9	Ca as Ca	mg/l	52.104	56.11	75.0	200.0
10	Mg as Mg	mg/l	80.19	80.19	30.0	100.0
11	Total Hardness	mg/l	460.0	470.0	200.0	600.0
12	Iron as Fe+3	mg/l	<0.01	<0.01	0.3	No Relaxation
13	Fluorides	mg/l	0.82	0.94	1.0	1.5
14	Sulphate	mg/l	30.00	34.80	200.0	400
15	Nitrite	mg/l	0.04	0.04	NS*	NS*
16	Nitrate	mg/l	4.93	4.79	45.0	No Relaxation
17	Salinity	%	0.81	0.90	NS*	NS*
18	Sodium as Na	mg/l	311.0	306.0	NS*	NS*
19	Potassium as K	mg/l	4.3	4.9	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent

*NS: Not Specified

2.3 Results & Discussion

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

pH

The limit of pH value for drinking water is specified as 6.5 to 8.5. pH value in the studied area varied from 6.9 to 7.8 pH unit. All the sampling points showed pH values within the prescribed limit by Indian Standards.

Total Dissolved Solids (TDS)

TDS values in the studied area varied between 600 -1800 mg/l. None of the sampling points showed higher TDS values than the prescribed limit by Indian standards .

Conductivity

Electrical Conductivity is the ability of a solution to transfer (conduct) electric current. Conductivity is used to measure the concentration of dissolved solids which have been ionized in a polar solution such as water. The conductivity in the samples collected during the month of June ranged from 2000-3800 µs/cm. Electrical conductivity standards do not appear in BIS standards for drinking water.

BOD

BOD value in the studied area was less than 2.0 mg/L. Indian standards does not show any standard values for BOD in drinking water.

Chlorides

Excessive chloride concentration increase rates of corrosion of metals in the distribution system. This can lead to increased concentration of metals in the supply. Chloride value in the studied area varied between 380-960 mg/l and is found to be within the Permissible limit of the Drinking Water Standard.

Calcium

Calcium value in the studied area varied between 60 - 90 mg/l and is found to be within the Permissible limit of the Drinking Water Standard. If calcium is present beyond the maximum acceptable limit, it causes incrustation of pipes.

Magnesium

Magnesium value in the studied area varied between 25 – 90 mg/l. All the locations had Magnesium within the prescribed limits of 30-100 mg/L.

Total Hardness

Hardness value in the studied area varied between 312-520 mg/l and is found to be within the Permissible limit of the Drinking Water Standard.The prescribed limit by Indian Standards is 200-600 mg/L.

Iron

Iron value in the studied area was below 0.01mg/L and hence well below the permissible limit as per Indian Standards is 0.3 mg/L. The excess amount of iron causes slight toxicity; gives stringent taste to water.

Fluoride

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

Sulphates

Sulphate value in the studied area varied between 100 – 330 mg/l. All the sampling points showed sulphate values within the prescribed limits by Indian Standards (200-400 mg/L). Sulphate content in drinking water exceeding the 400 mg/L imparts bitter taste.

Nitrites (NO_2) and Nitrates (NO_3)

Nitrite values in all the water samples were <0.1. There are no specified standard values for Nitrites in Drinking water. The mean Nitrate values in drinking water of KPT was 4.10 mg/l which is well within the permissible limit of the Drinking water Standard.

Salinity

Salinity in drinking water in the present samples collected ranged from 0.6 to 1.8 % . There are no prescribed Indian standards for salinity in Drinking water.

Sodium and Potassium Salts

Sodium values in the samples collected ranged from 80 - 460 mg/l and Potassium salts ranged from 2.8 to 4.6 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 permissible limits prescribed by the Indian Standards.

Bacteriological Study

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

2.4 Conclusions

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

3. Noise Level Monitoring

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

3.1 Method of Monitoring

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

3.2 Results

Table 16: Noise Monitoring data for ten locations of Deendayal Port and two 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	63.40	57.1
2	Nirman Building 1	57.8	53.9
3	Tuna Port	55.8	47.1
4	Main Gate North	57.1	52.8
5	West Gate I	62.1	54.6
6	Canteen Area	57.1	49.6
7	Main Road	60.0	57.8
8	ATM Building	63.5	56.2
9	Wharf Area /Jetty Area	67.1	57.8
10	Port & Custom Office	55.5	52.7
	Vadinar Port		
11	Entrance Gate of Vadinar Port	57.1	54.6
12	Nr. Port Colony, Vadinar	56.2	56.2
13	Nr. Vadinar Jetty	59.6	55.8

3.3 Conclusions- Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. The Day Time Average Noise Level (SPL)in all ten locations at Deendayal Port ranged from 56.25 dB(A) to 69.51 dB(A) and it was within the permissible limits of 75 dB(A) for the industrial area for the daytime. The Night Time Average Noise Level (SPL) in all ten locations of Deendayal Port ranged from 48.28 dB to 62.33 dB(A) and it was within the permissible limits of 70 dB(A) for the industrial area for the night time.

4. Soil Monitoring

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

4.1 Methodology

The soil samples were collected in the month of June 2021. The samples collected from the all locations are homogeneous representative of each location. At random locations were identified at each location and soil was dug from 30 cm below the surface. It was uniformly mixed before homogenizing the soil samples. The samples were filled in polythene bags, labeled in the field with number and site name and sent to laboratory for analysis.

4.2 Results

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

Sr. No.	Parameter	Unit	Station Name					
			SL1	SL2	SL3	SL4	SL5	SL6
			Tuna Port	IFFCO Plant	Khori Creek	Nakti Creek	KPT Admin Site	KPT Colony
			Near main gate of Port	10 m away from main gate	Sand from creek at low tide		Vadinar	
1	Texture		Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	pH	-	7.30	8.16	8.36	8.26	7.27	7.82
3	Electrical Conductivity	µs/cm	33400.0	48500.0	21800.0	37200.0	511.0	464.0
4	Moisture	%	21.45	13.94	18.82	14.26	6.28	4.56
5	Total Organic Carbon	%	0.31	0.19	0.26	0.24	0.15	0.11
6	Alkalinity	mg/kg	100.1	140.14	80.08	140.14	60.06	100.1
7	Total Nitrogen	%	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
8	Chloride	mg/kg	6228.7	6032.5	2550.3	7160.6	68.66	78.47
9	Sulphate	mg/kg	2056.4	75.86	292.0	87.84	14.37	13.58
10	Phosphorus	mg/kg	0.97	1.41	0.79	1.59	0.97	0.97
11	Potassium	mg/kg	1161.0	592.2	700.2	765.0	626.4	876.4
12	Calcium	mg/kg	641.3	561.12	701.4	661.32	124.2	172.3
13	Sodium	mg/kg	10821.6	2992.8	3164.4	3736.8	2116.8	2565.0
14	Copper as Cu	mg/kg	11.21	27.22	28.20	31.78	82.66	72.42
15	Lead as Pb	mg/kg	3.10	6.20	23.0	11.4	ND	ND
16	Nickel as Ni	mg/kg	20.71	1823	7.80	15.10	25.46	27.73
17	Zinc as Zn	mg/kg	32.26	72.62	65.90	77.21	23.46	43.20
18	Cadmium as Cd	mg/kg	ND	ND	ND	ND	ND	ND

4.3 Discussion

- The data shows that value of pH ranges from 8.68at Nakti Creek to 9.02 at Tuna Creek indicating that all soil sample sare neutral to basic. Iffco plant samples howed maximum conductivity of 36,200µmhos/cm, while Nakti Creek location showed minimum conductivity of 4790µmhos/cm. Conductivity at Vadinar Port was 439 and 634 µmhos/cm at Admin site and Vadinar Port colony respectively.
- Total organic Carbon ranged from 0.7 % to 2.3 at Deendayal Port. At Vadinar Port, organic carbon content ranged from 0.8 % to 1.04 %.
- The concentration of Phosphorus and Potassium in the soil samples varies from 34.0 to 53.0mg/kg and 700.0 to 1100 mg/kg respectively at Deendayal Port. The mean concentration of Phosphorous at Vadinar site was 6.82 mg/kg and mean concentration of Potassium at Vadinar site was 176.5 mg/kg.

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

Heavy Metals in the Soil

Traces of Copper, Lead, Nickel, Zinc were observed in the soil samples collected from all the four locations of Deendayal Port and two locations of Vadinar Port. Cadmium metal was not detected in the Soil.

4.4 Conclusion

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

5. Sewage Treatment Plant Monitoring

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

5.1 Methodology for STP Monitoring

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

5.2 Results

- **Kandla STP**

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

Date of Sampling	05.06.21

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	7.62	7.23
2	Total Suspended Solids	mg/l	450	38.2
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	494.9	40.4
5	BOD @ 27 °C	mg/l	152.0	12.0
Aeration Tank				
6	MLSS	mg/l	40.0	
7	MLVSS	%	82.0	

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

Date of Sampling	10.06.21

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	7.93	7.13
2	Total Suspended Solids	mg/l	268.3	58.3
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	289.87	63.63
5	BOD @ 27 °C	mg/l	94.0	16.0
Aeration Tank				
6	MLSS	mg/l	36.0	
7	MLVSS	%	74.0	

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

Date of Sampling	15.06.21

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	7.43	7.23
2	Total Suspended Solids	mg/l	210.5	99
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	259.57	31.31
5	BOD @ 27 °C	mg/l	72.0	8.0
Aeration Tank				
6	MLSS	mg/l	36.0	
7	MLVSS	%	78.0	

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

Date of Sampling	21.06.21

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	7.71	7.02
2	Total Suspended Solids	mg/l	226.1	18.3
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	303.0	96.0
5	BOD @ 27 °C	mg/l	110.0	18.0
Aeration Tank				
6	MLSS	mg/l	20.0	
7	MLVSS	%	96.0	

- **Gopalpuri Colony STP**

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

Date of Sampling	05.06.21

Sr. No.	Parameters	Unit	Results	
			Gopalpuri STP I/L	Gopalpuri STP O/L
1	pH	pH unit	7.21	7.09
2	Total Suspended Solids	mg/l	166.7	54.9
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	383.8	84.4
5	BOD @ 27 °C	mg/l	124.0	16.0
Aeration Tank				
6	MLSS	mg/l	28.0	
7	MLVSS	%	86.0	

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

Date of Sampling	10.06.21

Sr. No.	Parameters	Unit	Results	
			Gopalpuri STP I/L	Gopalpuri STP O/L
1	pH	pH unit	7.7	7.26
2	Total Suspended Solids	mg/l	95.21	41.9
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	431.27	109.8
5	BOD @ 27 °C	mg/l	138.0	19.0
Aeration Tank				
6	MLSS	mg/l	18.0	
7	MLVSS	%	96.0	

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

Date of Sampling	15.06.21

Sr. No.	Parameters	Unit	Results	
			Gopalpuri STP I/L	Gopalpuri STP O/L
1	pH	pH unit	7.53	7.29
2	Total Suspended Solids	mg/l	52.9	20.1
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	230.28	57.57
5	BOD @ 27 °C	mg/l	76.0	15.0
Aeration Tank				
6	MLSS	mg/l	12.0	
7	MLVSS	%	92.0	

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

Date of Sampling	21.06.21

Sr. No.	Parameters	Unit	Results	
			Gopalpuri STP I/L	Gopalpuri STP O/L
1	pH	pH unit	7.25	7.12
2	Total Suspended Solids	mg/l	183.8	89
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	202	20.2
5	BOD @ 27 °C	mg/l	68.0	6.0
Aeration Tank				
6	MLSS	mg/l	38.0	
7	MLVSS	%	98.0	

- **Vadinar STP**

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

Date of Sampling	05.06.21

Sr. No.	Parameters	Unit	Results	
			Vadinar STP I/L	Vadinar O/L
1	pH	pH unit	7.26	NOT WORKING
2	Total Suspended Solids	mg/l	139.5	
3	Residual Chlorine	mg/l	<1.0	
4	COD	mg/l	222.2	
5	BOD @ 27 °C	mg/l	86.0	

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

Date of Sampling	05.06.21

Sr. No.	Parameters	Unit	Results	
			Vadinar STP I/L	Vadinar O/L
1	pH	pH unit	7.36	NOT WORKING
2	Total Suspended Solids	mg/l	108.8	
3	Residual Chlorine	mg/l	<1.0	
4	COD	mg/l	353.5	
5	BOD @ 27 °C	mg/l	108.0	

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

Date of Sampling	15.06.21

Sr. No.	Parameters	Unit	Results	
			Vadinar STP I/L	Vadinar O/L
1	pH	pH unit	7.14	NOT WORKING
2	Total Suspended Solids	mg/l	166.7	
3	Residual Chlorine	mg/l	<1.0	
4	COD	mg/l	171.7	
5	BOD @ 27 °C	mg/l	52.0	

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

Date of Sampling	21.06.21

Sr. No.	Parameters	Unit	Results	
			Vadinar STP I/L	Vadinar O/l
1	pH	pH unit	7.26	Not working
2	Total Suspended Solids	mg/l	203.5	
3	Residual Chlorine	mg/l	<1.0	
4	COD	mg/l	90.9	
5	BOD @ 27 °C	mg/l	28.0	

5.3 Conclusions:

The GPCB standards of BOD, TSS and Residual Chlorine for STP outlet are 20 mg/lit, 30 mg/lit & 0.5 mg/lit respectively. It is suggested to do treatment on regular basis to avoid flow of contaminated/polluted water into the sea. Also, the STP at Vadinar is also non-functional and thus, steps should be taken to commission the STP at Vadinar Port. Hence, currently only inlet samples are collected and analysed.

6. Marine Water Monitoring

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

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

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

Marine Environment

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

Sampling Stations

The monitoring of marine environment for the study of biological and ecological parameters was carried out on 10th& 11th June -2021 in harbor regions of KPT and on 10th June-2021 at Vadinar during spring tide period of New moon phase of Lunar Cycle. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 18th& 19th June 2021 in harbor regions of KPT. 18th June -2021 in Vadinar during Neap tide period first quarter of Lunar Cycle..

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

Sampling Locations

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

6.1 Marine Water Quality

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

The results of marine water quality and Marine sediments are as below;

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

Sr. No.	Parameters	Unit	Kandla Creek Near KPT colony (1)			
			23°0'58"N 70°13'22."E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.21	7.35	7.18	7.14
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31.7	32.1	32.8	
5	Turbidity	NTU	29	28	28	24
6	Total Dissolved Solids	mg/l	31107.0	35947.0	37797.0	33665.0
7	Total Suspended Solids	mg/l	377.4	359.9	714.2	412.4
8	Total Solids	mg/l	31560.0	36800.0	38860.0	34260.0
9	DO	mg/l	4.9	4.6	3.5	3.3
10	COD	mg/l	78.0	82.0	72.0	76.0
11	BOD	mg/l	<2.0	<2.0	<2.0	<2.0
12	Silica	mg/l	0.23	0.25	0.56	0.38
13	Phosphate	mg/l	0.35	0.36	0.27	0.24
14	Sulphate	mg/l	3360	3156	2628	3216
15	Nitrate	mg/l	1.97	2.35	2.14	2.78
16	Nitrite	mg/l	<0.01	<0.01	<0.01	<0.01
17	Calcium	mg/l	561.12	641.28	641.28	521.04
18	Magnesium	mg/l	1676.7	1676.7	1555.2	1725.3
19	Sodium	mg/l	11220.0	12080.0	8194.0	7418.0
20	Potassium	mg/l	380.0	390.0	372.0	414.0
21	Iron	mg/l	1.48	1.66	1.76	1.92
22	Chromium	mg/l	0.11	0.13	0.12	0.13
23	Copper	mg/l	0.05	0.06	0.06	0.07
24	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01
25	Cadmium	mg/l	0.06	0.08	0.05	0.06
26	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001
27	Lead	mg/l	0.15	0.17	0.16	0.18
28	Zinc	mg/l	0.06	0.07	0.05	0.06

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

Sr. No.	Parameters	Unit	Near passenger Jetty One (2) 23° 0'18 "N 70°13'31"E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.5	7.5	7.28	7.15
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	32.0	32.1	32.6	32.1
5	Turbidity	NTU	29	31	39	29
6	Total Dissolved Solids	mg/l	39865.0	39935.0	41765.0	36900.0
7	Total Suspended Solids	mg/l	366.8	414.5	404.0	477.9
8	Total Solids	mg/l	40212.0	40500.0	46018.0	37338.0
9	DO	mg/l	5.1	5.0	3.5	3.5
10	COD	mg/l	82.0	92.0	78.0	80.0
11	BOD	mg/l	<2.0	<2.0	<2.0	<2.0
12	Silica	mg/l	0.25	0.27	0.81	0.32
13	Phosphate	mg/l	0.35	0.32	0.20	0.33
14	Sulphate	mg/l	3120.0	3708.0	3336.0	2880.0
15	Nitrate	mg/l	6.0	2.54	1.35	4.33
16	Nitrite	mg/l	<0.01	<0.01	<0.01	<0.01
17	Calcium	mg/l	721.44	601.2	681.36	561.12
18	Magnesium	mg/l	1701.0	1603.8	1676.7	1725.3
19	Sodium	mg/l	11460.0	13211.0	9929.0	10111.0
20	Potassium	mg/l	390.0	382.0	471.0	381.0
21	Iron	mg/l	1.76	1.56	1.72	1.80
22	Chromium	mg/l	0.13	0.11	0.14	0.12
23	Copper	mg/l	0.06	0.07	0.08	0.07
24	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01
25	Cadmium	mg/l	0.05	0.06	0.06	0.07
26	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001
27	Lead	mg/l	0.18	0.16	0.17	0.16
28	Zinc	mg/l	0.06	0.06	0.07	0.07

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

Sr. No.	Parameters	Unit	Near Coal Berth			
			22°59'12"N 70°13'40"E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.3	7.21	7.2	7.5
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31.0	32.2	32.0	32.3
5	Turbidity	NTU	33.0	31.0	31.8	32.0
6	Total Dissolved Solids	mg/l	34545.0	37030.0	35312.0	35363.0
7	Total Suspended Solids	mg/l	275.3	344.5	563.5	603.2
8	Total Solids	mg/l	35266.0	38080.0	36540	36100.0
9	DO	mg/l	4.8	4.6	4.2	4.3
10	COD	mg/l	86.0	92.0	101.0	100.0
11	BOD	mg/l	<2.0	<2.0	<2.0	<2.0
12	Silica	mg/l	0.27	0.20	0.38	0.22
13	Phosphate	mg/l	0.28	0.30	0.22	0.21
14	Sulphate	mg/l	1344	1500	2436	3240
15	Nitrate	mg/l	5.56	5.70	2.45	2.27
16	Nitrite	mg/l	0.028	0.02	0.04	0.02
17	Calcium	mg/l	641.28	681.36	601.2	641.28
18	Magnesium	mg/l	1555.2	1676.7	1652.4	1725.3
19	Sodium	mg/l	12015.0	11852.0	9320.0	9481.0
20	Potassium	mg/l	343.0	355.0	491.0	512.0
21	Iron	mg/l	1.44	1.23	1.64	1.34
22	Chromium	mg/l	0.12	0.10	0.12	0.13
23	Copper	mg/l	0.06	0.05	0.06	0.06
24	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01
25	Cadmium	mg/l	0.05	0.06	0.06	0.07
26	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001
27	Lead	mg/l	0.18	0.12	0.16	0.14
28	Zinc	mg/l	0.06	0.06	0.05	0.06

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

Sr. No.	Parameters	Unit	KPT 4			
			Near 15/16 Berth			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.43	7.59	7.21	7.39
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	32.2	33.1	31.8	31.6
5	Turbidity	NTU	37	35	25	47
6	Total Dissolved Solids	mg/l	40837.0	45070.0	33588.0	33133.0
7	Total Suspended Solids	mg/l	299.2	315.5	407.3	438.9
8	Total Solids	mg/l	42994.0	46208.0	34336.0	34040.0
9	DO	mg/l	4.7	4.5	4.4	3.6
10	COD	mg/l	86.0	92.0	78.0	80.0
11	BOD	mg/l	<2.0	<2.0	<2.0	<2.0
12	Silica	mg/l	0.24	2.34	0.63	0.41
13	Phosphate	mg/l	0.28	0.32	0.26	0.28
14	Sulphate	mg/l	2628	2124	2988	2148
15	Nitrate	mg/l	7.25	2.64	4.67	7.08
16	Nitrite	mg/l	0.02	0.02	0.02	0.02
17	Calcium	mg/l	641.28	601.2	641.28	601.2
18	Magnesium	mg/l	1628.1	1749.6	1676.7	1652.4
19	Sodium	mg/l	10920.0	10962.0	9381.0	9252.0
20	Potassium	mg/l	344.0	352.0	366.0	488.0
21	Iron	mg/l	1.72	1.49	1.56	1.66
22	Chromium	mg/l	0.12	0.11	0.12	0.10
23	Copper	mg/l	0.05	0.05	0.06	0.05
24	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01
25	Cadmium	mg/l	0.06	0.07	0.08	0.07
26	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001
27	Lead	mg/l	0.18	0.16	0.15	0.14
28	Zinc	mg/l	0.06	0.05	0.05	0.06

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

Sr. No.	Parameters	Unit	Nakti Creek Near Tuna Port			
			22°57'49."N 70° 7'0.67"E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.39	7.21	7.73	7.7
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	32.2	31.8	32.4	31.6
5	Turbidity	NTU	34	60	39	49
6	Total Dissolved Solids	mg/l	48922.0	26656.0	39244.0	26963.0
7	Total Suspended Solids	mg/l	287.3	243.68	326.4	214.2
8	Total Solids	mg/l	49728.0	27300.0	40996.0	27294.0
9	DO	mg/l	4.6	4.9	4.2	3.5
10	COD	mg/l	96.0	98.0	88.0	82.0
11	BOD	mg/l	<2.0	<2.0	<2.0	<2.0
12	Silica	mg/l	0.28	0.29	0.61	0.74
13	Phosphate	mg/l	0.35	0.37	0.18	0.18
14	Sulphate	mg/l	3480	2868	2316	3480
15	Nitrate	mg/l	5.28	2.80	4.50	4.58
16	Nitrite	mg/l	0.02	<0.01	<0.01	0.03
17	Calcium	mg/l	601.2	721.44	521.04	601.2
18	Magnesium	mg/l	1749.6	1628.1	1773.9	1773.9
19	Sodium	mg/l	12126.0	12102.0	10821.0	10728.0
20	Potassium	mg/l	352.0	372.0	521.0	510.0
21	Iron	mg/l	1.52	1.42	1.56	1.59
22	Chromium	mg/l	0.16	0.14	0.13	0.15
23	Copper	mg/l	0.07	0.08	0.07	0.07
24	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01
25	Cadmium	mg/l	0.08	0.07	0.07	0.07
26	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001
27	Lead	mg/l	0.14	0.12	0.12	0.13
28	Zinc	mg/l	0.05	0.06	0.06	0.07

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

Sr. No.	Parameters	Unit	Nakti Creek Near NH-8A			
			23° 02'01"N 70° 09'31"E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.3	Sampling not possible during Low Tide	7.51	Sampling not possible during Low Tide
2	Color	-	Colorless		Colorless	
3	Odor	-	Odorless		Odorless	
4	Salinity	ppt	32.2		32.8	
5	Turbidity	NTU	37		38	
6	Total Dissolved Solids	mg/l	34970		35210.0	
7	Total Suspended Solids	mg/l	736.8		318.3	
8	Total Solids	mg/l	36048.0		36110.0	
9	DO	mg/l	5.1		3.9	
10	COD	mg/l	98.0		110.0	
11	BOD	mg/l	<2.0		<2.0	
12	Silica	mg/l	0.31		0.98	
13	Phosphate	mg/l	0.28		0.29	
14	Sulphate	mg/l	3720		2220	
15	Nitrate	mg/l	5.45		3.62	
16	Nitrite	mg/l	0.03		0.04	
17	Calcium	mg/l	721.44		681.36	
18	Magnesium	mg/l	1506.6		1749.6	
19	Sodium	mg/l	11622.0		10303.0	
20	Potassium	mg/l	486.0		495.0	
21	Iron	mg/l	1.49		1.62	
22	Chromium	mg/l	0.13		0.14	
23	Copper	mg/l	0.08		0.08	
24	Arsenic	mg/l	<0.01		<0.01	
25	Cadmium	mg/l	0.05		0.07	
26	Mercury	mg/l	<0.001		<0.001	
27	Lead	mg/l	0.19		0.14	
28	Zinc	mg/l	0.07		0.06	

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

Sr. No.	Parameters	Unit	Nr.Vadinar Jetty			
			22°26'25.26"N 69°40'20.41"E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.25	7.36	7.26	7.21
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31.8	32.2	31.2	32.0
5	Turbidity	NTU	5	9	21	15
6	Total Dissolved Solids	mg/l	34444	31931	37088	41030
7	Total Suspended Solids	mg/l	258	482	405.5	399.5
8	Total Solids	mg/l	34948.0	32054.0	37892.0	41410.0
9	DO	mg/l	3.8	4.2	1.9	2.8
10	COD	mg/l	86.0	88.0	72.0	68.0
11	BOD	mg/l	<2.0	<2.0	<2.0	<2.0
12	Silica	mg/l	0.21	0.30	0.45	0.39
13	Phosphate	mg/l	0.28	0.30	0.16	0.14
14	Sulphate	mg/l	3012	3192	2388	1980
15	Nitrate	mg/l	5.7376	4.32256	0.07744	3.4496
16	Nitrite	mg/l	0.02	0.02	0.02	<0.01
17	Calcium	mg/l	561.12	521.04	561.12	521.04
18	Magnesium	mg/l	1409.4	1603.8	1579.5	1676.7
19	Sodium	mg/l	11720.0	12118.0	10062.0	10080.0
20	Potassium	mg/l	458.0	456.0	406.0	412.0
21	Iron	mg/l	1.77	1.56	1.66	1.62
22	Chromium	mg/l	0.13	0.12	0.16	0.15
23	Copper	mg/l	0.07	0.06	0.05	0.06
24	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01
25	Cadmium	mg/l	0.04	0.04	0.05	0.05
26	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001
27	Lead	mg/l	0.18	0.19	0.17	0.16
28	Zinc	mg/l	0.08	0.08	0.06	0.07

6.1.1 Marine Sediments

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

6.2 Results

The Sediment Quality results are given in below from table no. 33

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

Sr. No.	Parameters	Unit	KPT - 1	KPT - 2	KPT - 3	Khori - 1	Nakti Creek Near Tuna Port	Nakti - 1 (Near NH-8A)	Jetty
1	Texture		Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	1.20	1.88	1.20	1.30	1.76	1.88	1.56
3	Organic Carbon	mg/kg	0.80	0.96	0.87	0.87	0.69	0.78	0.78
4	Inorganic Phosphate	mg/kg	132.0	126.0	156.0	177.0	167.0	182.0	175.0
5	Moisture	%	24.96	26.86	21.33	16.64	26.33	22.78	23.01
6	Aluminium	mg/kg	ND	ND	ND	ND	ND	ND	ND
7	Silica	mg/kg	23.0	22.0	26.0	28.0	32.0	36.0	40.0
8	Phosphate	mg/kg	10.80	11.50	11.77	12.71	9.24	9.88	10.20
9	Sulphate	mg/kg	218.0	252.0	138.0	225.2	239.0	280.0	252.0
10	Nitrite	mg/kg	0.1	0.12	0.13	0.12	0.13	0.12	0.13
11	Nitrate	mg/kg	9.20	7.22	10.42	8.88	8.02	7.89	6.88
12	Calcium	mg/kg	861.0	1102.0	801.0	862.0	922.0	1082.0	802.0
13	Magnesium	mg/kg	437.0	851.0	693.0	765.0	449.0	522.0	422.0
14	Sodium	mg/kg	2083.0	2387.0	1937.0	1859.0	2857.0	2034.0	2185.0
15	Potassium	mg/kg	707.0	918.0	954.0	774.0	1058.0	779.0	792.0
16	Chromium	mg/kg	123.0	180.0	140.0	138.2	146.0	92.0	145.0
17	Nickel	mg/kg	26.0	23.2	28.9	26.2	32.6	33.6	37.7
18	Copper	mg/kg	46	42.7	21.20	36.0	37.2	29.6	26.8
19	Zinc	mg/kg	32.35	38.30	36.70	40.	41.00	39.00	40.00
20	Cadmium	mg/kg	ND	ND	ND	ND	ND	ND	ND
21	Lead	mg/kg	2.86	2.8	5.2	5.0	4.2	5.6	7.2
22	Mercury	mg/kg	ND	ND	ND	ND	ND	ND	ND
23	Arsenic	mg/kg	ND	ND	ND	ND	ND	ND	ND

*Grab samples could not be collected due high current at Vadinar SBM

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

Sr. No.	Parameters	Unit	KPT - 1	KPT - 3	Khori - 1	Nakti Creek Near Tuna Port	Nakti – 1 (Near NH-8A)	Jetty
1	Texture		Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam
2	Organic Matter	mg/kg	1.46	1.22	1.66	1.55	1.46	1.35
3	Organic Carbon	mg/kg	0.84	0.69	0.48	0.90	0.96	0.78
4	Inorganic Phosphate	mg/kg	155.0	148.0	162.0	149.0	164.0	166.0
5	Moisture	%	24.9	22.05	28.4	30.08	28.62	20.30
6	Aluminium	mg/kg	ND	ND	ND	ND	ND	ND
7	Silica	mg/kg	23.8	22.5	21.82	33.6	32.8	26.0
8	Phosphate	mg/kg	8.53	7.97	9.80	8.62	9.88	11.06
9	Sulphate	mg/kg	196.6	163.89	184.45	140.0	152.0	171.88
10	Nitrite	mg/kg	0.11	0.13	0.14	0.12	0.14	0.12
11	Nitrate	mg/kg	6.42	7.77	6.88	6.89	7.02	8.88
12	Calcium	mg/kg	288.6	212.0	232.4	284.0	296.0	224.0
13	Magnesium	mg/kg	177.4	177.0	170.76	197.2	188.0	535.0
14	Sodium	mg/kg	2662.0	1216.0	990.0	828.0	910.0	1150.0
15	Potassium	mg/kg	200.0	106.0	50.2	79.0	89.0	110.0
16	Chromium	mg/kg	145.0	133.0	146.0	126.0	101.0	166.0
17	Nickel	mg/kg	31.2	26.6	20.3	28.2	27.8	20.9
18	Copper	mg/kg	54.2	26.5	16.2	12.10	11.02	42.0
19	Zinc	mg/kg	23.0	31.0	24.62	29.42	33.36	42.52
20	Cadmium	mg/kg	ND	ND	ND	ND	ND	ND
21	Lead	mg/kg	ND	4.2	4.0	4.2	4.2	3.8
22	Mercury	mg/kg	ND	ND	ND	ND	ND	ND
23	Arsenic	mg/kg	ND	ND	ND	ND	ND	ND

*Grab samples could not be collected due high current at KPT 2, Vadinar Jetty and Vadinar SBM

REPORT

ON

ECOLOGICAL MONITORING

OF MARINE ENVIRONMENT

IN

DPT HARBOURAREA, NEAR BY CREEKS

For

DEENDAYAL PORT TRUST

JUNE, 2021

DCPL/DPT/20-21/14-June - 2021

INTRODUCTION:

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

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

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

MARINE ENVIRONMENT:

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

Sampling Stations:

The monitoring of marine environment for the study of biological and ecological Parameters was carried out on 10th June, 2021 in in harbour region of DPT, and on 11thJune, 2021 in creeks near by the port during spring tide .The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 18th June, 2021 in harbour region of DPT and on19thJune, 2021 in creeks near by the port during neap tidal condition .

Plankton samples from sub surface layer was collected both during high tide period and low tide period from 3 water quality monitoring stations of DPT harbour area andone 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. Collected water samples were processed for estimation of Chlorophyll- a, Pheophytin- a, qualitative &quantitative evaluation of phytoplankton, qualitative &quantitative evaluation zooplanktons (density and their population).

TABLE #1 SAMPLING LOCATIONS

monitoring requirement	**Number of locations**
Kandla creek Nakti creek Khori Creek	3 in Kandla creek 2 in Nakti creek 1 in Khori creek
Total Number of locations	**6**

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

Samples Processing for chlorophyll estimation:

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

PLANKTON:

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

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

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

Phytoplankton in the marine environment:

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

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

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

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

Zooplankton in the marine environment:

Zooplankton includes a taxonomically and morphologically diverse community of heterotrophic organisms that drift in the waters of the world's oceans. Qualitative and quantitative studies on zooplankton community is 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, growth and survival rate are all significant factors determining the recruitment and abundance of fish stocks as they form an essential food for larval, juvenile and adult fishes (Beaugrand et al., 2004). Zooplankton grazing in the marine environment controls the primaryProduction and helps in determining the pelagic ecosystem (Banse, 1995). Through grazing in surface waters and following the production of sinking faecal matters and also by the active transportation of dissolved and particulate matter to deeper waters via vertical migration, they help in the transport of organic carbon to deep ocean layers and thus act as key drivers of biological pump' in the marine ecosystem. Zooplankton grazing and metabolism also, transform particulate organic matter into dissolved forms, promoting primary producer community, microbial demineralization, and particle export to the ocean's interior.

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

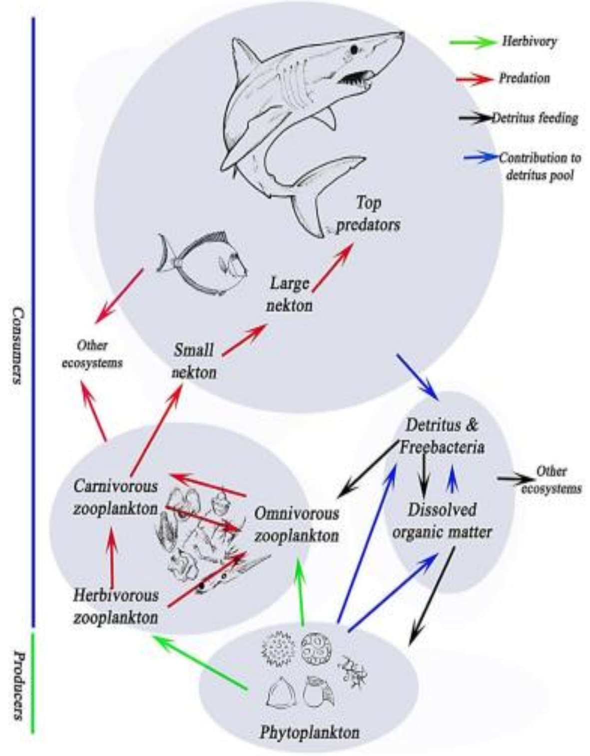
Based on the duration of planktonic life, zooplankton are categorised into Holoplankton (organisms which complete their entire lifecycle as plankton) and Meroplankton (organisms which are planktonic during the early part of their lives such as the larval stages of benthic and nektonic organisms). Tychoplankton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

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

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

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

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



Simplified marine food web

Spatial distribution of Plankton:

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

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

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

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

Methodology adopted for Plankton sampling:

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

Preservation and storage:

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

Sample concentration:

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

Taxonomic evaluation:

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

Cell counts by drop count method:

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

BENTHIC ORGANISMS:

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

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

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

SAMPLING METHODOLOGY ADOPTED FOR SUB TIDAL REGION:

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

Sample sieving:

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

Sample staining:

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

DIVERSITY INDICES:

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

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

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

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

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

Simpson's diversity index

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

The formula for calculating D is presented as:

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

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

N = the total number of organisms of all species

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

Low species diversity suggests:

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

High species diversity suggests:

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

Species richness indices

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

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

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

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

Shannon-Wiener's index:

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

Shannon and Weiner index represents entropy. It is a diversity index taking into account the number of individuals as well as the number of taxa. It varies from 0 for communities with only single taxa to high values for community with many taxa each with few individuals. This index can also determine the pollution status of a water body. Normal values range from 0 to 4. This index is a combination of species present and the evenness of the species. Examining the diversity in the range of polluted and unpolluted ecosystems, Wilham and Dorris (1968) concluded that the values of the index greater than 3 indicate clean water, values in the range of 1 to 3 are characterized by moderate pollution and values less than 1 are characterized as heavily polluted

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

RESULTS:

CHLOROPHYLL-a:

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

In the sub surface water chlorophyll-a was varying from 0.314 -0.468mg/m^3.in harbour region of DPT during sampling done in spring tide period of June, 2021. In the nearby creeks chlorophyll-a was varying from 0.329-0.739 mg/m^3.Pheophytin –a level was below detectable limit- the all the sampling stations during spring in the harbour region of DPT.

In the sub surface water chlorophyll-a was varying from 0.527 -0.765 mg/m^3.in harbour region of DPT during sampling done in neap tide period of June, 2021 . In the nearby creeks chlorophyll-a was varying from 0.425- 0.850 mg/m^3. Pheophytin –a level was below detectable limit- the all the sampling stations during spring in the harbour region of DPT

TABLE #2 VARIATIONS IN CHLOROPHYLL –a PHEOPHYTIN- a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS DURING SPRING TIDE IN JUNE,2021

Sr.No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPTHARBOUR AREA					
1	KPT1	High tide	0.381	BDL	25.53
		Low tide	0.440	BDL	29.48
2	KPT 2	High tide	0.314	BDL	21.04
		Low tide	0.417	BDL	27.94
3	KPT 3	High tide	0.468	BDL	31.36
		Low tide	0.424	BDL	28.41
CREEKS					
4	KPT-4 Khori-I	High tide	0.739	BDL	49.51
		Low tide	0.578	BDL	38.73
5	KPT-5 Nakti-I	High tide	0.637	BDL	42.68
		Low tide	0.409	BDL	27.40
6	KPT-5 Nakti-II	High tide	0.329	BDL	22.04

BDL: Below Detectable Limit.

TABLE #3 VARIATIONS IN CHLOROPHYLL –aPHEOPHYTIN- a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS DURING NEAP TIDE IN JUNE,2021

Sr.No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPTHARBOUR AREA					
1	KPT1	High tide	0.631	BDL	42.28
		Low tide	0.765	BDL	51.25
2	KPT 2	High tide	0.731	BDL	48.98
		Low tide	0.614	BDL	41.14
3	KPT 3	High tide	0.527	BDL	35.31
		Low tide	0.615	BDL	41.21
CREEKS					
4	KPT-4 Khori-I	High tide	0.748	BDL	50.12
		Low tide	0.850	BDL	56.95
5	KPT-5 Nakti-I	High tide	0.715	BDL	47.90
		Low tide	0.715	BDL	47.90
6	KPT-5 Nakti-II	High tide	0.425	BDL	28.47

BDL: Below Detectable Limit.

PHYTOPLANKTON POPULATION:

For the evaluation of the Phytoplankton population in DPT harbour area and within the immediate surroundings of the port, sampling was conducted from 5 sampling locations (3 in harbour area and two in Nakti creek) during high tide period and low tide period of spring tide. The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by,Diatoms and dinoflagellates during spring tide period.Diatoms were represented by 14 genera. Dinoflagellates wererepresented by onegenera .during the sampling conducted in spring tide in June,2021. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 112-216 units/ L during high tide period and 147-172 units/ L during low tide of Spring Tide.

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by Diatoms and dinoflagellates during spring tide period.Diatoms were represented by 15genera and Dinoflagellateswere represented onegenera during the sampling conducted in Neap tide in June, 2021. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 72-293 units/ L during high tide period and 202-375 units/ L during low tide of Neap Tide.

Species Richness Indices and Diversity Indices :

Margalef's diversity index (Species Richness)S

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

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations was varying from 1.907-2.660 with an average of 2.381during the sampling conducted in High tide period of spring tide While .Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla Harbour region and nearby creeks was varying from. 1.603-2.395 with an average of 2.140 during the consecutive in low tide period .

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations was varying from 1.775-2.614 with an average of 2.212 during the sampling conducted in High tide period of Neaptide While .Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla Harbour region and nearby creeks was varying from. 1.695-2.193 with an average of 1.966 during the consecutive in low tide period .

Shannon-Wiener's index:

Shannon-Wiener’s Index (H) of phytoplankton communities in the sampling stations was in the range of 0.794-0.908 (H'(log10)) between selected sampling stations with an average value of 0.844. during high tide period of spring tide .Shannon-Wiener’s Index (H) of phytoplankton communities in the sampling stations was in the range of 0.788-0.845 (H'(log10)) between selected sampling stations with an average value of 0.813 during consecutive lowtide. Shannon-Wiener’s Index (H) of phytoplankton communities in the sampling stations was in the range of 0.722-0.883 (H'(log10)) between selected sampling stations with an average value of 0.814. during high tide period of neap tide . Shannon-Wiener’s Index (H) of phytoplankton communities in the sampling stations was in the range of 0.723-0.883 (H'(log10)) between selected sampling stations with an average value of 0.813 during consecutive low tide. Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon-Wiener’s index increases as both the richness and the evenness of the community increase. This result indicates that diversity of phytoplankton of Kandla Harbour region and nearby creeks is less but with abundant population of few, with relatively few ecological niches and only very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson’s diversity index:

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

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks, which was varying from 0.796- 0.840 between selected sampling stations with an average of 0.815 during high tide period of spring tide . Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks, which was varying from 0.790- 0.821 between selected sampling stations with an average of 0.803 during consecutive low tide . Low species diversity suggests a relatively few successful species in this habitat. The environment is quite stressful with relatively few ecological niches and only a few organisms are really well adapted to that environment. Any change in the environment would probably have quite serious effects.

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in Kandla Harbour region and nearby creeks, during high tide period and low tide period during neap tide also, which was varying from 0.741-0.831 with an average value of 0.800

between selected sampling stations during high tide period and varying from 0.719-0.808 with an average value of 0.758 between selected sampling stations duringconsecutive low tide period Low species diversity suggests a relatively few successful species in this habitat.

Table # 4PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS DURING SPRING TIDE IN JUNE,2021

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	158	14/15	93.33	2.568	0.89	0.8401
	2	151	14/15	93.33	2.591	0.8397	0.8165
	3	170	12/15	80	2.142	0.7942	0.7962
	4	216	14/15	93.33	2.418	0.8223	0.8042
	5	193	15/15	100	2.66	0.9078	0.8326
	6	112	10/15	66.66	1.907	0.8103	0.8029
LOW TIDE	1	156	13/15	86.66	2.376	0.8446	0.8209
	2	147	9/15	60	1.603	0.7909	0.8148
	3	152	12/15	80	2.19	0.8051	0.791
	4	172	12/15	80	2.137	0.788	0.7904
	5	150	13/15	86.66	2.395	0.8371	0.7996

Table # 5 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS DURING NEAP TIDE IN JUNE,2021

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	240	15/16	93.75	2.554	0.883	0.8308
	2	248	12/16	75	1.995	0.7916	0.7925
	3	212	15/16	93.75	2.614	0.8664	0.8285
	4	293	15/16	93.75	2.465	0.8666	0.8224
	5	280	11/16	68.75	1.775	0.7227	0.7413
	6	72	9/16	56.25	1.871	0.7522	0.7891
LOW TIDE	1	278	11/16	68.75	1.777	0.7379	0.7658
	2	206	12/16	75	2.065	0.7625	0.784
	3	202	10/16	62.50	1.695	0.7941	0.8008
	4	375	14/16	87.5	2.193	0.7182	0.7189
	5	303	13/16	81.25	2.1	0.7164	0.7232

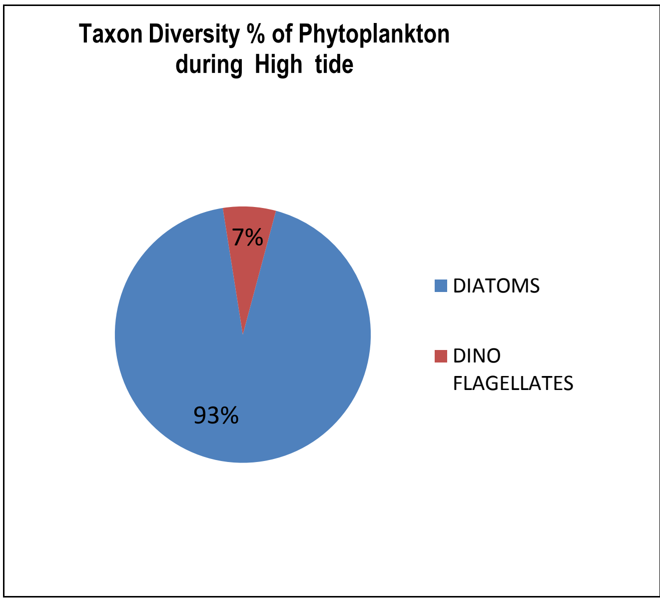
Table # 6 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA, NEAR BY CREEKS DURING SPRING TIDE IN JUNE,2021

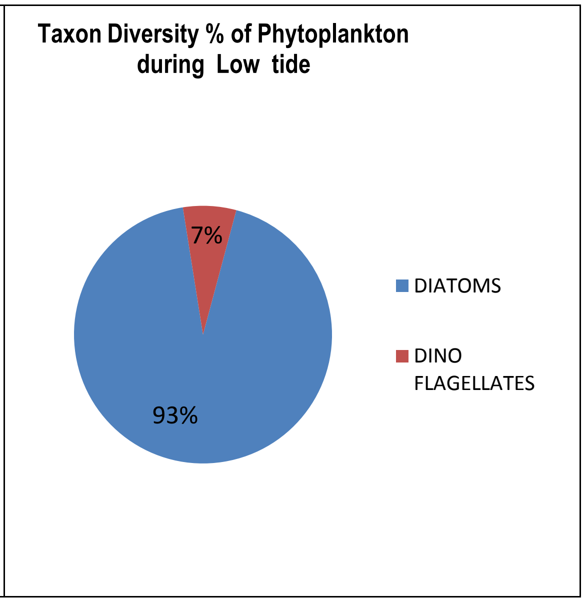
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	DIATOMS	112-214	14/15	93.33
			DINO FLAGELLATES	0-2	1/15	6.67
			TOTAL PHYTO PLANKTON	112-216	15	-
LOW TIDE	Sub surface	5	DIATOMS	147-171	14/15	93.33
			DINO FLAGELLATES	0-2	1/15	6.67
			TOTAL PHYTO PLANKTON	147-172	15	-

Table # 7 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA, NEAR BY CREEKS DURING NEAP TIDE IN JUNE, 2021

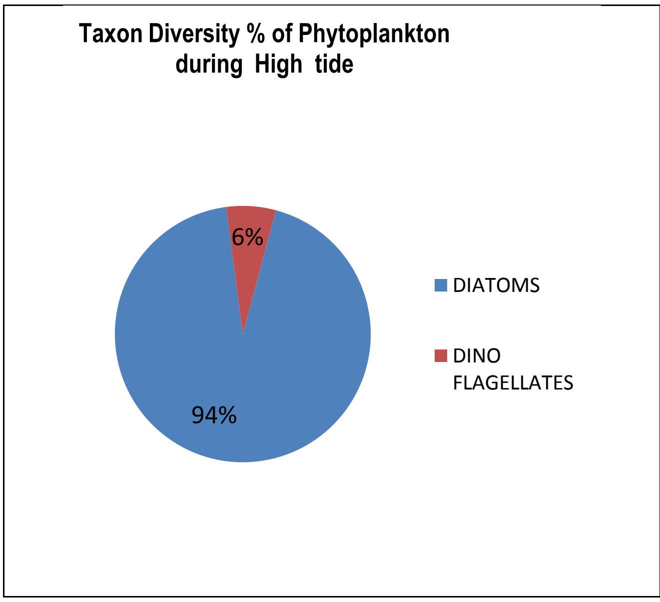
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	DIATOMS	72-291	15/16	93.75
			DINO FLAGELLATES	0-2	1/16	6.25
			TOTAL PHYTO PLANKTON	72-293	16	-
LOW TIDE	Sub surface	5	DIATOMS	202-374	15/16	93.75
			DINO FLAGELLATES	0-1	1/16	6.25
			TOTAL PHYTO PLANKTON	202-375	16	

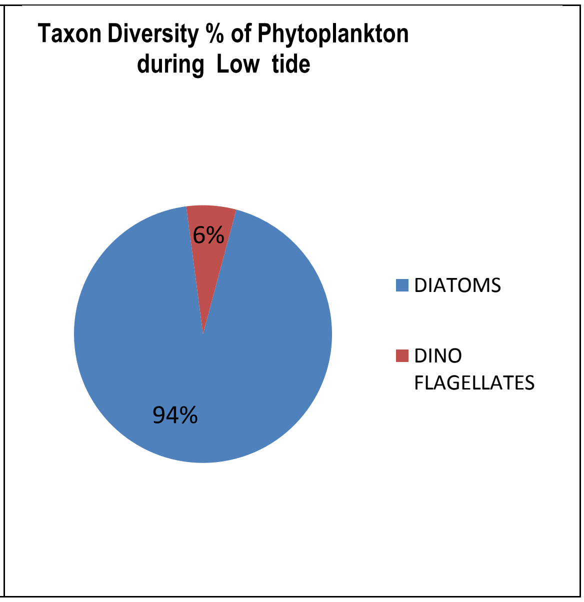
Taxon Diversity % of Phytoplankton during High tide and Low tide period during spring tide





Taxon Diversity % of Phytoplankton during High tide and Low tide period during Neap tide





ZOOPLANKTON POPULATION:

For the evaluation of the Zooplankton population in DPT harbour area and within the immediate surroundings of the port sampling was conducted from 6 sampling locations (3 in harbour area and two in Nakti creek and one in Khoricreek) during high tide period and low tide period of spring tide and Neap tide in June 2021 . The Zooplankton community of the sub surface water in the harbour and nearby creeks during spring tide was represented by mainly four groups, Tintinids, Copepods,Foraminiferans and larval forms of Crustacea, Molluscans. The Zooplankton community of the sub surface water in the harbour and nearby creeks during neap tide was represented by mainly five groups, Tintinids, Copepods, Arrow worms, Mysids and larval forms of Crustacea and Polychates,.

Zooplankton of the sampling stations at sub surface layer in the DPT harbour area and nearby creek was varying from 61-138x10^3 N/ m^3 during high tide and 78-112x10^3 N/ m^3during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPT harbour area and nearby creek was varying from 47-176 x10^3 N/ m^3 during high tide and80-157 N/ L during low tide of Neap Tide period.

Species Richness Indices and Diversity Indices:

Margalef's diversity index (Species Richness)S

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

Margalef's diversity index (Species Richness) S of Zooplankton communities in the stations Kandla Harbour region and nearby creeks was varying from 2.563-3.067 with an average of 2.804 during the sampling conducted in High tide period.Margalef's diversity index (Species Richness) S of Zooplankton communities varying from.2.136-2.875 with an average of 2.485 during the sampling conducted in low tide period during Spring tide.

Margalef's diversity index (Species Richness) S of Zooplankton communities in the Kandla Harbour region and nearby creeks sampling stations was varying from3.610-453 with an average of 4.016 during the sampling conducted in high tide and varying from. 2.755-4.747 with an average of 3.779 during the sampling conducted in low tide during Neap 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 0.912-1.017 (H'(log10)) between selected sampling stations with an average value of 0.947 (H'(log10)) during high tide period of spring tide .Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.872-0.939 (H'(log10)) between selected sampling stations with an average value of 0.908 (H'(log10)) during consecutive low tide period .

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.962-1.143 (H'(log10)) between selected sampling stations with an average value of 1.071 (H'(log10)) during high tide period of Neap tide . Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.952-1.168(H'(log10)) between selected sampling stations with an average value of 1.051 (H'(log10)) during 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 Zooplankton of Kandla Harbour region and nearby creeks stations is slightly high with very minimum diverse population but very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson's diversity index:

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

Simpson diversity index (1-D) of Zooplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeksduring high tide and low tide of spring tide period except few during high tide period, which was varying from 0.838-0.904 between selected sampling stations with an average of 0.862 during high tide period and was varying from 0.838-0.865 with an average value of 0.849 between selected sampling stations during low tide

Simpson diversity index (1-D) of Zooplankton communities was below 0.9 at all sampling stationsin the Kandla Harbour region and nearby creeks during high tide and except one duringhigh tide of Neap tide, which was varying from 0.853-0.905 between selected sampling stations with an average of 0.886 during high tide period and was varying from 0.840- 0.909 with an average value of 0.881 between selected sampling stations during consecutive low tide

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

Table # 8 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS DURING SPRING TIDE IN JUNE,2021

Tide	Sampling Station	Abundance In No / 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	96 $X10^3$	15/17	88.24	3.067	1.01	0.8836
	2	77 $X10^3$	13/17	76.47	2.763	0.9118	0.8506
	3	92 $X10^3$	14/17	82.35	2.875	0.9144	0.8385
	4	138 $X10^3$	14/17	82.35	2.638	0.9177	0.8445
	5	108 $X10^3$	13/17	76.47	2.563	0.9144	0.852
	6	61 $X10^3$	13/17	76.47	2.919	1.017	0.9038
LOW TIDE	1	78 $X10^3$	11/17	64.70	2.295	0.8723	0.8382
	2	92 $X10^3$	14/17	82.35	2.875	0.9395	0.8538
	3	105 $X10^3$	12/17	70.58	2.364	0.8972	0.8443
	4	112 $X10^3$	14/17	82.35	2.755	0.9159	0.8468
	5	108 $X10^3$	11/17	64.70	2.136	0.9189	0.8654

Table # 9 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS DURING NEAP TIDE IN JUNE,2021

Tide	Sampling Station	Abundance In No / 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	111 $X10^3$	18/26	69.23	3.61	0.9985	0.8526
	2	100 $X10^3$	19/26	73.07	3.909	1.068	0.8846
	3	103 $X10^3$	22/26	84.61	4.531	1.129	0.905
	4	176 $X10^3$	24/26	92.31	4.448	1.143	0.904
	5	155 $X10^3$	21/26	80.77	3.966	1.13	0.9041
	6	47 $X10^3$	15/26	57.69	3.636	0.9622	0.8668
LOW TIDE	1	80 $X10^3$	16/26	61.54	3.423	1	0.8684
	2	103 $X10^3$	17/26	65.38	3.452	0.9526	0.8401
	3	112 $X10^3$	14/26	53.85	2.755	1.005	0.8795
	4	157 $X10^3$	25/26	96.15	4.747	1.168	0.9082
	5	130 $X10^3$	23/26	88.46	4.52	1.131	0.9095

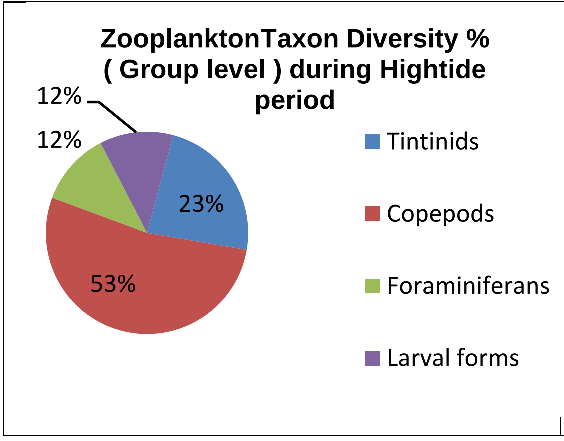
Table # 10 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS DURING SPRING TIDE IN JUNE,2021

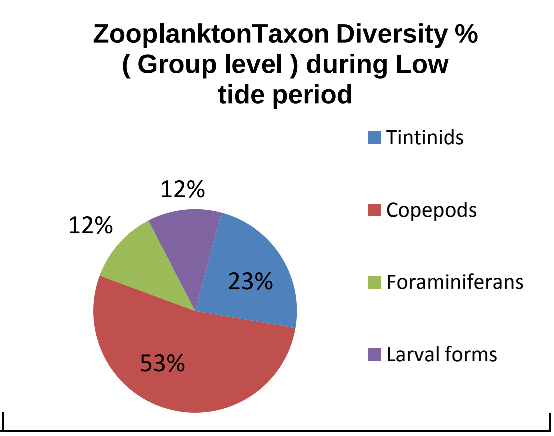
Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton x10^3 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinids	10-16	4/17	23.53
			Copepods	31-72	9/17	52.95
			Foraminiferans	0-4	2/17	11.76
			Larval forms	15-50	2/17	11.76
			TOTAL ZOOPLANKTON NO/L	**61-138**	**17**	**-**
LOW TIDE	Sub surface	5	Tintinids	8-15	4/17	23.53
			Copepods	45-57	9/17	52.95
			Foraminiferans	0-2	2/17	11.76
			Larval forms	25-43	2/17	11.76
			TOTAL ZOOPLANKTON NO/L	**78-112**	**17**	**-**

Table # 11 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA , NEAR BY CREEKS DURING NEAP TIDE IN JUNE,2021

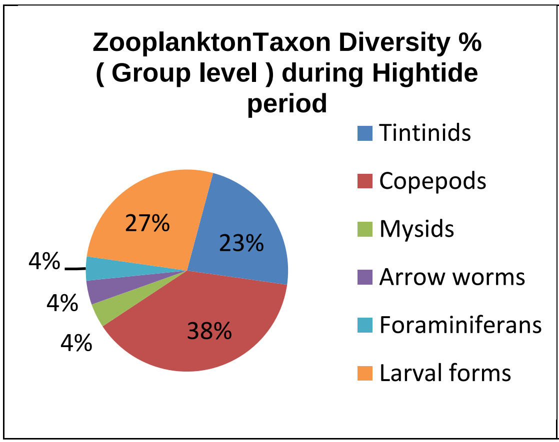
Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton x10^3 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinids	4-15	6/26	23.07
			Copepods	25-98	10/26	38.46
			Mysids	1-2	1/26	3.85
			Arrow worms	1-2	1/26	3.85
			Foraminiferans	0-2	1/26	3.85
			Larval forms	17-59	7/26	26.92
			TOTAL ZOOPLANKTON NO/L	**47-176**	**26**	**-**
LOW TIDE	Sub surface	5	Tintinids	4-15	6/26	23.07
			Copepods	38-85	10/26	38.46
			Mysids	0-2	1/26	3.85
			Arrow worms	0-2	1/26	3.85
			Foraminiferans	0-1	1/26	3.85
			Larval forms	37-52	7/26	26.92
			TOTAL ZOOPLANKTON NO/L	**80-157**	**26**	**-**

Taxon Diversity % of Zooplankton during High tide and Low tide period of Spring tide





Taxon Diversity % of Zooplankton during High tide and Low tide period of Neap tide



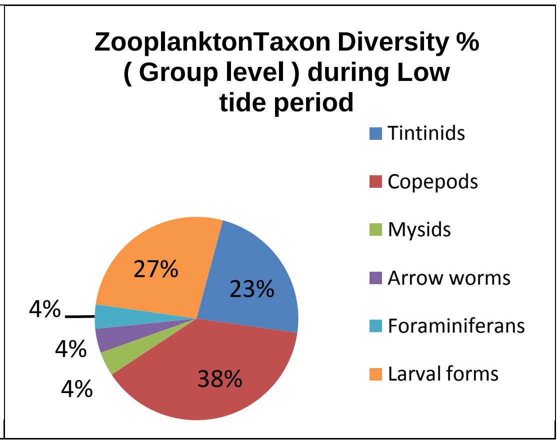


TABLE # 12 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPT HARBOUR AREA AND NEARBY CREEKS DURINGSPRING TIDE OF JUNE,2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Thalassiosirales	Thalassiosiraceae	*Planktoniella*sp	D1	Rare
			Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D2	Abundant
			Triceratiales	Triceratiaceae	*Odontella*sp	D3	Rare
					*Triceratium*sp.	D4	Occasional
			Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D5	Frequent
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D6	Occasional
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros*sp	D7	Occasional
			Lithodesmiales	Lithodesmiaceae	*Ditylum*sp	D8	Dominant
			Thalassiosirales	Thalassiosiraceae	*Thalassiosira*sp	D9	Rare
		Bacillariophyceae	Naviculales	Pleurosigmataceae	*Pleurosigma*sp	D10	Rare
		Fragilariophyceae	Thalassionematales	Thalassionemataceae	*Thalassiothrix sp.*	D11	Frequent
					Thalassionema sp.	D12	Rare
			Fragilariales	Fragilariaceae	*Fragilaria*sp	D13	Occasional
					*Synedra*sp	D14	Frequent
DINO FLAGELLATES	Dinoflagellata / Dinozoa	Dinophyceae	Gonyaulacales	Ceratiaceae	*Ceratiumfurca*	DF1	Rare

TABLE # 12 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPT HARBOUR AREA AND NEARBY CREEKS DURING AND NEAP TIDE OF JUNE,2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Thalassiosirales	Thalassiosiraceae	*Planktoniella*sp	D1	Occasional
			Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D2	Dominant
			Triceratiales	Triceratiaceae	*Triceratium*sp	D3	Occasional
					*Odontella*sp	D4	Rare
			Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D5	Abundant
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D6	Rare
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros*sp	D7	Rare
			Lithodesmiales	Lithodesmiaceae	*Ditylum*sp	D8	Abundant
		Bacillariophyceae	Naviculales	Pleurosigmataceae	*Pleurosigma*sp	D9	Occasional
			Bacillariales	Bacillariaceae	*Bacillaria* sp.	D10	Rare
		Fragilariophyceae	Thalassionematales	Thalassionemataceae	*Thalassiothrix sp.*	D11	Frequent
					Thalassionema sp.	D12	Rare
			Fragilariales	Fragilariaceae	*Fragilaria*sp	D13	Rare
					*Synedra*sp	D14	Frequent
					*Asterionella*sp	D15	Occasional
DINO FLAGELLATES	Dinoflagellata / Dinozoa	Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Rare

TABLE #13 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS IN DPT HARBOUR AREA, AND NEAR BY CREEKS DURING SPRING TIDE OF JUNE,2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnussp.*	T1	Occasional
				Codonellidae	*Tintinnopsisfailakkaensis*	T2	Occasional
					Tintinnopsisgracilis	T3	Occasional
					Tintinnopsis radix	T4	Rare
COPEPODS	ATHROPODA	Crustacea Sub class copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Frequent
					Bestiolina sp.	C2	Rare
					Parvocalanus sp.	C3	Occasional
				Eucalanidae	*Pareucalanus sp.*	C4	Rare
				Clausocalanidae	*Clausocalanus sp.*	C5	Occasional
				Temoridae	*Temora sp.*	C6	Rare
			Cyclopoida	Oithonidae	*Oithona sp.*	C7	Abundant
			Harpacticoida	Ectinosomatidae	*Microsetella*sp.	C8	Frequent
			Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C9	Rare
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of Copepods	L1	Dominant
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of Bivalves	L2	Occasional
FORAMINIFERA	FORAMINIFERA	Globothalamea	Rotaliida	Globigerinidae	*Globigerina* sp.	F1	Rare
				Rotalliidae	*Rotalia* sp.	F2	Rare

TABLE # 13 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS IN DPT HARBOUR AREA, AND NEAR BY CREEKS DURING NEAP TIDE OF JUNE,2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnussp.*	T1	Rare
				Codonellidae	*Tintinnopsisaccuminata*	T2	Occasional
					Tintinnopsisfailakkaensis	T3	Occasional
					Tintinnopsisgracilis	T4	Rare
					Tintinnopsis radix	T5	Rare
				Codonellopsidae	*Codonellopsis* sp.	T6	Rare
COPEPODS	ATHROPODA	Crustacea Sub class copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Abundant
					Parvocalanus sp.	C2	Rare
				Eucalanidae	*Pareucalanus sp.*	C3	Frequent
					Subeucalanus sp.	C4	Occasional
				Temoridae	*Temora sp.*	C5	Frequent
				Acartiidae	*Acartia sp.*	C6	Occasional
			Cyclopoida	Oithonidae	*Oithona sp.*	C7	Frequent
			Harpacticoida	Ectinosomatidae	*Microsetella*sp.	C8	Frequent
				Euterpinidae	*Euterpina sp.*	C9	Frequent
			Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C1 0	Rare
ARROW WORMS	CHAETOGNATHA	Sagittoideae	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Rare
MYSIDS	ATHROPODA CRUSTACEA	Malacostraca	Mysida, Decapoda	Penaeidae	*Metapenaeussp.*	M1	Rare

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of Copepods	L1	Dominant
POLYCHAETE LARVA	ANNELIDA	Polychaeta			Trochophore larvae	L2	Occasional

BENTHIC ORGANISMS:

No Benthic organism was observed in the collected sediments by using the Van-veen grabs during the sampling conducted during spring tide periodfrom DPT harbour region and nearby creek except few dead shells. Benthic organisms form the sample collected during Neap tide is represented by mainly Polychates ,*Pontodra*sp. *Paronis* sp. and *Phalacophorus*sp and few Amphipods. The benthic organisms at subtidal region of harbour region and creek varies from 30-100 N/m^2

Table # 14 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPT HARBOUR AREA CREEKS DURING NEAP TIDE IN JUNE,2021

Benthic fauna	ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS REPRESENTATION BY GROUP						
	DPT HARBOUR			CREEKS			
POLYCHATES	KPT-1	KPT-2	KPT-3	KPT-4	KPT-5	KPT-6	
Family : Iospilidae *Pondodora sp.*	10	NS	0	20	30	NS	
Family : Syllidae *Syllis sp*.	20	NS	10	30	10	NS	
Family Glyceredae *Glycerasp.*	30	NS	0	0	0	NS	
Total Polychates N/M^2		NS				NS	
Un identified Nematode worms		NS		0		NS	
Amhipods Un identified	0	NS	0	50	0	NS	
TOTAL Benthic Fauna NUMBER/ M^2	60	NS	10	100	30	NS	

NS : No sample

7. Meteorological Data

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

Temperature

The mean day time temperature for Deendayal Port was 29.77 °C. The day-time maximum temperature was 34.1 °C. The mean night time temperature was 32.53 °C. The minimum mean night time temperature recorded was 28.2 °C.

Air Pressure

The mean absolute air pressure for the month of June was 1004.93 hpa, whereas the mean relative pressure was 1005.03 hpa. The maximum absolute air pressure recorded for the month of June was 1008.9 hpa.

Heat Index

The mean day-time heat index for the month of June was 35.20 ^{o}C. The maximum heat index recorded was 44^{o}C.

Solar Radiation

The mean Solar Radiation in June was 208.28 w/m^2. The maximum solar radiation recorded in the month of June was 654.8 w/m^2.

Humidity

The mean day-time humidity was 76.42 % for the month of June and mean night time humidity was 65.97%. Maximum humidity recorded during day-time was 84.0 % and maximum humidity recorded during night-time was 82.0%.

Wind Velocity and Wind Direction

The mean wind velocity for the entire month of June was 9.72 km/hour (i.e. 2.7 mtr/sec). Maximum wind velocity recorded was 46.8 Km/hr (13 mtr/sec). The wind direction was mostly S to SW.

Conclusive Summary and Remedial measures Suggested

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

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

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

- The sewage treated water of Deendayal Port Colony (Gopalpuri) was in line with the standards set by the Gujarat Pollution Control Board. The STP at Deendayal Port is not fully operational and STP at Vadinar Port was found non-operational.

Reasons for higher Values of PM_{10}

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

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

Remedial Measures

The values of PM_{10} during the month of June, 2021 were observed beyond the permissible limit at four locations mentioned above. Given below are the remedial measures suggest to minimize the Air pollution at Deendayal Port.

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

- Sewage Treatment Plan at Vadinar Port is not working. Hence, it is recommended to commission the sewage treatment plant at Vadinar immediately.

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

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ENVIRONMENTAL MONITORING REPORT
FOR
DEENDAYAL PORT TRUST

REPORT NO.	:	DCPL/DPT/20-21/15
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Prepared by	:	DETOX CORPORATION PVT. LTD., SURAT

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Introduction

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

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

1. Ambient Air Quality Monitoring

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

1.1 Air Quality Monitoring Methodology

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

The AAQ samples are collected twice a week from all the eight locations as per the EMP.

1.2 Results

The ambient air quality monitoring data for six stations, viz. Marine Bhavan, Oil Jetty, Port Colony,Gopalpuri Hospital,Tuna Port and Nr. Coal Storage Area for the month of July 2021 are given in Tables 1A to 6B. The ambient air quality monitoring data for two stations at Vadinar (Nr. Admin Building &Nr. Signal Building) are given in Tables 7A to 8B.

Location 1: Marine Bhavan (AL1)

Table 1 : Results of Air Pollutant Concentration at Marine Bhavan										
Parameter	**Date**	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period	-	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit	-	**NS**	**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL1 – 1	01.07.2021	417	302	96	3.08	2.78	59.07	48.70	13.53	15.32
					3.52		55.26		16.08	
					1.76		31.76		16.34	
AL1 – 2	05.07.2021	875	776	40	6.59	5.71	57.16	52.51	15.83	12.34
					5.71		47.64		10.21	
					4.84		52.72		10.98	
AL1 – 3	09.07.2021	769	693	11	8.79	7.62	33.03	34.30	13.79	13.87
					8.35		31.76		13.53	
					5.71		38.11		14.30	
AL1 – 4	14.07.2021	267	257	31	2.64	4.69	14.61	24.98	19.15	10.21
					5.28		28.58		5.11	
					6.15		31.76		6.38	
AL1 – 5	16.07.2021	234	143	8	10.55	10.11	13.34	20.11	9.19	12.34
					13.19		22.87		14.04	
					6.59		24.14		13.79	
AL1 - 6	21.07.2021	314	257	202	4.84	2.93	13.34	13.76	7.66	12.17
					1.32		15.24		12.25	
					2.64		12.70		16.59	
AL1 - 7	23.07.2021	387	256	163	1.76	3.08	38.11	28.16	16.34	61.10
					3.52		27.31		13.79	
					3.96		19.05		153.17	
AL1 – 8	27.07.2021	471	299	163	6.15	6.01	12.70	16.09	137.85	53.78
					6.59		18.42		10.98	
					5.28		17.15		12.51	
Monthly Average		467	373	89		5.37		29.83		23.89
Standard Deviation		234	230	78		2.58		14.43		20.85

NS: Not Specified

Table 1B : Results of Air Pollutant Concentration at Marine Bhavan					
Parameter	**Date**	**C_6H_6 [µg/m³]**	**HC* ppm**	**CO [mg/m³]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m³**	**NS**	**4.0 mg/m³**	**NS**
AL1 – 1	01.07.2021	1.13	BDL	1.46	508
AL1 – 2	05.07.2021	1.1	BDL	1.52	489
AL1 – 3	09.07.2021	1.04	BDL	1.36	512
AL1 – 4	14.07.2021	1.14	BDL	1.48	562
AL1 – 5	16.07.2021	1.12	BDL	1.52	496
AL1 - 6	21.07.2021	1.05	BDL	1.48	485
AL1 – 7	23.07.2021	1.04	BDL	1.78	508
AL1 – 8	27.07.2021	1.1	BDL	1.69	495
Monthly Average		**1.09**	**-**	**1.54**	**507**
Standard Deviation		**0.04**	**-**	**0.13**	**24**

* NMHC- Non- Methane Hydrocarbons

BDL- Below Detection Limit (Detection Limit – NMHC: 0.5ppm)

NS -Not Specified

At Marine Bhavan, the overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_X and NH_3 is attributed mainly by motor vehicle emission produced from various types of automobiles (both diesel and petrol driven). Moreover, the loading and unloading of Food Grains and Timber at Jetty no. 1 and 2 also contributes to the high levels of TSPM and PM_{10}. The mean TSPM value at Marine Bhavan was 467 µg/m³, The mean PM_{10} values were 373.0 µg/m³, which is above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean = 89 µg/m³). The average values of SO_2, NO_x and NH_3 were within the permissible limit. The average values of SO_2, NO_x and NH3 were 5.37 µg/ m³, 29.83 µg/ m³ & 23.89 µg/ m³ respectively. These were within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Marine Bhavan. The mean Benzene concentration was 1.09 µg/m³,well below the permissible limit of 5.0 µg/m³. HC's were below the detectable limit and Carbon Monoxide concentration was 1.54 mg/m³, well below the permissible limit of 4.0 mg/m³.

Location 2: Oil Jetty (AL2)

Table 2 : Results of Air Pollutant Concentration at Oil Jetty											
Parameters	**Date**	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period	-	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit	-	**NS**	**100 µg/m3**	**60 µg/m3**	-	**80 µg/m3**	-	**80 µg/m3**	-	**400 µg/m3**
AL2 – 1	01.07.2021	265	392	127	2.20	1.47	55.26	45.94	7.66	9.96
					0.88		52.72		10.98	
					1.32		29.85		11.23	
AL2 – 2	05.07.2021	812	737	42	0.88	2.93	44.46	47.64	13.53	13.96
					2.64		47.64		13.53	
					5.28		50.81		14.81	
AL2 – 3	09.07.2021	807	707	35	5.28	8.35	17.15	24.56	7.91	10.98
					10.11		24.77		12.76	
					9.67		31.76		12.25	
AL2 – 4	14.07.2021	602	280	5	3.08	3.37	19.05	20.33	15.32	16.59
					2.64		17.15		16.08	
					4.40		24.77		18.38	
AL2 – 5	16.07.2021	578	539	6	4.40	4.10	16.51	17.15	6.13	6.98
					3.52		17.15		5.11	
					4.40		17.78		9.70	
AL2 – 6	21.07.2021	867	772	10	4.84	5.13	29.22	28.16	10.98	13.36
					4.40		32.39		12.76	
					6.15		22.87		16.34	
AL2 – 7	23.07.2021	244	194	76	2.20	2.20	23.50	26.25	13.79	15.40
					1.76		26.68		15.83	
					2.64		28.58		16.59	
AL2 – 8	27.07.2021	448	350	76	6.15	6.45	23.50	18.84	12.00	12.59
					7.03		14.61		13.02	
					6.15		18.42		12.76	
Monthly Average		578	496	47		4.25		28.61		12.48
Standard Deviation		244	224	43		2.30		11.83		3.10

NS: Not Specified

Table 2B : Results of Air Pollutant Concentration at Oil Jetty					
Parameter	**Date**	**C_6H_6 [µg/m³]**	**HC* ppm**	**CO [mg/m³]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m³**	**NS**	**4.0 mg/m³**	**NS**
AL2 -1	01.07.2021	1.12	BDL	1.76	512
AL2 -2	05.07.2021	1.16	BDL	1.85	498
AL2 -3	09.07.2021	1.06	BDL	1.77	506
AL2 -4	14.07.2021	1.15	BDL	1.54	489
AL2 – 5	16.07.2021	1.14	BDL	1.78	490
AL2 – 6	21.07.2021	1.19	BDL	1.62	506
AL2 -7	23.07.2021	1.72	BDL	1.82	515
AL2 – 8	27.07.2021	1.58	BDL	1.78	510
Monthly Average		**1.27**	**-**	**1.74**	**503**
Standard Deviation		**0.24**	**-**	**0.11**	**10**

* NMHC- Non- Methane Hydrocarbons

BDL- Below Detection Limit (Detection Limit – NMHC : 0.5ppm)

NS- Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Oil Jetty area was mainly by motor vehicle emission produced from various types of vehicles Oil Jetty Area. The mean TSPM values at Oil Jetty were 578 µg/m³ The mean PM_{10} values were 496 µg/m³, which is above the permissible limit. $PM_{2.5}$ values were below the permissible limit (mean = 47 µg/m³).The average values of SO_2, NO_x and NH_3 were within the permissible limit; The mean concentration of SO_2, NO_x and NH3 were 4.25 µg/m³, 28.61 µg/m³ and 12.48 µg/m³ respectively.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Oil Jetty. The mean Benzene concentration was 1.27 µg/m³ .Well below the permissible limit of 5.0 µg/m³. , HC's were below the detectable limit and Carbon Monoxide concentration was 1.74 mg/m³, well below the permissible limit of 4.0 mg/m³.

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

Table 3 : Results of Air Pollutant Concentration at Estate Office										
Parameters	**Date**	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period	-	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit	-	**NS**	**100 µg/m3**	**60 µg/m3**	-	**80 µg/m3**	-	**80 µg/m3**	-	**400 µg/m3**
AL3 – 1	01.07.2021	168	153	55	3.52	3.81	20.96	21.38	14.30	10.21
					5.28		27.31		9.45	
					2.64		15.88		6.89	
AL3 – 2	05.07.2021	467	373	21	3.52	2.49	21.60	23.50	14.04	15.91
					1.32		18.42		15.83	
					2.64		30.49		17.87	
AL3 – 3	09.07.2021	297	139	37	3.08	4.98	23.50	24.77	9.19	7.66
					6.15		29.85		6.38	
					5.71		20.96		7.40	
AL3 – 4	14.07.2021	292	121	80	4.84	5.86	21.60	19.27	14.55	72.33
					5.71		18.42		186.35	
					7.03		17.78		16.08	
AL3 – 5	16.07.2021	629	566	96	17.58	10.11	17.15	14.82	13.53	12.00
					7.91		15.24		9.70	
					4.84		12.07		12.76	
AL3 – 6	21.07.2021	721	668	57	3.96	2.49	6.99	14.82	20.42	18.98
					1.32		15.88		21.44	
					2.20		21.60		15.06	
AL3 – 7	23.07.2021	490	406	51	2.64	2.49	22.87	23.29	11.23	11.91
					3.08		19.69		9.70	
					1.76		27.31		14.81	
AL3 – 8	27.07.2021	640	500	51	1.76	3.66	20.96	18.00	11.23	10.04
					4.40		17.15		8.17	
					4.84		15.88		10.72	
Monthly Average		463	366	56		4.49		19.98		19.88
Standard Deviation		196	210	23		2.59		3.89		21.49

NS: Not Specified

Table 3B : Results of Air Pollutant Concentration at Kandla Port Colony					
Parameter	Date	C_6H_6 [µg/m³]	HC*	CO [mg/m³]	CO_2 [ppm]
Sampling Period		8 hr	Grab Sampling	Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m³	NS	4.0 mg/m³	NS
AL3 -1	01.07.2021	1.12	BDL	1.78	510
AL3 -2	05.07.2021	1.22	BDL	1.84	526
AL3 -3	09.07.2021	1.16	BDL	1.96	520
AL3 -4	14.07.2021	1.26	BDL	1.88	542
AL3 – 5	16.07.2021	1.18	BDL	1.78	533
AL3 – 6	21.07.2021	1.26	BDL	1.6	525
AL3 – 7	23.07.2021	1.21	BDL	1.58	542
AL3 – 8	27.07.2021	1.11	BDL	1.78	502
Monthly Average		**1.19**	**-**	**1.78**	**525**
Standard Deviation		**0.06**	**-**	**0.13**	**14**

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

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Kandla Port Colony was attributed by vehicle emission produced from trucks and heavy duty vehicles that pass through the road outside Kandla Port Colony. The mean TSPM values at Oil Jetty were 463 µg/m³, The mean PM_{10} values were 366 µg/m³, which is above the permissible limit. $PM_{2.5}$ values were slightly above the permissible limit (mean = 56 µg/m³). The average values of SO_2, NO_x and NH3 were 4.49 µg/m³, 19.98 µg/m³ and 19.88 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 1.19 µg/m³, well below the permissible limit of 5.0 µg/m³. HC's were below the detectable limit and Carbon Monoxide concentration was 1.78 mg/m³, well below the permissible limit of 4.0 mg/m³.

Location 4: Gopalpuri Hospital (AL-4)

Table 4 : Results of Air Pollutant Concentration at Gopalpuri Hospital										
Parameter	**Date**	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period	-	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit	-	**NS**	**100 µg/m3**	**60 µg/m3**	-	**80 µg/m3**	-	**80 µg/m3**	-	**400 µg/m3**
AL4 -1	01.07.2021	148	138	21	1.32	2.20	12.70	13.34	3.57	5.36
					2.20		13.34		7.40	
					3.08		13.97		5.11	
AL4 -2	05.07.2021	313	277	115	3.52	1.76	24.14	19.48	5.36	6.72
					1.32		13.34		8.42	
					0.44		20.96		6.38	
AL4 -3	09.07.2021	287	152	40	1.32	2.49	12.70	30.06	5.87	5.79
					2.64		22.23		5.11	
					3.52		55.26		6.38	
AL4 -4	14.07.2021	143	77	8	1.32	0.88	13.34	11.64	11.74	9.19
					0.88		11.43		8.17	
					0.44		10.16		7.66	
AL4 – 5	16.07.2021	196	119	83	1.32	2.93	20.33	15.24	5.62	7.49
					3.52		13.34		9.45	
					3.96		12.07		7.40	
AL4 – 6	21.07.2021	228	128	100	2.64	1.90	22.87	17.57	7.15	6.89
					1.32		13.34		7.40	
					1.76		16.51		6.13	
AL4 – 7	23.07.2021	338	200	109	0.88	1.32	19.05	26.25	7.15	9.36
					1.32		28.58		9.70	
					1.76		31.12		11.23	
AL4 – 8	27.07.2021	806	746	27	1.76	2.49	19.05	16.94	6.89	6.47
					2.20		14.61		6.38	
					3.52		17.15		6.13	
Monthly Average		307	230	63		2.00		18.82		7.16
Standard Deviation		214	217	43		0.67		6.34		1.46

NS: Not Specified

Table 4B : Results of Air Pollutant Concentration at Gopalpuri Hospital					
Parameter	**Date**	**C_6H_6 [µg/m^3]**	**HC***	**CO [mg/m^3]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m^3**	**NS**	**4.0 mg/m^3**	**NS**
AL4 -1	01.07.2021	1.22	BDL	1.62	502
AL4 -2	05.07.2021	1.16	BDL	1.48	499
AL4 -3	09.07.2021	1.32	BDL	1.62	501
AL4 -4	14.07.2021	1.28	BDL	1.78	489
AL4 – 5	16.07.2021	1.25	BDL	1.46	496
AL4 – 6	21.07.2021	1.18	BDL	1.62	510
AL4 – 7	23.07.2021	1.14	BDL	1.78	502
AL4 – 8	27.07.2021	1.23	BDL	1.48	496
Monthly Average		**1.22**	**-**	**1.61**	**499**
Standard Deviation		**0.06**	**-**	**0.13**	**6**

* NMHC- Non- Methane Hydrocarbons

BDL- Below Detection Limit (Detection Limit – NMHC: 0.5 ppm)

NS-Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Gopalpuri Hospital was attributed by vehicle emission produced from light motor vehicles of the colony residents. The mean TSPMvalues at Oil Jetty were 307 µg/m^3, The mean PM_{10} values were 230 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were slight above the permissible limit (mean= 63 µg/m^3). The average values of SO_2, NO_x and NH_3 were 2.00 µg/m^3, 18.82 µg/m^3 and 7.16 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Gopalpuri Hospital. The mean Benzene concentration was 1.22 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.61 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 5: Coal Storage Area (AL-5)

Table 5 : Results of Air Pollutant Concentration at Coal Storage Area

Parameters	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period	-	24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit	-	NS	100 µg/m3	60 µg/m3	-	80 µg/m3	-	80 µg/m3	-	400 µg/m3
AL5 – 1	01.07.2021	428	158	47	3.08	3.37	42.56	48.70	15.83	14.04
					4.84		50.81		12.76	
					2.20		52.72		13.53	
AL5 – 2	05.07.2021	496	150	44	9.67	6.01	57.16	54.84	10.21	14.98
					4.84		49.54		13.53	
					3.52		57.80		21.19	
AL5 – 3	09.07.2021	222	135	76	9.67	7.62	60.98	50.60	16.85	17.44
					3.52		57.16		18.89	
					9.67		33.66		16.59	
AL5 – 4	14.07.2021	349	309	21	17.58	9.23	22.87	31.97	9.45	15.32
					4.84		32.39		21.70	
					5.28		40.65		14.81	
AL5 – 5	16.07.2021	264	123	12	9.67	11.87	16.51	21.38	12.00	14.21
					13.19		22.23		14.04	
					12.75		25.41		16.59	
AL5 – 6	21.07.2021	358	303	33	4.40	5.28	22.87	19.69	16.85	18.47
					6.15		19.05		16.34	
					5.28		17.15		22.21	
AL5 – 7	23.07.2021	268	194	45	4.40	5.28	27.95	23.71	12.76	16.76
					5.28		20.96		16.59	
					6.15		22.23		20.93	
AL5 – 8	27.07.2021	446	273	45	6.15	6.89	14.61	17.15	10.21	13.19
					7.03		22.23		14.04	
					7.47		14.61		15.32	
Monthly Average		354	206	40		6.94		33.50		15.55
Standard Deviation		98	77	19		2.65		15.50		1.84

NS: Not Specified

Table 5B : Results of Air Pollutant Concentration at Coal Storage Area					
Parameter	**Date**	**C_6H_6 [µg/m³]**	**HC***	**CO [mg/m³]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m³**	**NS**	**4.0 mg/m³**	**NS**
AL5 – 1	01.07.2021	1.28	BDL	1.82	526
AL5 – 2	05.07.2021	1.11	BDL	1.78	522
AL5 – 3	09.07.2021	1.16	BDL	1.88	520
AL5 – 4	14.07.2021	1.32	BDL	1.78	530
AL5 – 5	16.07.2021	1.28	BDL	1.82	536
AL5 – 6	21.07.2021	1.22	BDL	1.77	522
AL5 – 7	23.07.2021	1.18	BDL	1.86	526
AL5 – 8	27.07.2021	1.26	BDL	1.9	530
Monthly Average		**1.23**	**-**	**1.83**	**527**
Standard Deviation		**0.07**	**-**	**0.05**	**5**

* NMHC- Non- Methane Hydrocarbons

BDL- Below Detection Limit (Detection Limit – NMHC: 0.5 ppm)

NS-Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Coal Storage Area was comparatively highest among all the locations of Air Quality monitoring in Kandla Port. High values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_X at this location was due to lifting of coal with grab and other coal handling processes near Berth no. 6 & 7. Moreover, the traffic was also heavy around this place for transport of coal thus emissions produced from heavy vehicles. The mean TSPM values at Coal storage were 354 µg/m³. The mean PM_{10} values were 206 µg/m³, which is well above the permissible limit. $PM_{2.5}$ values were below the permissible limit (mean = 40 µg/m³). The average values of SO_2, NO_x and NH_3 were 6.94 µg/m³, 33.50 µg/m³ and 15.55 µg/m³ respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Coal Storage Area. The mean Benzene concentration was 1.23 µg/m³, well below the permissible limit of 5.0 µg/m³. HC's were below the detectable limit and Carbon Monoxide concentration was 1.83 mg/m³, well below the permissible limit of 4.0 mg/m³.

Location 6: Tuna Port (AL-6)

Table 6 : Results of Air Pollutant Concentration at Tuna Port

Parameters	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period	-	24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit	-	NS	100 µg/m3	60 µg/m3	-	80 µg/m3	-	80 µg/m3	-	400 µg/m3
AL6 -1	01.07.2021	149	97	39	0.88	2.20	16.51	15.24	5.87	7.32
					2.20		17.15		7.91	
					3.52		12.07		8.17	
AL6 – 2	05.07.2021	270	169	97	2.20	2.20	13.97	17.36	12.76	12.00
					1.32		14.61		11.74	
					3.08		23.50		11.49	
AL6 – 3	09.07.2021	513	198	86	5.71	4.98	21.60	20.96	6.89	7.06
					6.15		17.15		6.64	
					3.08		24.14		7.66	
AL6 – 4	14.07.2021	230	97	98	2.20	3.08	8.26	9.53	7.40	8.76
					2.64		9.53		8.93	
					4.40		10.80		9.96	
AL6 – 5	16.07.2021	554	484	18	1.76	2.20	14.61	12.07	10.72	10.89
					3.52		12.07		10.98	
					1.32		9.53		10.98	
AL6 – 6	21.07.2021	405	302	98	2.20	2.64	6.35	9.95	16.34	14.89
					1.76		10.80		15.57	
					3.96		12.70		12.76	
AL6 – 7	23.07.2021	211	128	12	1.32	2.05	21.60	19.05	10.98	11.83
					2.20		13.34		13.27	
					2.64		22.23		11.23	
AL6 – 8	27.07.2021	645	524	12	0.88	2.05	14.61	18.84	10.21	9.36
					2.64		17.15		8.68	
					2.64		24.77		9.19	
Monthly Average		372	250	58		2.67		15.38		10.26
Standard Deviation		183	171	41		1.00		4.40		2.65

NS: Not Specified

Table 6B : Results of Air Pollutant Concentration at Tuna Port					
Parameter	**Date**	**C_6H_6 [µg/m³]**	**HC***	**CO [mg/m³]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m³**	**NS**	**4.0 mg/m³**	**NS**
AL6 -1	01.07.2021	1.2	BDL	1.79	510
AL6 – 2	05.07.2021	1.11	BDL	1.84	502
AL6 – 3	09.07.2021	1.19	BDL	1.72	511
AL6 – 4	14.07.2021	1.15	BDL	1.69	496
AL6 – 5	16.07.2021	1.06	BDL	1.88	499
AL6 – 6	21.07.2021	1.11	BDL	1.87	502
AL6 – 7	23.07.2021	1.06	BDL	1.74	506
AL6 – 8	27.07.2021	1.15	BDL	1.7	512
Monthly Average		**1.13**	**-**	**1.78**	**505**
Standard Deviation		**0.05**	**-**	**0.08**	**6**

* NMHC- Non- Methane Hydrocarbons

BDL- Below Detection Limit (Detection Limit – NMHC : 0.5 ppm)

NS- Not Specified

The mean TSPM values at Tuna Port were 372 µg/m³, The mean PM_{10} values were 250 µg/m³, which is above the permissible limit. $PM_{2.5}$ values were within the permissible limit (mean = 58 µg/m³ µg/m³). The average values of SO_2, NO_x and NH_3 were 2.63 µg/m³, 15.38 µg/m³ and 10.26 µg/m³ respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Tuna Port. The mean Benzene concentration was 1.13 µg/m³, well below the permissible limit of 5.0 µg/m³. HC's were below the detectable limit and Carbon Monoxide concentration was 1.78 mg/m³, well below the permissible limit of 4.0 mg/m³.

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

Table 7 : Results of Air Pollutant Concentration at Signal Building											
Parameters	**Date**	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**		
Sampling Period	-	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	
NAAQMS limit	-	**NS**	**100 µg/m3**	**60 µg/m3**	-	**80 µg/m3**	-	**80 µg/m3**	-	**400 µg/m3**	
AL7 -1	01.07.2021	119	72	37	3.20	3.08	8.05	8.26	4.41	4.34	
					2.97		8.49		4.42		
					3.06		8.24		4.19		
AL7 -2	05.07.2021	104	81	30	3.40	3.52	13.07	12.70	5.45	5.36	
					3.18		12.38		5.29		
					3.99		12.65		5.35		
AL7 -3	09.07.2021	62	73	42	4.28	3.96	6.35	6.35	6.09	5.87	
					3.60		6.50		5.82		
					4.01		6.20		5.69		
AL7 -4	14.07.2021	104	74	110	4.18	3.96	6.24	6.35	18.21	17.88	
					3.87		6.47		17.45		
					3.84		6.34		17.97		
AL7 -5	16.07.2021	96	63	40	2.82	2.64	20.65	20.33	9.23	8.93	
					2.65		19.80		8.86		
					2.45		20.54		8.69		
AL7 -6	21.07.2021	102	68	12	8.02	7.47	5.73	5.72	2.71	2.81	
					7.18		6.03		2.59		
					7.22		5.40		3.13		
AL7 -7	23.07.2021	143	95	35	5.17	4.84	33.65	33.57	3.29	3.57	
					5.10		33.82		3.8		
					4.26		33.23		3.62		
AL7 -8	27.07.2021	107	74	18	7.26	7.46	31.49	31.46	4.5	4.45	
					7.49		31.78		4.75		
					7.62		31.12		4.1		
Monthly Average		105	75	40		5		16		7	
Standard Deviation		23	10	30		2		12		5	

NS: Not Specified

Table 7B : Results of Air Pollutant Concentration at Signal Building					
Parameter	Date	C_6H_6 [µg/m^3]	HC*	CO [mg/m^3]	CO_2 [ppm]
Sampling Period		8 hr	Grab Sampling	Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m^3	NS	4.0 mg/m^3	NS
AL7 -1	01.07.2021	1.1	BDL	1.56	489
AL7 – 2	05.07.2021	1.06	BDL	1.66	488
AL7 – 3	09.07.2021	1.02	BDL	1.72	479
AL7 – 4	14.07.2021	1.1	BDL	1.62	496
AL7 – 5	16.07.2021	1.11	BDL	1.68	488
AL7 – 6	21.07.2021	1.16	BDL	1.58	490
AL7 – 7	23.07.2021	1.12	BDL	1.66	481
AL7 – 8	27.07.2021	1.1	BDL	1.6	475
Monthly Average		**1.10**	**-**	**1.64**	**486**
Standard Deviation		**0.04**	**-**	**0.05**	**7**

* NMHC- Non- Methane Hydrocarbons
BDL- Below Detection Limit (Detection Limit – NMHC : 0.5 ppm)
NS_ Not Specified

The mean TSPM values at Vadinar Port were 105 µg/m^3. The mean PM_{10} values were 75 µg/m^3, which is below the permissible limit. $PM_{2.5}$ values were also within the permissible limit (mean = 40 µg/m^3 µg/m^3). The average values of SO_2, NO_x and NH_3 were 5.0 µg/m^3, 16.0 µg/m^3 and 7.0 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Vadinar Port. The mean Benzene concentration was 1.10 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.64 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

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

Table 8 : Results of Air Pollutant Concentration at Admin Building										
Parameters	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period	-	24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit	-	NS	100 µg/m3	60 µg/m3	-	80 µg/m3	-	80 µg/m3	-	400 µg/m3
AL8 -1	01.07.2021	172	96	25	2.71	2.64	10.75	10.80	3.42	3.57
					2.64		10.55		3.71	
					2.58		11.09		3.58	
AL8 -2	05.07.2021	121	100	16	4.05	3.96	8.89	8.89	4.51	4.85
					3.95		8.81		5.18	
					3.88		8.96		4.86	
AL8 -3	09.07.2021	108	88	14	5.02	4.84	5.80	5.72	9.48	9.19
					4.79		5.70		8.94	
					4.72		5.67		9.15	
AL8 -4	14.07.2021	169	68	84	6.74	6.59	5.76	5.72	22.65	22.61
					6.16		5.52		23.06	
					6.88		5.89		22.12	
AL8 -5	16.07.2021	136	85	37	1.40	1.32	18.40	18.42	23.67	22.98
					1.23		18.53		22.46	
					1.32		18.33		22.81	
AL8 -6	21.07.2021	140	65	87	9.58	9.67	9.04	8.89	6.65	6.63
					9.80		8.86		6.72	
					9.62		8.76		6.52	
AL8 -5	23.07.2021	168	96	47	6.10	6.15	44.85	44.46	9.23	8.93
					6.24		44.21		8.46	
					6.10		44.32		9.1	
AL8-6	27.07.2021	153	53	40	3.46	3.52	45.00	44.46	3.95	4.08
					3.72		44.05		4.09	
					3.38		44.32		4.2	
Monthly Average		146	81	44		5		18		10
Standard Deviation		24	17	28		3		17		8

NS: Not Specified

Table 8B : Results of Air Pollutant Concentration at Admin Building					
Parameter	Date	C_6H_6 [µg/m³]	HC*	CO [mg/m³]	CO_2 [ppm]
Sampling Period		8 hr	Grab Sampling	Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m³	NS	4.0 mg/m³	NS
AL8 -1	01.07.2021	1.1	BDL	1.56	489
AL8-2	05.07.2021	1.06	BDL	1.66	488
AL8 -3	09.07.2021	1.02	BDL	1.72	479
AL8-4	14.07.2021	1.1	BDL	1.62	496
AL8 -5	16.07.2021	1.11	BDL	1.68	488
AL8-6	21.07.2021	1.16	BDL	1.58	490
AL8-7	23.07.2021	1.12	BDL	1.66	481
AL8-8	27.07.2021	1.1	BDL	1.6	475
Monthly Average		**1.10**	**-**	**1.64**	**486**
Standard Deviation		**0.04**	**-**	**0.05**	**7**

* NMHC- Non- Methane Hydrocarbons

BDL- Below Detection Limit (Detection Limit – NMHC: 0.5 ppm)

NS-Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Admin Building Vadinar was comparatively low among all the locations of Air Quality monitoring in Kandla Port and Vadinar Port. The mean TSPM values at Vadinar Port were 146 µg/m³. The mean PM_{10} values were 81 µg/m³, which is below the permissible limit. $PM_{2.5}$ values were also within the permissible limit (mean = 44.0 µg/m³). The average values of SO_2, NO_x and NH_3 were 5.0µg/m³, 18.0 µg/m³ and 10.0 µg/m³ respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Admin Building, Vadinar Port. The mean Benzene concentration was 1.10 µg/m³, well below the permissible limit of 5.0 µg/m³. HC's were below the detectable limit and Carbon Monoxide concentration was 1.64 mg/m³, well below the permissible limit of 4.0 mg/m³.

1.4 Observations and Conclusion

During the monitoring period, the overall Ambient Air Quality of the port area was found to be well within the desired levels for various pollutants. However, Near Coal storage area, Marine Bhavan and Oil Jetty area, PM_{10} values was above the permissible standards. All other pollutants were recorded well below the prescribed limits.

2. Drinking Water Quality Monitoring

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

2.1 Drinking Water Monitoring Methodology

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

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

2.2 Results

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

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

Sr. No.	Parameter	Unit	Nirman Building 1	P & C building	Main Gate North	Acceptable Limits as per IS 10500 : 2012	Permissible Limits as per IS 10500 : 2012
1	pH	pH Unit	7.7	7.4	7.6	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1290	1530	1180	500	2000
3	Turbidity	NTU	0	1	0	1.0	5.0
4	Odor	-	Odourless	Odourless	Odourless	Agreeable	Agreeable
5	Color	Hazen Units	Colourless	Colourless	Colourless	5.0	15.0
6	Conductivity	µs/cm	2500	3010	2200	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2	<2	<2	NS*	NS*
8	Chloride as Cl	mg/l	416	436	451	250.0	1000.0
9	Ca as Ca	mg/l	72.14	52.10	64.13	75.0	200.0
10	Mg as Mg	mg/l	51.03	68.04	65.61	30.0	100.0
11	Total Hardness	mg/l	390	410	430	200.0	600.0
12	Iron as Fe	mg/l	<0.01	<0.01	<0.01	0.3	No Relaxation
13	Fluorides as F	mg/l	0.26	0.47	0.21	1.0	1.5
14	Sulphate as SO4	mg/l	140.52	166.8	156	200.0	400
15	Nitrite as NO2	mg/l	<0.01	<0.01	<0.01	NS*	NS*
16	Nitrate as NO3	mg/l	10.21	8.45	7.74	45.0	No Relaxation
17	Salinity	%	0.75	0.79	0.81	NS*	NS*
18	Sodium as Na	mg/l	170	168	148	NS*	NS*
19	Potassium as K	mg/l	2.2	2.3	2.8	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Sr. No.	Parameter	Unit	Canteen	West Gate - I	Wharf Area	Acceptable Limits as per IS 10500 : 2012	Permissible Limits as per IS 10500 : 2012
1	pH	pH Unit	7.5	7.3	7.6	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1590	1190	1670	500	2000
3	Turbidity	NTU	0	0	1	1.0	5.0
4	Odor	-	Odourless	Odourless	Odourless	Agreeable	Agreeable
5	Color	Hazen Units	Colourless	Colourless	Colourless	5.0	15.0
6	Conductivity	µs/cm	3110	2330	3300	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2	<2	<2	NS*	NS*
8	Chloride as Cl	mg/l	411	416	426	250.0	1000.0
9	Ca as Ca	mg/l	56.11	64.13	52.10	75.0	200.0
10	Mg as Mg	mg/l	60.75	48.60	63.18	30.0	100.0
11	Total Hardness	mg/l	390	360	390	200.0	600.0
12	Iron as Fe	mg/l	<0.01	<0.01	<0.01	0.3	No Relaxation
13	Fluorides as F	mg/l	0.18	0.53	1.05	1.0	1.5
14	Sulphate as SO4	mg/l	166.8	165.6	226.8	200.0	400
15	Nitrite as NO2	mg/l	<0.01	<0.01	<0.01	NS*	NS*
16	Nitrate as NO3	mg/l	10.56	11.97	7.53	45.0	No Relaxation
17	Salinity	%	0.74	0.75	0.77	NS*	NS*
18	Sodium as Na	mg/l	133	168	156	NS*	NS*
19	Potassium as K	mg/l	3	2.2	2.4	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Sr. No.	Parameter	Unit	SewaSadan – 3	Workshop	Custom Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits as per IS 10500 : 2012
1	pH	pH Unit	7.7	7.9	7.3	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1490	1090	1330	500	2000
3	Turbidity	NTU	1	0	0	1.0	5.0
4	Odor	-	Odourless	Odourless	Odourless	Agreeable	Agreeable
5	Color	Hazen Units	Colourless	Colourless	Colourless	5.0	15.0
6	Conductivity	µs/cm	2990	2090	2680	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2	<2	<2	NS*	NS*
8	Chloride	mg/l	451	456	461	250.0	1000.0
9	Ca as Ca	mg/l	60.12	56.11	64.13	75.0	200.0
10	Mg as Mg	mg/l	60.75	63.18	53.46	30.0	100.0
11	Total Hardness	mg/l	400	400	380	200.0	600.0
12	Iron as Fe	mg/l	<0.01	<0.01	<0.01	0.3	No Relaxation
13	Fluorides	mg/l	0.93	0.70	1.45	1.0	1.5
14	Sulphate	mg/l	156	171.6	195.6	200.0	400
15	Nitrite	mg/l	<0.01	<0.01	<0.01	NS*	NS*
16	Nitrate	mg/l	14.78	16.83	9.50	45.0	No Relaxation
17	Salinity	%	0.81	0.82	0.83	NS*	NS*
18	Sodium as Na	mg/l	162	152	162	NS*	NS*
19	Potassium as K	mg/l	2.3	2.4	2.8	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Sr. No.	Parameter	Unit	Port Colony Kandla	Hospital Kandla	A.O. Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits as per IS 10500 : 2012
1	pH	pH Unit	7.8	7.7	7.0	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1210	1450	1010	500	2000
3	Turbidity	NTU	1	2	2	1.0	5.0
4	Odor	-	Odourless	Odourless	Odourless	Agreeable	Agreeable
5	Color	Hazen Units	Colourless	Colourless	Colourless	5.0	15.0
6	Conductivity	µs/cm	2370	2880	2030	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2	<2	<2	NS*	NS*
8	Chloride	mg/l	526	541	491	250.0	1000.0
9	Ca as Ca	mg/l	52.10	52.10	48.10	75.0	200.0
10	Mg as Mg	mg/l	58.32	68.04	75.33	30.0	100.0
11	Total Hardness	mg/l	370	410	430	200.0	600.0
12	Iron as Fe	mg/l	<0.01	<0.01	<0.01	0.3	No Relaxation
13	Fluorides	mg/l	1.05	1.16	0.93	1.0	1.5
14	Sulphate	mg/l	204	214.8	147.6	200.0	400
15	Nitrite	mg/l	<0.01	<0.01	<0.01	NS*	NS*
16	Nitrate	mg/l	9.01	9.72	9.15	45.0	No Relaxation
17	Salinity	%	0.95	0.98	0.89	NS*	NS*
18	Sodium as Na	mg/l	178	160	180	NS*	NS*
19	Potassium as K	mg/l	2.7	2.3	2.8	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Sr. No.	Parameter	Unit	School Gopalpuri	Guest House	E - Type Quarter	Acceptable Limits as per IS 10500 : 2012	Permissible Limits as per IS 10500 : 2012
1	pH	pH Unit	7.1	7.3	7.2	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	990	1410	1330	500	2000
3	Turbidity	NTU	1	0	1	1.0	5.0
4	Odor	-	Odourless	Odourless	Odourless	Agreeable	Agreeable
5	Color	Hazen Units	Colourless	Colourless	Colourless	5.0	15.0
6	Conductivity	µs/cm	1900	2900	2660	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2	<2	<2	NS*	NS*
8	Chloride	mg/l	526	476	516	250.0	1000.0
9	Ca as Ca	mg/l	60.12	56.11	68.14	75.0	200.0
10	Mg as Mg	mg/l	55.89	53.46	53.46	30.0	100.0
11	Total Hardness	mg/l	380	360	390	200.0	600.0
12	Iron as Fe	mg/l	<0.01	<0.01	<0.01	0.3	No Relaxation
13	Fluorides	mg/l	1.08	0.82	1.14	1.0	1.5
14	Sulphate	mg/l	183.6	157.2	150	200.0	400
15	Nitrite	mg/l	<0.01	<0.01	<0.01	NS*	NS*
16	Nitrate	mg/l	10.35	11.48	10.35	45.0	No Relaxation
17	Salinity	%	0.95	0.86	0.93	NS*	NS*
18	Sodium as Na	mg/l	196	203	200	NS*	NS*
19	Potassium as K	mg/l	2.4	2.3	2.6	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Sr. No.	Parameter	Unit	F - Type Quarter	Hospital Gopalpuri	Tuna Port	Acceptable Limits as per IS 10500 : 2012	Permissible Limits as per IS 10500 : 2012
1	pH	pH Unit	7.5	7.2	7.3	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1100	1020	1050	500	2000
3	Turbidity	NTU	1	1	0	1.0	5.0
4	Odor	-	Odourless	Odourless	Odorless	Agreeable	Agreeable
5	Color	Hazen Unit	Colourless	Colourless	Colorless	5.0	15.0
6	Conductivity	µs/cm	2200	2050	1940	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2	<2	<2	NS*	NS*
8	Chloride	mg/l	506	546	592	250.0	1000.0
9	Ca as Ca	mg/l	64.13	72.14	72.14	75.0	200.0
10	Mg as Mg	mg/l	65.61	43.74	36.45	30.0	100.0
11	Total Hardness	mg/l	430	360	330	200.0	600.0
12	Iron as Fe+3	mg/l	<0.01	<0.01	<0.01	0.3	No Relaxation
13	Fluorides	mg/l	0.94	1.02	0.46	1.0	1.5
14	Sulphate	mg/l	165.6	159.6	120	200.0	400
15	Nitrite	mg/l	<0.01	<0.01	<0.01	NS*	NS*
16	Nitrate	mg/l	10.63	9.36	1.33	45.0	No Relaxation
17	Salinity	%	0.91	0.99	0.92	NS*	NS*
18	Sodium as Na	mg/l	180	180	188	NS*	NS*
19	Potassium as K	mg/l	2.5	2.4	2.6	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Sr. No.	Parameter	Unit	Vadinar Jetty	Port Colony Vadinar	Acceptable Limits as per IS 10500 : 2012	Permissible Limits as per IS 10500 : 2012
1	pH	pH Unit	7.9	7.6	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	950.0	620.0	500	2000
3	Turbidity	NTU	ND	ND	1.0	5.0
4	Odor	-	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	1580.0	1030.0	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2	<2	NS*	NS*
8	Chloride	mg/l	445.99	466.04	250.0	1000.0
9	Ca as Ca	mg/l	60.12	52.10	75.0	200.0
10	Mg as Mg	mg/l	63.18	60.75	30.0	100.0
11	Total Hardness	mg/l	410	380	200.0	600.0
12	Iron as Fe+3	mg/l	<0.01	<0.01	0.3	No Relaxation
13	Fluorides	mg/l	0.99	0.94	1.0	1.5
14	Sulphate	mg/l	16.80	17.64	200.0	400
15	Nitrite	mg/l	<0.01	<0.01	NS*	NS*
16	Nitrate	mg/l	11.48	9.50	45.0	No Relaxation
17	Salinity	%	0.81	0.84	NS*	NS*
18	Sodium as Na	mg/l	142.0	156.0	NS*	NS*
19	Potassium as K	mg/l	2.3	2.4	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent

*NS: Not Specified

2.3 Results & Discussion

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

pH

The limit of pH value for drinking water is specified as 6.5 to 8.5. pH value in the studied area varied from 7.0 to 7.9 pH unit. All the sampling points showed pH values within the prescribed limit by Indian Standards.

Total Dissolved Solids (TDS)

TDS values in the studied area varied between 600 -1800 mg/l. None of the sampling points showed higher TDS values than the prescribed limit by Indian standards .

Conductivity

Electrical Conductivity is the ability of a solution to transfer (conduct) electric current. Conductivity is used to measure the concentration of dissolved solids which have been ionized in a polar solution such as water. The conductivity in the samples collected during the month of July ranged from 1000-3300 µs/cm. Electrical conductivity standards do not appear in BIS standards for drinking water.

BOD

BOD value in the studied area was less than 2.0 mg/L. Indian standards does not show any standard values for BOD in drinking water.

Chlorides

Excessive chloride concentration increase rates of corrosion of metals in the distribution system. This can lead to increased concentration of metals in the supply. Chloride value in the studied area varied between 400-600 mg/l and is found to be within the Permissible limit of the Drinking Water Standard.

Calcium

Calcium value in the studied area varied between 45 - 80 mg/l and is found to be within the Permissible limit of the Drinking Water Standard. If calcium is present beyond the maximum acceptable limit, it causes incrustation of pipes.

Magnesium

Magnesium value in the studied area varied between 30 – 80 mg/l. All the locations had Magnesium within the prescribed limits of 30-100 mg/L.

Total Hardness

Hardness value in the studied area varied between 330-430 mg/l and is found to be within the Permissible limit of the Drinking Water Standard.The prescribed limit by Indian Standards is 200-600 mg/L.

Iron

Iron value in the studied area was below 0.01mg/L and hence well below the permissible limit as per Indian Standards is 0.3 mg/L. The excess amount of iron causes slight toxicity; gives stringent taste to water.

Fluoride

Fluoride value in the studied area varied between 0.1 – 1.4 mg/l and hence well below the permissible limit as per Indian Standards is 1.0-1.5 mg/L. Moderate amounts lead to dental effects, but long-term ingestion of large amounts can lead to potentially severe skeletal problems.

Sulphates

Sulphate value in the studied area varied between 100 – 330 mg/l. All the sampling points showed sulphate values within the prescribed limits by Indian Standards (200-400 mg/L). Sulphate content in drinking water exceeding the 400 mg/L imparts bitter taste.

Nitrites (NO_2) and Nitrates (NO_3)

Nitrite values in all the water samples were <0.1. There are no specified standard values for Nitrites in Drinking water. The mean Nitrate values in drinking water of KPT was 4.10 mg/l which is well within the permissible limit of the Drinking water Standard.

Salinity

Salinity in drinking water in the present samples collected ranged from 0.6 to 0.9 %. There are no prescribed Indian standards for salinity in Drinking water**.**

Sodium and Potassium Salts

Sodium values in the samples collected ranged from 100 - 2000 mg/l and Potassium salts ranged from 2.2 to 3.0 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 permissible limits prescribed by the Indian Standards.

Bacteriological Study

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

2.4 Conclusions

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

3. Noise Level Monitoring

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

3.1 Method of Monitoring

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

3.2 Results

Table 16: Noise Monitoring data for ten locations of Deendayal Port and two 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	60.71	55.49
2	Nirman Building 1	58.02	52.12
3	Tuna Port	53.16	46.37
4	Main Gate North	56.47	53.21
5	West Gate I	61.41	53.6
6	Canteen Area	56.78	48.45
7	Main Road	59.41	56.44
8	ATM Building	63.81	55.02
9	Wharf Area /Jetty Area	65.66	56.59
10	Port & Custom Office	53.59	49.22
	Vadinar Port		
11	Entrance Gate of Vadinar Port	56.32	54.2
12	Nr. Port Colony, Vadinar	55.5	54.8
13	Nr. Vadinar Jetty	58.76	55.4

3.3 Conclusions- Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. The Day Time Average Noise Level (SPL)in all ten locations at Deendayal Port ranged from 56.25 dB(A) to 69.51 dB(A) and it was within the permissible limits of 75 dB(A) for the industrial area for the daytime. The Night Time Average Noise Level (SPL) in all ten locations of Deendayal Port ranged from 48.28 dB to 62.33 dB(A) and it was within the permissible limits of 70 dB(A) for the industrial area for the night time.

4. Soil Monitoring

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

4.1 Methodology

The soil samples were collected in the month of July 2021. The samples collected from the all locations are homogeneous representative of each location. At random locations were identified at each location and soil was dug from 30 cm below the surface. It was uniformly mixed before homogenizing the soil samples. The samples were filled in polythene bags, labeled in the field with number and site name and sent to laboratory for analysis.

4.2 Results

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

Sr. No.	Parameter	Unit	Station Name					
			SL1	SL2	SL3	SL4	SL5	SL6
			Tuna Port	IFFCO Plant	Khori Creek	Nakti Creek	KPT Admin Site	KPT Colony
			Near main gate of Port	10 m away from main gate	Sand from creek at low tide		Vadinar	
1	Texture		Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	pH	-	8.56	8.11	8.38	8.33	8.12	8.42
3	Electrical Conductivity	µs/cm	26,800.0	23,800.0	23,700.0	16,260.0	509.0	419.0
4	Moisture	%	23.66	22.09	24.41	23.65	9.44	7.59
5	Total Organic Carbon	%	0.16	0.24	0.32	0.10	0.20	0.12
6	Alkalinity	mg/kg	140.14	140.14	100.10	80.08	100.10	60.06
7	Total Nitrogen	%	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
8	Chloride	mg/kg	3,908.6	4,309.5	6,114.0	3,959.0	39.3	68.7
9	Sulphate	mg/kg	203.0	177.9	113.8	93.8	13.4	15.5
10	Phosphorus	mg/kg	0.97	0.80	1.24	1.77	0.80	0.97
11	Potassium	mg/kg	779.4	644.4	1,135.8	766.8	129.6	180.0
12	Sodium	mg/kg	2,241.0	3,556.8	3,981.6	3,038.4	1,220.0	1,445.4
13	Calcium	mg/kg	144.29	128.22	168.30	224.40	104.20	56.11
14	Copper as Cu	mg/kg	42.6	61.2	38.2	22.6	16.2	23
15	Lead as Pb	mg/kg	4.2	3.2	3.6	3.8	ND	ND
16	Nickel as Ni	mg/kg	36.2	31.6	39.4	22.6	18.3	21.2
17	Zinc as Zn	mg/kg	58.60	39.25	52.4	46.60	46.80	38.20
18	Cadmium as Cd	mg/kg	ND	ND	ND	ND	ND	ND

4.3 Discussion

- The data shows that value of pH ranges from 8.11 at Nakti Creek to 8.56 at Tuna Creek indicating that all soil samples are neutral to slight basic. Tuna port samples howed maximum conductivity of 26,800µmhos/cm, while Nakti Creek location showed minimum conductivity of 16,260 µmhos/cm. Conductivity at Vadinar Port was 509 and 419 µmhos/cm at Admin site and Vadinar Port colony respectively.
- Total organic Carbon ranged from 0.1 % to 0.3 at Deendayal Port. At Vadinar Port, organic carbon content ranged from 0.1 % to 0.2 %.
- The concentration of Phosphorus and Potassium in the soil samples varies from 0.8 to 1.77 mg/kg and 600.0 to 1150 mg/kg respectively at Deendayal Port. The mean concentration of Phosphorous at Vadinar site was 0.89 mg/kg and mean concentration of Potassium at Vadinar site was 154.8 mg/kg.

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

Heavy Metals in the Soil

Traces of Copper, Lead, Nickel and Zinc were observed in the soil samples collected from all the four locations of Deendayal Port and two locations of Vadinar Port. Cadmium metal was not detected in the Soil.

4.4 Conclusion

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

5. Sewage Treatment Plant Monitoring

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

5.1 Methodology for STP Monitoring

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

5.2 Results

- **Kandla STP**

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

Date of Sampling	05.07.2021

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	7.5	7.8
2	Total Suspended Solids	mg/l	125.4	64.3
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	333.3	102
5	BOD @ 27 °C	mg/l	110.0	26.0
Aeration Tank				
6	MLSS	mg/l	18.0	
7	MLVSS	%	88.0	

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

Date of Sampling	15.07.2021

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	7.6	7.68
2	Total Suspended Solids	mg/l	350	46
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	585	98
5	BOD @ 27 °C	mg/l	196.0	26.0
Aeration Tank				
6	MLSS	mg/l	24.0	
7	MLVSS	%	82.0	

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

Date of Sampling	20.07.2021

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	7.73	7.61
2	Total Suspended Solids	mg/l	192.6	62
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	222	20
5	BOD @ 27 °C	mg/l	68.0	8.0
Aeration Tank				
6	MLSS	mg/l	16.0	
7	MLVSS	%	86.0	

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

Date of Sampling	26.07.2021

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	Plant was not working	
2	Total Suspended Solids	mg/l		
3	Residual Chlorine	mg/l		
4	COD	mg/l		
5	BOD @ 27 °C	mg/l		
Aeration Tank				
6	MLSS	mg/l	-	
7	MLVSS	%	-	

- **Gopalpuri Colony STP**

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

Date of Sampling	05.07.2021

Sr. No.	Parameters	Unit	Results	
			Gopalpuri STP I/L	Gopalpuri STP O/L
1	pH	pH unit	7.7	7.63
2	Total Suspended Solids	mg/l	408.3	38.3
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	262.6	102
5	BOD @ 27 °C	mg/l	82.0	28.0
Aeration Tank				
6	MLSS	mg/l	12.0	
7	MLVSS	%	92.0	

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

Date of Sampling	15.07.2021

Sr. No.	Parameters	Unit	Results	
			Gopalpuri STP I/L	Gopalpuri STP O/L
1	pH	pH unit	7.3	7.43
2	Total Suspended Solids	mg/l	333	69
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	444.4	103
5	BOD @ 27 °C	mg/l	142.0	28.0
Aeration Tank				
6	MLSS	mg/l	16.0	
7	MLVSS	%	89.0	

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

Date of Sampling	20.07.2021

Sr. No.	Parameters	Unit	Results	
			Gopalpuri STP I/L	Gopalpuri STP O/L
1	pH	pH unit	7.39	7.43
2	Total Suspended Solids	mg/l	166.6	36.7
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	230	58
5	BOD @ 27 °C	mg/l	70.0	19.0
Aeration Tank				
6	MLSS	mg/l	12.0	
7	MLVSS	%	92.0	

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

Date of Sampling	26.07.2021

Sr. No.	Parameters	Unit	Results	
			Gopalpuri STP I/L	Gopalpuri STP O/L
1	pH	pH unit	7.28	7.4
2	Total Suspended Solids	mg/l	160	38
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	210	62
5	BOD @ 27 °C	mg/l	62.0	19.0
Aeration Tank				
6	MLSS	mg/l	11.0	
7	MLVSS	%	96.0	

- **Vadinar STP**

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

Date of Sampling	05.07.2021

Sr. No.	Parameters	Unit	Results	
			Vadinar STP I/L	Vadinar O/L
1	pH	pH unit	7.23	NOT WORKING
2	Total Suspended Solids	mg/l	8	
3	Residual Chlorine	mg/l	70.0	
4	COD	mg/l	86.0	
5	BOD @ 27 °C	mg/l	27.0	

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

Date of Sampling	15.07.2021

Sr. No.	Parameters	Unit	Results	
			Vadinar STP I/L	Vadinar O/L
1	pH	pH unit	7.22	NOT WORKING
2	Total Suspended Solids	mg/l	62	
3	Residual Chlorine	mg/l	<1.0	
4	COD	mg/l	82.0	
5	BOD @ 27 °C	mg/l	27.0	

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

Date of Sampling	20.07.2021

Sr. No.	Parameters	Unit	Results	
			Vadinar STP I/L	Vadinar O/L
1	pH	pH unit	7.22	NOT WORKING
2	Total Suspended Solids	mg/l	62	
3	Residual Chlorine	mg/l	<1.0	
4	COD	mg/l	82.0	
5	BOD @ 27 °C	mg/l	27.0	

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

Date of Sampling	26.07.2021

<table>
<tr><th rowspan="2">Sr. No.</th><th rowspan="2">Parameters</th><th rowspan="2">Unit</th><th colspan="2">Results</th></tr>
<tr><th>Vadinar STP I/L</th><th>Vadinar O/L</th></tr>
<tr><td>1</td><td>pH</td><td>pH unit</td><td>7.18</td><td rowspan="5">NOT WORKING</td></tr>
<tr><td>2</td><td>Total Suspended Solids</td><td>mg/l</td><td>72</td></tr>
<tr><td>3</td><td>Residual Chlorine</td><td>mg/l</td><td><1.0</td></tr>
<tr><td>4</td><td>COD</td><td>mg/l</td><td>80.0</td></tr>
<tr><td>5</td><td>BOD @ 27 °C</td><td>mg/l</td><td>26.0</td></tr>
</table>

5.3 Conclusions:

The GPCB standards of BOD, TSS and Residual Chlorine for STP outlet are 20 mg/lit, 30 mg/lit & 0.5 mg/lit respectively. It is suggested to do treatment on regular basis to avoid flow of contaminated/polluted water into the sea. Also, the STP at Vadinar is also non-functional and thus, steps should be taken to commission the STP at Vadinar Port. Hence, currently only inlet samples are collected and analysed. And the sample of kandla stp was not collected in the last week of July 2021 as plant was not working.

6. Marine Water Monitoring

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

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

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

Marine Environment

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

Sampling Stations

The monitoring of marine environment for the study of biological and ecological parameters was carried out on 10th& 12th July -2021 in harbor regions of KPT and on 10th July-2021 at Vadinar during spring tide period of New moon phase of Lunar Cycle. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 17th& 19th July 2021 in harbor regions of KPT. 17th July -2021 in Vadinar during Neap tide period first quarter of Lunar Cycle..

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

Sampling Locations

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

6.1 Marine Water Quality

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

The results of marine water quality and Marine sediments are as below;

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

Sr. No.	Parameters	Unit	Kandla Creek Near KPT colony (1)			
			23°0'58"N 70°13'22."E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.29	7.25	7.13	7.15
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	32.0	31.8	32.1	32.6
5	Turbidity	NTU	30	28	35	27
6	Total Dissolved Solids	mg/l	37802.0	23743	43720.0	43881.0
7	Total Suspended Solids	mg/l	624	412	409	261
8	Total Solids	mg/l	38426.2	24155.4	44129.0	44142.0
9	DO	mg/l	4.5	5	4.9	5.3
10	COD	mg/l	72.0	68.0	74.0	76.0
11	BOD	mg/l	<2	<2	<2	<2
12	Silica	mg/l	0.23	0.38	0.30	0.48
13	Phosphate	mg/l	0.31	0.28	0.19	0.35
14	Sulphate	mg/l	2856	2556	2076	2160
15	Nitrate	mg/l	2.10	2.04	2.40	2.04
16	Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05
17	Calcium	mg/l	521.04	561.12	521.04	440.88
18	Magnesium	mg/l	1798.2	1798.2	1773.9	1871.1
19	Sodium	mg/l	14122.0	14820.0	10110.0	10872.0
20	Potassium	mg/l	325.0	289.0	321.0	289.0
21	Iron	mg/l	1.12	1.42	1.52	1.45
22	Chromium	mg/l	0.12	0.13	0.12	0.11
23	Copper	mg/l	0.12	0.19	0.06	0.08
24	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01
25	Cadmium	mg/l	0.07	0.06	0.05	0.06
26	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001
27	Lead	mg/l	0.20	0.19	0.11	0.12
28	Zinc	mg/l	0.05	0.06	0.06	0.07

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

Sr. No.	Parameters	Unit	Near passenger Jetty One (2)			
			23° 0'18 "N 70°13'31"E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	5.3	4.7	7.3	7.27
2	Color	-	80.0	76.0	Colorless	Colorless
3	Odor	-	<2	<2	Odorless	Odorless
4	Salinity	ppt	0.32	0.68	33.0	32.6
5	Turbidity	NTU	0.32	0.26	22	28
6	Total Dissolved Solids	mg/l	2976	2748	46102.0	47052.0
7	Total Suspended Solids	mg/l	2.25	2.03	211	312
8	Total Solids	mg/l	<0.05	<0.05	46313.0	47364.0
9	DO	mg/l	521.04	521.04	4.6	4.9
10	COD	mg/l	1846.8	1773.9	86.0	79.0
11	BOD	mg/l	11052.0	13425.0	<2	<2
12	Silica	mg/l	325.0	306.0	0.39	0.72
13	Phosphate	mg/l	1.55	1.62	0.34	0.30
14	Sulphate	mg/l	0.12	0.14	1956	2520
15	Nitrate	mg/l	0.18	0.16	1.74	2.52
16	Nitrite	mg/l	<0.01	<0.01	<0.05	<0.05
17	Calcium	mg/l	0.07	0.05	480.96	480.96
18	Magnesium	mg/l	<0.001	<0.001	1822.5	1822.5
19	Sodium	mg/l	0.28	0.16	11011.0	10452.0
20	Potassium	mg/l	0.05	0.06	333.0	315.0
21	Iron	mg/l	5.3	4.7	1.56	1.89
22	Chromium	mg/l	80.0	76.0	0.16	0.14
23	Copper	mg/l	<2	<2	0.09	0.08
24	Arsenic	mg/l	0.32	0.68	<0.01	<0.01
25	Cadmium	mg/l	0.32	0.26	0.06	0.07
26	Mercury	mg/l	2976	2748	<0.001	<0.001
27	Lead	mg/l	2.25	2.03	0.16	0.19
28	Zinc	mg/l	<0.05	<0.05	0.06	0.08

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

Sr. No.	Parameters	Unit	Near Coal Berth			
			22°59'12"N 70°13'40"E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.51	7.30	7.29	7.5
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	32.6	32.8	32.4	33.1
5	Turbidity	NTU	35	47	35	47
6	Total Dissolved Solids	mg/l	40788	35363	41086.0	42830.0
7	Total Suspended Solids	mg/l	563	601	215	161
8	Total Solids	mg/l	41351.3	35964.2	41301.0	42991.0
9	DO	mg/l	4.8	5	4.8	5
10	COD	mg/l	88.0	70.0	90.0	79.0
11	BOD	mg/l	<2	<2	<2	<2
12	Silica	mg/l	0.30	0.34	0.42	0.36
13	Phosphate	mg/l	0.28	0.32	0.35	0.38
14	Sulphate	mg/l	2580	3444	3156	3240
15	Nitrate	mg/l	1.93	2.10	2.56	2.46
16	Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05
17	Calcium	mg/l	561.12	480.96	561.12	601.2
18	Magnesium	mg/l	1725.3	1798.2	1725.3	1725.3
19	Sodium	mg/l	15555.0	13252.0	11052.0	11412.0
20	Potassium	mg/l	389.0	296.0	315.0	296.0
21	Iron	mg/l	1.47	2.02	2.10	2.02
22	Chromium	mg/l	0.19	0.15	0.12	0.20
23	Copper	mg/l	0.14	0.12	0.06	0.10
24	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01
25	Cadmium	mg/l	0.04	0.06	0.08	0.07
26	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001
27	Lead	mg/l	0.20	0.18	0.10	0.12
28	Zinc	mg/l	0.08	0.06	0.07	0.06

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

Sr. No.	Parameters	Unit	KPT 4			
			Near 15/16 Berth			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.25	7.20	7.39	7.45
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	32.4	32.8	32.4	32.2
5	Turbidity	NTU	50	29	51	55
6	Total Dissolved Solids	mg/l	35588	33113	43563.0	44059.0
7	Total Suspended Solids	mg/l	407	420	213	265
8	Total Solids	mg/l	35995.3	33533.4	43776.0	44324.0
9	DO	mg/l	5.2	4.8	5.3	4.7
10	COD	mg/l	68.0	79.0	76.0	86.0
11	BOD	mg/l	<2	<2	<2	<2
12	Silica	mg/l	0.81	0.29	0.79	0.37
13	Phosphate	mg/l	0.26	0.34	0.43	0.42
14	Sulphate	mg/l	2388	2652	2280	2376
15	Nitrate	mg/l	1.74	1.96	2.10	2.57
16	Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05
17	Calcium	mg/l	601.20	561.12	601.2	561.12
18	Magnesium	mg/l	1749.6	1822.5	1725.3	1798.2
19	Sodium	mg/l	10026.0	11252.0	10512.0	9899.0
20	Potassium	mg/l	302.0	378.0	266.0	275.0
21	Iron	mg/l	1.66	1.48	1.45	1.60
22	Chromium	mg/l	0.16	0.16	0.18	0.16
23	Copper	mg/l	0.15	0.10	0.12	0.10
24	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01
25	Cadmium	mg/l	0.07	0.06	0.06	0.05
26	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001
27	Lead	mg/l	0.16	0.2	0.08	0.10
28	Zinc	mg/l	0.07	0.08	0.05	0.05

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

Sr. No.	Parameters	Unit	Nakti Creek Near Tuna Port 22°57'49."N 70° 7'0.67"E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.29	7.35	7.2	7.28
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	32.6	33.2	33.6	33.0
5	Turbidity	NTU	35	29	29	29
6	Total Dissolved Solids	mg/l	38200	18212	46852.0	47695.0
7	Total Suspended Solids	mg/l	324	214	200	196
8	Total Solids	mg/l	38524.4	18426.2	47052.0	47891.0
9	DO	mg/l	5.1	5.1	4.9	5
10	COD	mg/l	80.0	68.0	89.0	78.0
11	BOD	mg/l	<2	<2	<2	<2
12	Silica	mg/l	0.26	0.29	0.62	0.30
13	Phosphate	mg/l	0.28	0.26	0.31	0.38
14	Sulphate	mg/l	2964	3408	3240	3156
15	Nitrate	mg/l	1.95	2.18	2.56	2.49
16	Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05
17	Calcium	mg/l	561.12	521.04	601.2	440.88
18	Magnesium	mg/l	1822.5	1749.6	1798.2	1822.5
19	Sodium	mg/l	11256.0	12625.0	11021.0	11425.0
20	Potassium	mg/l	302.0	366.0	396.0	378.0
21	Iron	mg/l	1.83	1.76	2.02	2.11
22	Chromium	mg/l	0.15	0.18	0.20	0.18
23	Copper	mg/l	0.12	0.11	0.16	0.10
24	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01
25	Cadmium	mg/l	0.04	0.06	0.07	0.08
26	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001
27	Lead	mg/l	0.18	0.19	0.12	0.16
28	Zinc	mg/l	0.06	0.05	0.06	0.07

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

Sr. No.	Parameters	Unit	Nakti Creek Near NH-8A			
			23° 02'01"N 70° 09'31"E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.37	Sampling not possible during Low Tide	7.37	Sampling not possible during Low Tide
2	Color	-	Colorless		Colorless	
3	Odor	-	Odorless		Odorless	
4	Salinity	ppt	33.4		32.4	
5	Turbidity	NTU	27		33	
6	Total Dissolved Solids	mg/l	35166		42125.0	
7	Total Suspended Solids	mg/l	180		164.3	
8	Total Solids	mg/l	35346.3		42289.3	
9	DO	mg/l	5		5.5	
10	COD	mg/l	72.0		79.0	
11	BOD	mg/l	<2		<2	
12	Silica	mg/l	0.61		0.62	
13	Phosphate	mg/l	0.30		0.39	
14	Sulphate	mg/l	2988		3036	
15	Nitrate	mg/l	2.43		2.72	
16	Nitrite	mg/l	<0.05		<0.05	
17	Calcium	mg/l	601.20		521.04	
18	Magnesium	mg/l	1749.6		1749.6	
19	Sodium	mg/l	14485.0		11528.0	
20	Potassium	mg/l	396.0		311.0	
21	Iron	mg/l	1.52		2.06	
22	Chromium	mg/l	0.16		0.19	
23	Copper	mg/l	0.16		0.11	
24	Arsenic	mg/l	<0.01		<0.01	
25	Cadmium	mg/l	0.04		0.06	
26	Mercury	mg/l	<0.001		<0.001	
27	Lead	mg/l	0.17		0.10	
28	Zinc	mg/l	0.06		0.07	

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

Sr. No.	Parameters	Unit	Nr.Vadinar Jetty 22°26'25.26"N 69°40'20.41"E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.60	7.45	7.5	7.8
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	33.2	32.6	33.0	33.1
5	Turbidity	NTU	32	28	35	25
6	Total Dissolved Solids	mg/l	37530	35780	43940.0	46623.0
7	Total Suspended Solids	mg/l	327	417	405.5	399.5
8	Total Solids	mg/l	37856.5	36197.4	44345.5	47022.5
9	DO	mg/l	5.2	5.1	5.2	5.1
10	COD	mg/l	68.0	72.0	78.0	79.0
11	BOD	mg/l	<2	<2	<2	<2
12	Silica	mg/l	0.32	0.31	0.42	0.62
13	Phosphate	mg/l	0.26	0.26	0.35	0.33
14	Sulphate	mg/l	2136	2352	2220	2304
15	Nitrate	mg/l	2.72	2.80	2.09	2.44
16	Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05
17	Calcium	mg/l	480.96	561.12	561.12	521.04
18	Magnesium	mg/l	1749.6	1749.6	1579.5	1555.2
19	Sodium	mg/l	16458.0	15555.0	11425.0	12021.0
20	Potassium	mg/l	345.0	388.0	316.0	296.0
21	Iron	mg/l	2.06	2.10	2.45	2.3
22	Chromium	mg/l	0.16	0.20	0.15	0.16
23	Copper	mg/l	0.17	0.18	0.09	0.08
24	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01
25	Cadmium	mg/l	0.05	0.06	0.05	0.06
26	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001
27	Lead	mg/l	0.14	0.13	0.10	0.10
28	Zinc	mg/l	0.08	0.09	0.05	0.06

6.1.1 Marine Sediments

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

6.2 Results

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

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

Sr. No.	Parameters	Unit	KPT - 1	KPT - 2	Khori - 1	Nakti - 1 (Near NH-8A)	Jetty
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	0.64	1.12	0.39	1.03	1.06
3	Organic Carbon	mg/kg	0.37	0.65	0.22	0.60	0.52
4	Inorganic Phosphate	mg/kg	126.0	125.0	136.0	146.0	152.0
5	Moisture	%	11.70	18.10	6.60	26.1	23.50
6	Aluminium	mg/kg	ND	ND	ND	ND	ND
7	Silica	mg/kg	26.0	24.0	42.0	49.0	41.2
8	Phosphate	mg/kg	9.88	7.82	8.80	9.70	18.00
9	Sulphate	mg/kg	170.0	192.0	259.0	259.0	362.0
10	Nitrite	mg/kg	0.12	0.13	0.11	0.11	0.11
11	Nitrate	mg/kg	9.23	7.82	9.25	9.25	7.52
12	Calcium	mg/kg	144.3	148.0	132.0	124.0	169.0
13	Magnesium	mg/kg	165.2	214.0	122.0	136.0	162.0
14	Sodium	mg/kg	2221.0	1686.0	1882.0	1775.0	3785.0
15	Potassium	mg/kg	641.0	542.0	738.0	562.0	658.0
16	Chromium	mg/kg	123	145	126	130	162
17	Nickel	mg/kg	24.8	22.5	18.9	26.02	38
18	Copper	mg/kg	48	42	20.6	27.5	23.6
19	Zinc	mg/kg	32.60	36.00	30.40	36.00	32.00
20	Cadmium	mg/kg	ND	ND	ND	ND	ND
21	Lead	mg/kg	2.8	1.8	1.2	4.5	5.8
22	Mercury	mg/kg	ND	ND	ND	ND	ND
23	Arsenic	mg/kg	ND	ND	ND	ND	ND

*Grab samples could not be collected due high current at KPT 3, Natki Creek Near Tuna port & Vadinar SBM

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

Sr. No.	Parameters	Unit	KPT - 1	KPT - 2	Jetty
1	Texture	-	Sandy loam	Sandy loam	Sandy loam
2	Organic Matter	mg/kg	0.74	1.10	1.10
3	Organic Carbon	mg/kg	0.52	0.62	0.63
4	Inorganic Phosphate	mg/kg	162.0	142.0	162.0
5	Moisture	%	15.62	14.20	21.52
6	Aluminium	mg/kg	ND	ND	ND
7	Silica	mg/kg	16.60	20.30	39.2
8	Phosphate	mg/kg	9.8	7.26	16.66
9	Sulphate	mg/kg	342.0	280.0	289.0
10	Nitrite	mg/kg	0.10	0.11	0.1
11	Nitrate	mg/kg	10.6	9.8	8.02
12	Calcium	mg/kg	141.0	152.0	178.0
13	Magnesium	mg/kg	156.0	214.0	206.0
14	Sodium	mg/kg	2210.0	1786.0	3682.0
15	Potassium	mg/kg	590.0	562.0	666.0
16	Chromium	mg/kg	136	149	158
17	Nickel	mg/kg	26.2	23.5	32
18	Copper	mg/kg	52	46	18.2
19	Zinc	mg/kg	33.20	34.00	22.00
20	Cadmium	mg/kg	ND	ND	ND
21	Lead	mg/kg	2.4	2.2	4.6
22	Mercury	mg/kg	ND	ND	ND
23	Arsenic	mg/kg	ND	ND	ND

*Grab samples could not be collected due high current at KPT 3,Khori, Natki Creek Near Tuna Port, Vadinar Jetty and Vadinar SBM

REPORT

ON

ECOLOGICAL MONITORING

OF MARINE ENVIRONMENT

IN

DPT HARBOUR AREA, NEAR BY CREEKS

For

DEENDAYAL PORT TRUST

JULY, 2021

INTRODUCTION:

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

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

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

MARINE ENVIRONMENT:

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

Sampling Stations:

The monitoring of marine environment for the study of biological and ecological Parameters was carried out on 10th July, 2021 in in harbour region of DPT, and on 12thJuly, 2021 in creeks near by the port during spring tide .The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 17th July, 2021 in harbour region of DPT and on 19thJuly, 2021 in creeks near by the port during neap tidal condition.

Plankton samples from sub surface layer was collected both during high tide period and low tide period from 3 water quality monitoring stations of DPT harbour area andone 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. Collected water samples were processed for estimation of Chlorophyll- a, Pheophytin- a, qualitative &quantitative evaluation of phytoplankton, qualitative &quantitative evaluation zooplanktons(density and their population).

TABLE #1 SAMPLING LOCATIONS

monitoring requirement	**Number of locations**
Kandla creek Nakti creek Khori Creek	3 in Kandla creek 2 in Nakti creek 1 in Khori creek
Total Number of locations	**6**

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

Samples Processing for chlorophyll estimation:

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

PLANKTON:

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

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

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

Phytoplankton in the marine environment:

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

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

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

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

Zooplankton in the marine environment:

Zooplankton includes a taxonomically and morphologically diverse community of heterotrophic organisms that drift in the waters of the world's oceans. Qualitative and quantitative studies on zooplankton community is 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, growth and survival rate are all significant factors determining the recruitment and abundance of fish stocks as they form an essential food for larval, juvenile and adult fishes (Beaugrand et al., 2004). Zooplankton grazing in the marine environment controls the primaryProduction and helps in determining the pelagic ecosystem (Banse, 1995). Through grazing in surface waters and following the production of sinking faecal matters and also by the active transportation of dissolved and particulate matter to deeper waters via vertical migration, they help in the transport of organic carbon to deep ocean layers and thus act as key drivers of biological pump’ in the marine ecosystem. Zooplankton grazing and metabolism also, transform particulate organic matter into dissolved forms, promoting primary producer community, microbial demineralization, and particle export to the ocean’s interior.

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

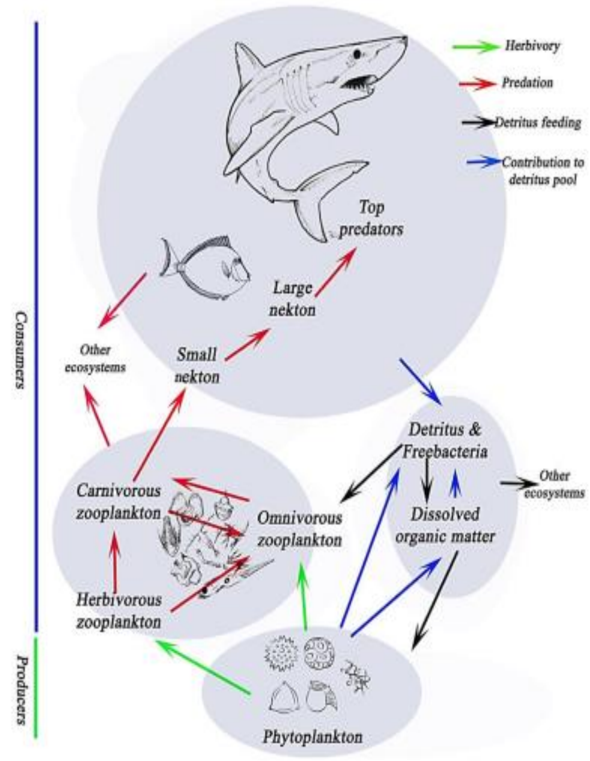
Based on the duration of planktonic life, zooplankton are categorised into Holoplankton (organisms which complete their entire lifecycle as plankton) and Meroplankton (organisms which are planktonic during the early part of their lives such as the larval stages of benthic and nektonic organisms). Tychoplankton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

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

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

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

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



Simplified marine food web

Spatial distribution of Plankton:

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

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

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

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

Methodology adopted for Plankton sampling:

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

Preservation and storage:

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

Sample concentration:

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

Taxonomic evaluation:

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

Cell counts by drop count method:

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

BENTHIC ORGANISMS:

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

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

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

SAMPLING METHODOLOGY ADOPTED FOR SUB TIDAL REGION:

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

Sample sieving:

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

Sample staining:

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

DIVERSITY INDICES:

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

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

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

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

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

Simpson's diversity index

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

The formula for calculating D is presented as:

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

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

N = the total number of organisms of all species

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

Low species diversity suggests:

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

High species diversity suggests:

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

Species richness indices

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

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

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

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

Shannon-Wiener's index:

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

Shannon and Weiner index represents entropy. It is a diversity index taking into account the number of individuals as well as the number of taxa. It varies from 0 for communities with only single taxa to high values for community with many taxa each with few individuals. This index can also determine the pollution status of a water body. Normal values range from 0 to 4. This index is a combination of species present and the evenness of the species. Examining the diversity in the range of polluted and unpolluted ecosystems, Wilham and Dorris (1968) concluded that the values of the index greater than 3 indicate clean water, values in the range of 1 to 3 are characterized by moderate pollution and values less than 1 are characterized as heavily polluted

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

RESULTS:

CHLOROPHYLL-a:

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

In the sub surface water chlorophyll-a was varying from 0.511 -0.921mg/m^3.in harbour region of DPT during sampling done in spring tide period of July, 2021. In the nearby creeks chlorophyll-a was varying from 0.173-0.980 mg/m^3.Pheophytin –a level was below detectable limit- the all the sampling stations during spring in the harbour region of DPT.

In the sub surface water chlorophyll-a was varying from 0.391 -0.835mg/m^3.in harbour region of DPT during sampling done in neap tide period of July, 2021 . In the nearby creeks chlorophyll-a was varying from 0.308-0.991 mg/m^3.·Pheophytin –a level was below detectable limit- the all the sampling stations during spring in the harbour region ofDPT

TABLE #2 VARIATIONS IN CHLOROPHYLL –a PHEOPHYTIN- a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS DURING SPRING TIDE IN JULY,2021

Sr.No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPTHARBOUR AREA					
1	KPT1	High tide	0.629	BDL	42.14
		Low tide	0.921	BDL	61.71
2	KPT 2	High tide	0.745	BDL	49.92
		Low tide	0.558	BDL	37.39
3	KPT 3	High tide	0.511	BDL	34.24
		Low tide	0.598	BDL	40.06
CREEKS					
4	KPT-4 Khori-I	High tide	0.425	BDL	28.48
		Low tide	0.473	BDL	31.69
5	KPT-5 Nakti-I	High tide	0.714	BDL	47.84
		Low tide	0.980	BDL	65.66
6	KPT-5 Nakti-II	High tide	0.173	BDL	11.59

BDL: Below Detectable Limit.

TABLE #3 VARIATIONS IN CHLOROPHYLL –aPHEOPHYTIN- a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS DURING NEAP TIDE IN JULY,2021

Sr.No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPTHARBOUR AREA					
1	KPT1	High tide	0.730	BDL	48.91
		Low tide	0.835	BDL	55.94
2	KPT 2	High tide	0.391	BDL	26.20
		Low tide	0.484	BDL	32.43
3	KPT 3	High tide	0.612	BDL	41.00
		Low tide	0.513	BDL	34.37
CREEKS					
4	KPT-4 Khori-I	High tide	0.385	BDL	25.80
		Low tide	0.497	BDL	33.30
5	KPT-5 Nakti-I	High tide	0.991	BDL	66.39
		Low tide	0.692	BDL	46.36
6	KPT-5 Nakti-II	High tide	0.308	BDL	20.64

BDL: Below Detectable Limit.

PHYTOPLANKTON POPULATION:

For the evaluation of the Phytoplankton population in DPT harbour area and within the immediate surroundings of the port, sampling was conducted from 5 sampling locations (3 in harbour area and two in Nakti creek) during high tide period and low tide period of spring tide. The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by,Diatoms andblue green algae during spring tide period.Diatoms were represented by 14 genera. Blue green wererepresented by onegenera .during the sampling conducted in spring tide in July,2021. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 68 -196 units/ L during high tide period and 171-212 units/ L during low tide of Spring Tide.

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by Diatoms andBlue green algae during spring tide period.Diatoms were represented by 14genera and Blue green algae were represented two genera during the sampling conducted in Neap tide in July , 2021. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 86-224 units/ L during high tide period and 222-254 units/ L during low tide of Neap Tide.

Species Richness Indices and Diversity Indices :

Margalef's diversity index (Species Richness)S

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

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations was varying from 1.896 -2.495 with an average of 2.315during the sampling conducted in High tide period of spring tide.While Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla Harbour region and nearby creeks was varying from. 2.054-2.334 with an average of 2.170 during the consecutive in low tide period .

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations was varying from 2.245-2.630 with an average of 2.495 during the sampling conducted in High tide period of Neaptide While .Margalef's diversity index (Species Richness) S ofphytoplankton communities in the Kandla Harbour region and nearby creeks was varying from. 2.003-2.709 with an average of 2.232 during the consecutive in low tide period .

Shannon-Wiener's index:

Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.878-0.959 (H'(log10)) between selected sampling stations with an average value of 0.905 during high tide period of spring tide .Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.863-0.904 (H'(log10)) between selected sampling stations with an average value of 0.892 during consecutive lowtide. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.960-1.025 (H'(log10)) between selected sampling stations with an average value of 0.990. during high tide period of neap tide . Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.969-1.008 (H'(log10)) between selected sampling stations with an average value of 0.990 during consecutive low tide. Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon-Wiener's index increases as both the richness and the evenness of the community increase. This result indicates that diversity of phytoplankton of Kandla Harbour region and nearby creeks is less but with abundant population of few, with relatively few ecological niches and only very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson's diversity index:

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

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks, which was varying from 0.837- 0.878 between selected sampling stations with an average of 0.855 during high tide period of spring tide . Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks, which was varying from 0.840- 0.856 between selected sampling stations with an average of 0.849 during consecutive low tide . Low species diversity suggests a relatively few successful species in this habitat. The environment is quite stressful with relatively few ecological niches and only a few organisms are really well adapted to that environment. Any change in the environment would probably have quite serious effects.

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in Kandla Harbour region and nearby creeks, during high tide period and low tideperiod during neap tide also, which was varying from 0.872-0.891 with an average value of 0.881 between selected sampling stations during high tide period and varying from 0.882-0.889 with an average value of 0.885 between selected sampling stations during consecutive low tide period Low species diversity suggests a relatively few successful species in this habitat.

Table # 4PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS DURING SPRING TIDE IN JULY,2021

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	183	14/15	93.33	2.495	0.906	0.8502
	2	154	13/15	86.66	2.382	0.8957	0.8537
	3	159	13/15	86.66	2.367	0.8948	0.8424
	4	188	13/15	86.66	2.292	0.8783	0.8372
	5	196	14/15	93.33	2.463	0.9587	0.8667
	6	68	9/15	60	1.896	0.899	0.8784
LOW TIDE	1	171	13/15	86.66	2.334	0.9041	0.8535
	2	212	12/15	80	2.054	0.8992	0.8565
	3	197	13/15	86.66	2.271	0.89	0.8406
	4	203	12/15	80	2.07	0.8634	0.8401
	5	179	12/15	80	2.121	0.9037	0.856

Table # 5 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS DURING NEAP TIDE IN JULY2021

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	205	15/16	93.75	2.63	1.002	0.8735
	2	184	14/16	87.5	2.493	0.9603	0.872
	3	221	14/16	87.5	2.408	0.9762	0.8773
	4	213	15/16	93.75	2.611	1.025	0.8905
	5	224	15/16	93.75	2.587	1.011	0.8859
	6	86	11/16	68.75	2.245	0.9685	0.8914
LOW TIDE	1	243	12/16	75	2.003	0.9696	0.8823
	2	222	12/16	75	2.036	0.9893	0.8893
	3	222	13/16	81.25	2.221	1.001	0.8872
	4	254	16/16	100	2.709	1.008	0.883
	5	239	13/16	81.25	2.191	0.985	0.8864

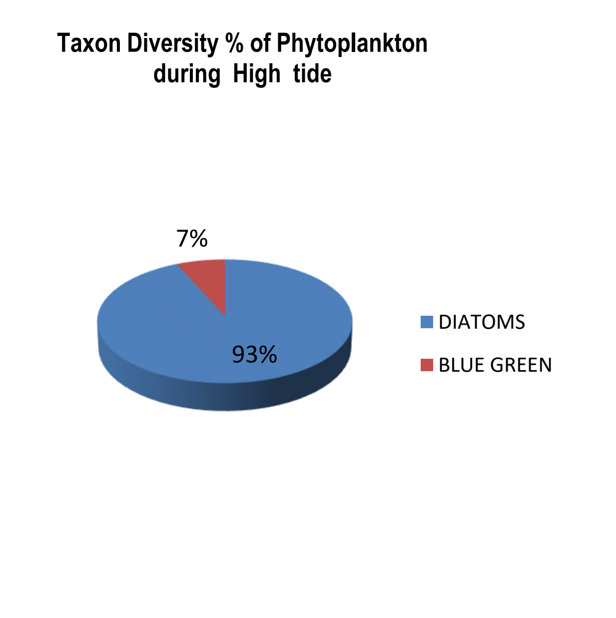
Table # 6 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA, NEAR BY CREEKS DURING SPRING TIDE IN JULY,2021

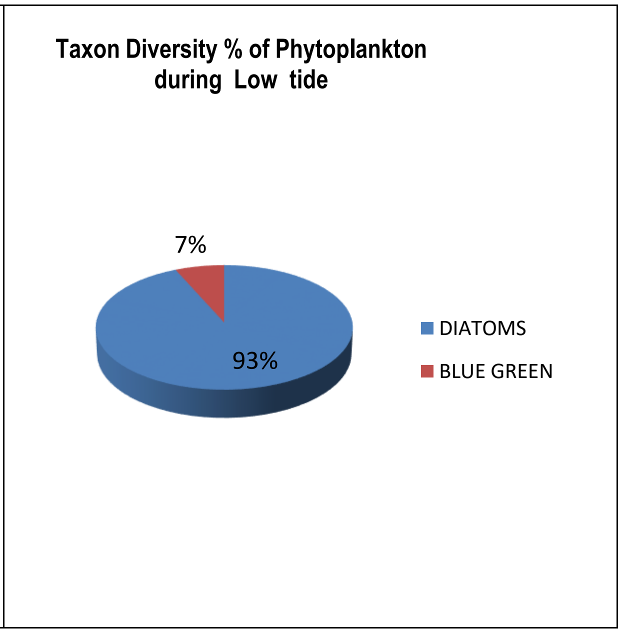
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	DIATOMS	68-194	14/15	93.33
			BLUE GREEN	0-2	1/15	6.67
			TOTAL PHYTO PLANKTON	68-196	15	-
LOW TIDE	Sub surface	5	DIATOMS	170-211	14/15	93.33
			BLUE GREEN	0-1	1/15	6.67
			TOTAL PHYTO PLANKTON	171-212	15	-

Table # 7 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA, NEAR BY CREEKS DURING NEAP TIDE IN JULY,2021

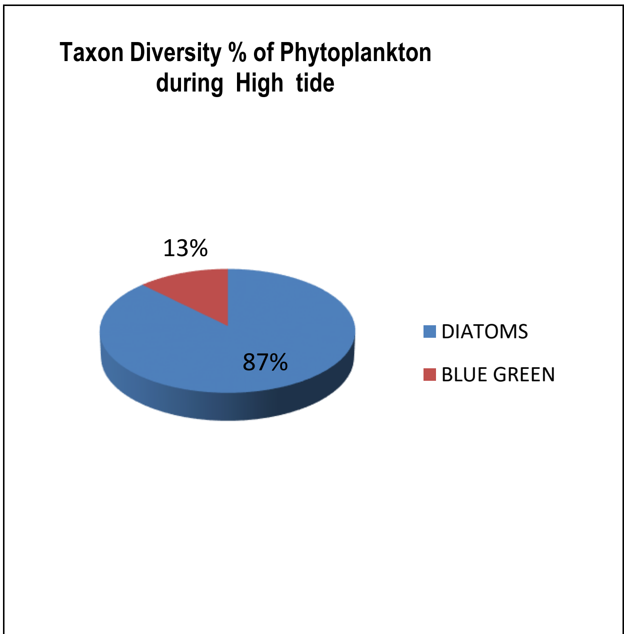
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	DIATOMS	74-202	14/16	87.5
			BLUE GREEN	12-26	2/16	12.5
			TOTAL PHYTO PLANKTON	86-224	16	-
LOW TIDE	Sub surface	5	DIATOMS	201-236	14/16	87.5
			BLUE GREEN	16-21	2/16	12.5
			TOTAL PHYTO PLANKTON	222-254	16	-

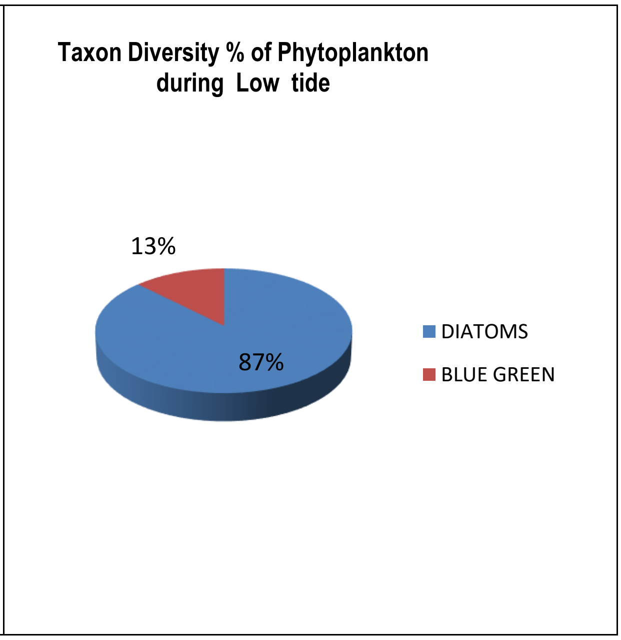
Taxon Diversity % of Phytoplankton during High tide and Low tide period during spring tide





Taxon Diversity % of Phytoplankton during High tide and Low tide period during Neap tide





ZOOPLANKTON POPULATION:

For the evaluation of the Zooplankton population in DPT harbour area and within the immediate surroundings of the port sampling was conducted from 6 sampling locations (3 in harbour area and two in Nakti creek and one in Khoricreek) during high tide period and low tide period of spring tide and Neap tide in July 2021 . The Zooplankton community of the sub surface water in the harbour and nearby creeks during spring tide was represented by mainly four groups, Tintinids, Copepods,Foraminiferans and larval forms of Crustacea, Molluscans and Polychates. The Zooplankton community of the sub surface water in the harbour and nearby creeks during neap tide was represented by mainly five groups, Tintinids, Copepods, Arrow worms, Mysids and larval forms of Crustaceans , Mollusacansand Polychates,.

Zooplankton of the sampling stations at sub surface layer in the DPT harbour area and nearby creek was varying from 59-142x10^3 N/ m^3 during high tide and 123 -147x10^3 N/ m^3during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPT harbour area and nearby creek was varying from 59-147x10^3 N/ m^3 during high tide and 141-164 N/ L during low tide of Neap Tide period.

Species Richness Indices and Diversity Indices:

Margalef's diversity index (Species Richness)S

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

Margalef's diversity index (Species Richness) S of Zooplankton communities in the stations Kandla Harbour region and nearby creeks was varying from 2.850 -3.366 with an average of 3.040 during the sampling conducted in High tide period.Margalef's diversity index (Species Richness) S of Zooplankton communities varying from.2.263-2.701 with an average of 2.562 during the sampling conducted in low tide period during Spring tide.

Margalef's diversity index (Species Richness) S of Zooplankton communities in the Kandla Harbour region and nearby creeks sampling stations was varying from3.188-4. 133 with an average of 3.754 during the sampling conducted in high tide and varying from.2.802 -4.314 with an average of 3.548 during the sampling conducted in low tide during Neap tide period**Shannon-Wiener's index:**

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 1.011-1.080 (H'(log10)) between selected sampling stations with an average value of 1.050 (H'(log10)) during high tide period of spring tide .Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.953 -1.011 (H'(log10)) between selected sampling stations with an average value of 0.988 (H'(log10)) during consecutive low tide period .

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.884-1.145 (H'(log10)) between selected sampling stations with an average value of 1.075 (H'(log10)) during high tide period of Neap tide. Shannon-Wiener's Index (H) of Zooplankton communities in the samplingstations in Kandla Harbour region and nearby creeks was in the range of 1.004- 1.177 (H'(log10)) between selected sampling stations with an average value of 1.056 (H'(log10)) during 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 Zooplankton of Kandla Harbour region and nearby creeks stations is slightly high with very minimum diverse population but very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson's diversity index:

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

Simpson diversity index (1-D) of Zooplankton communities was below 0.9 most of sampling stations except few in the Kandla Harbour region and nearby creeksduring high tide and low tide of spring tide period, which was varying from 0.882-0.911between selected sampling stations with an average of 0.899 during high tide period and was varying from 0.875- 0.888 with an average value of 0.882 between selected sampling stations during low tide

Simpson diversity index (1-D) of Zooplankton communities was below 0.9 at all sampling stationsin the Kandla Harbour region and nearby creeks during high tide and low tide period except few, which was varying from 0.829-0.907 between selected sampling stations with an average of 0.887 during high tide period and was varying from 0.872- 0.913 with an average value of 0.886 between selected sampling stations during consecutive low tide

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

Table # 8 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS DURING SPRING TIDE IN JULY,2021

Tide	Sampling Station	Abundance In No / 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	125 $X10^3$	15/19	78.95	2.9	1.02	0.8906
	2	116 $X10^3$	16/19	84.21	3.156	1.08	0.9076
	3	116 $X10^3$	17/19	89.47	3.366	1.076	0.8961
	4	142 $X10^3$	16/19	84.21	3.027	1.011	0.8821
	5	136 $X10^3$	15/19	78.95	2.85	1.077	0.9077
	6	59 $X10^3$	13/19	68.42	2.943	1.037	0.9112
LOW TIDE	1	129 $X10^3$	12/19	63.16	2.263	0.9534	0.8751
	2	123 $X10^3$	14/19	73.68	2.701	0.9887	0.8835
	3	145 $X10^3$	14/19	73.68	2.612	1.011	0.8879
	4	147 $X10^3$	14/19	73.68	2.605	0.9919	0.8823
	5	140 $X10^3$	14/19	73.68	2.631	0.9951	0.8808

Table # 9 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS DURING NEAP TIDE IN JULY,2021

Tide	Sampling Station	Abundance In No / 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	162 $X10^3$	19/23	82.61	3.538	1.094	0.895
	2	152 X10	20/23	86.96	3.782	1.088	0.8906
	3	146 X10	20/23	86.96	3.812	1.106	0.9011
	4	174 X10	22/23	95.65	4.071	1.134	0.9015
	5	161 X10	22/23	95.65	4.133	1.145	0.9069
	6	59 X10	14/23	60.86	3.188	0.8842	0.8299
LOW TIDE	1	141 X10	17/23	73.91	3.233	1.004	0.8719
	2	142 X10	18/23	78.26	3.43	1.022	0.8797
	3	148 X10	15/23	65.22	2.802	1.034	0.8911
	4	164 X10	23/23	100	4.314	1.177	0.9134
	5	156 X10	21/23	91.30	3.961	1.046	0.8781

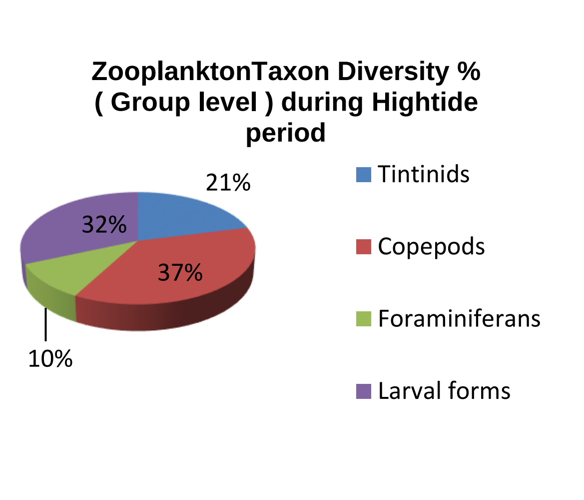
Table # 10 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS DURING SPRING TIDE IN JULY2021

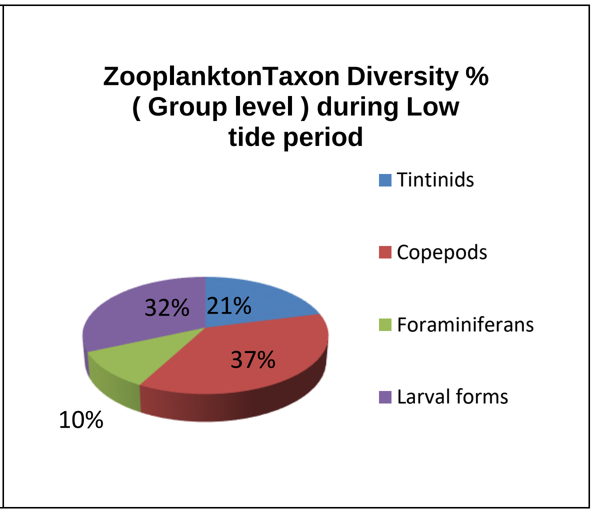
Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton x10^3 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinids	3-10	4/19	21.05
			Copepods	34-77	7/19	36.84
			Foraminiferans	2-6	2/19	10.53
			Larval forms	20-57	6/19	31.58
			TOTAL ZOOPLANKTON NO/L	**59-142**	**19**	**-**
LOW TIDE	Sub surface	5	Tintinids	3-8	4/19	21.05
			Copepods	76-80	7/19	36.84
			Foraminiferans	0-2	2/19	10.53
			Larval forms	40-63	6/19	31.58
			TOTAL ZOOPLANKTON NO/L	**123-147**	**19**	**-**

Table # 11 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA , NEAR BY CREEKS DURING NEAPTIDE IN JULY,2021

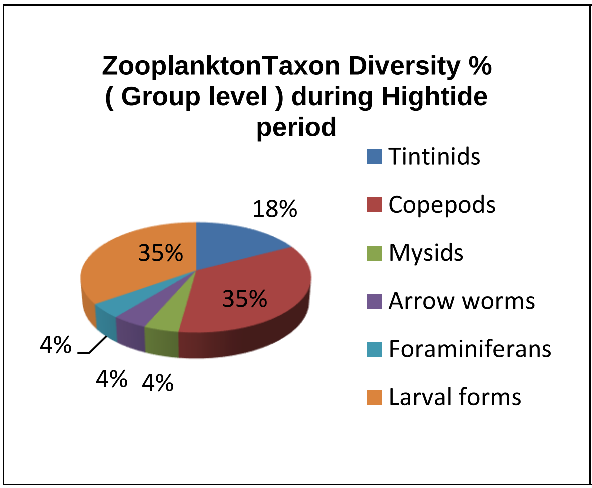
Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton x10^3 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinids	4-13	4/23	17.39
			Copepods	37-83	8/23	34.78
			Mysids	0-2	1/23	4.35
			Arrow worms	1-2	1/23	4.35
			Foraminiferans	0-4	1/23	4.35
			Larval forms	17-74	8/23	34.78
			TOTAL ZOOPLANKTON NO/L	**59-173**	**23**	**-**
LOW TIDE	Sub surface	5	Tintinids	3-13	4/23	17.39
			Copepods	70-84	8/23	34.78
			Mysids	0-2	1/23	4.35
			Arrow worms	0-2	1/23	4.35
			Foraminiferans	0-2	1/23	4.35
			Larval forms	60-70	8/23	34.78
			TOTAL ZOOPLANKTON NO/L	**140-164**	**23**	

Taxon Diversity % of Zooplankton during High tide and Low tide period of Spring tide





Taxon Diversity % of Zooplankton during High tide and Low tide period of Neap tide



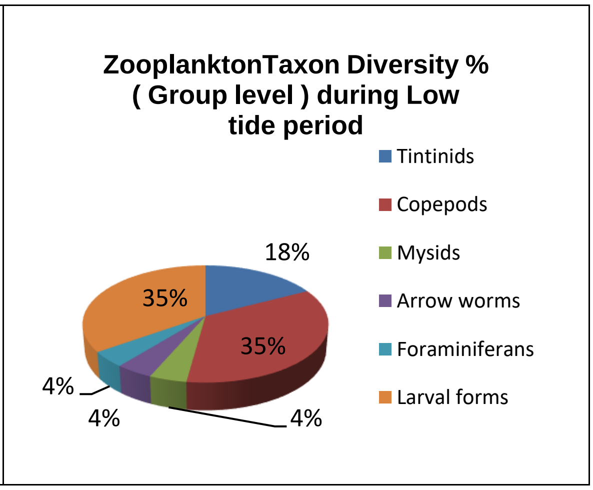


TABLE # 12 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPT HARBOUR AREA AND NEARBY CREEKS DURINGSPRING TIDE OF JUlY,2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALAGE	Cynophyta	Cynophyceae	Stigonematales	Stigonemataceae	*Stigonema*sp	**B1**	Rare
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Thalassiosirales	Thalassiosiraceae	*Planktoniella*sp	D1	Rare
			Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D2	Abundant
					*Palmeria*sp	D3	Occasional
			Triceratiales	Triceratiaceae	*Odontellasp*	D4	Frequent
					*Triceratium*sp.	D5	Frequent
			Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D6	Abundant
			Hemiaulales	Bellerocheaceae	Bellerocheasp	D7	Occasional
				Hemiaulaceae	*Eucampia*sp	D8	Rare
			Lithodesmiales	Lithodesmiaceae	*Ditylumsp*	D9	Frequent
			Thalassiosirales	Thalassiosiraceae	*Thalassiosira*sp	D10	Rare
		Bacillariophyceae	Naviculales	Pleurosigmataceae	*Pleurosigma*sp	D11	Rare
			Bacillariales	Bacillariaceae	*Nitzschia*sp	D12	Rare
		Fragilariophyceae	Thalassionematales	Thalassionemataceae	*Thalassiothrix sp.*	D13	Dominant
			Fragilariales	Fragilariaceae	*Synedra*sp	D14	Occasional

TABLE # 12 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPT HARBOUR AREA AND NEARBY CREEKS DURING AND NEAP TIDE OF JULY,2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALAGE	Cynophyta	Cynophyceae	Chlorococcales	Chroococcaceae	*Microcystis* sp.	B1	Occasional
			Stigonematales	Stigonemataceae	*Stigonema*sp	B2	Frequent
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Thalassiosirales	Thalassiosiraceae	*Planktoniella*sp	D1	Rare
			Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D2	Abundant
					Palmeriasp	D3	Occasional
			Triceratiales	Triceratiaceae	*Odontella*sp	D4	Frequent
					*Triceratium*sp.	D5	Abundant
			Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D6	Dominant
			Hemiaulales	Bellerocheaceae	Bellerocheasp	D7	Occasional
				Hemiaulaceae	*Eucampia*sp	D8	Rare
			Lithodesmiales	Lithodesmiaceae	*Ditylum*sp	D9	Abundant
			Thalassiosirales	Thalassiosiraceae	*Thalassiosira*sp	D10	Frequent
		Bacillariophyceae	Naviculales	Pleurosigmataceae	*Pleurosigma*sp	D11	Rare
			Bacillariales	Bacillariaceae	*Nitzschia*sp	D12	Rare
		Fragilariophyceae	Thalassionematales	Thalassionemataceae	*Thalassiothrix sp*.	D13	Frequent
			Fragilariales	Fragilariaceae	*Synedra*sp	D14	Frequent

TABLE #13 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS IN DPT HARBOUR AREA, AND NEAR BY CREEKS DURING SPRING TIDE OF JULY,2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnussp.*	T1	Rare
				Codonellidae	*Tintinnopsisfailakkaensis*	T2	Rare
					Tintinnopsisgracilis	T3	Rare
					Tintinnopsis radix	T4	Rare
COPEPODS	ATHROPODA	Crustacea Sub class copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Abundant
					Bestiolina sp.	C2	Rare
					Parvocalanus sp.	C3	Occasional
				Temoridae	*Temora sp.*	C4	Frequent
			Cyclopoida	Oithonidae	*Oithona sp.*	C5	Frequent
			Harpacticoida	Ectinosomatidae	*Microsetella*sp.	C6	Abundant
				Euterpinidae	*Euterpina*	C7	Occasional
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of Copepods	L1	Dominant
(Brachyuraian LARVAE	ARTHROPODA CRUSTACEA	DECAPODA (BRACHYURA)			Zoea larvae	L2	Rare
CYPHONAUTES LARVAE	BRYOZOA				Cyphonautes larvae	L3	Occasional
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of Bivalves	L4	Rare
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L5	Rare
POLYCHAETE LARVAE	ANNELIDA				Trochophore larvae	L6	Frequent
FORAMINIFERA	FORAMINIFERA	Globothalamea	Rotaliida	Globigerinidae	*Globigerina* sp.	F1	Rare
				Rotalliidae	*Rotalia* sp.	F2	Rare

TABLE # 13 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS IN DPT HARBOUR AREA, AND NEAR BY CREEKS DURING NEAP TIDE OF JULY,2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnussp.*	T1	Rare
				Codonellidae	*Tintinnopsisfailakkaensis*	T2	Occasional
					Tintinnopsisgracilis	T3	Occasional
					Tintinnopsis radix	T4	Rare
COPEPODS	ATHROPODA	Crustacea Sub class copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Abundant
					Parvocalanus sp.	C2	Rare
				Eucalanidae	*Subeucalanus sp.*	C3	Frequent
				Temoridae	*Temora sp.*	C5	Frequent
				Acartiidae	*Acartia sp.*	C6	Occasional
			Cyclopoida	Oithonidae	*Oithona sp.*	C7	Frequent
			Harpacticoida	Ectinosomatidae	*Microsetella*sp.	C8	Abundant
				Euterpinidae	*Euterpina sp.*	C9	Frequent
ARROW WORMS	CHAETOGNATHA	Sagittoideae	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Rare
MYSIDS	ATHROPODA CRUSTACEA	Malacostraca	Mysida, Decapoda	Penaeidae	*Metapenaeus sp.*	M1	Rare
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of Copepods	L1	Dominant
POLYCHAETE LARVA	ANNELIDA	Polychaeta			Trochophore larvae	L2	Occasional
BARNACLE LARVAE	ATHROPODA CRUSTACEA	Maxillopoda Thecostraca			Cirripede larvae	L3	Rare
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of Bivalves	L4	Occasional

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L5	Rare
BRACHYURAIAN LARVAE	ARTHROPODA CRUSTACEA	DECAPODA (BRACHYURA)			Zoea larvae	L6	Occasional
CYPHONAUTES LARVAE	BRYOZOA				Cyphonautes larvae	L7	Occasional
ECHINODERMATA larvae	ECHINODERMATA	Ophiuroidea			Ophiopluetus larvae	L8	Occasional
FORAMINIFERA	FORAMINIFERA	Globothalamea	Rotaliida	Rotalliidae	*Rotalia* sp.	F1	Rare

BENTHIC ORGANISMS:

No Benthic organisms were observed in the collected sediments by using the Van-veen grabs during the sampling conducted IN spring tide period as well as Neap tide period from DPT harbour region and nearby creek except few dead shells.

7. Meteorological Data

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

Temperature

The mean day time temperature for Deendayal Port was 28.5 °C. The day-time maximum temperature was 32.1 °C. The mean night time temperature was 30.3 °C. The minimum mean night time temperature recorded was 27.8 °C.

Air Pressure

The mean absolute air pressure for the month of July was 1002.4 hpa, whereas the mean relative pressure was 1000.2 hpa. The maximum absolute air pressure recorded for the month of July was 1004.1 hpa.

Heat Index

The mean day-time heat index for the month of July was 36.1 ^{o}C. The maximum heat index recorded was 43^{o}C.

Solar Radiation

The mean Solar Radiation in July was 158.4 w/m^2. The maximum solar radiation recorded in the month of July was 751.7 w/m^2.

Humidity

The mean day-time humidity was 80.3 % for the month of July and mean night time humidity was 71.2%. Maximum humidity recorded during day-time was 89.0 % and maximum humidity recorded during night-time was 85.0%.

Wind Velocity and Wind Direction

The mean wind velocity for the entire month of July was 11.72 km/hour (i.e. 2.7 mtr/sec). Maximum wind velocity recorded was 47.2 Km/hr (13 mtr/sec). The wind direction was mostly S to SW.

Rainfall

The mean Rainfall in July was 58.1 mm. The maximum Rainfall recorded in the month of July was 132.7 mm.

Conclusive Summary and Remedial measures Suggested

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

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

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

- The sewage treated water of Deendayal Port Colony (Gopalpuri) was in line with the standards set by the Gujarat Pollution Control Board. The STP at Deendayal Port is not fully operational and STP at Vadinar Port was found non-operational.

Reasons for higher Values of PM_{10}

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

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

Remedial Measures

The values of PM_{10} during the month of July, 2021 were observed beyond the permissible limit at four locations mentioned above. Given below are the remedial measures suggest to minimize the Air pollution at Deendayal Port.

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

- Sewage Treatment Plan at Vadinar Port is not working. Hence, it is recommended to commission the sewage treatment plant at Vadinar immediately.

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

SOURCE OF LITERATURE AND ADDITIONAL REFERENCE FOR ECOLOGICAL STUDY

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ENVIRONMENTAL MONITORING REPORT
FOR
DEENDAYAL PORT TRUST

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Introduction

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

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

1. Ambient Air Quality Monitoring

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

1.1 Air Quality Monitoring Methodology

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

The AAQ samples are collected twice a week from all the eight locations as per the EMP.

1.2 Results

The ambient air quality monitoring data for six stations, viz. Marine Bhavan, Oil Jetty, Port Colony,Gopalpuri Hospital,Tuna Port and Nr. Coal Storage Area for the month of August 2021 are given in Tables 1A to 6B. The ambient air quality monitoring data for two stations at Vadinar (Nr. Admin Building &Nr. Signal Building) are given in Tables 7A to 8B.

Location 1: Marine Bhavan (AL1)

Table 1 : Results of Air Pollutant Concentration at Marine Bhavan

Parameter	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period	-	24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit	-	NS	100 µg/m3	60 µg/m3		80 µg/m3		80 µg/m3		400 µg/m3
AL1 – 1	04.08.2021	328	179	68	2.64	2.40	20.33	21.17	9.45	9.87
					0.62		19.05		9.70	
					3.96		24.14		10.47	
AL1 – 2	06.08.2021	659	211	75	7.03	6.15	14.61	20.11	13.79	13.70
					5.71		15.88		13.53	
					5.71		29.85		13.79	
AL1 – 3	11.08.2021	813	247	70	8.35	7.03	29.85	27.10	12.00	11.49
					7.91		31.76		13.02	
					4.84		19.69		9.45	
AL1 – 4	13.08.2021	549	272	89	2.20	2.05	18.42	17.15	14.55	15.68
					1.76		15.88		17.69	
					2.20		17.15		14.81	
AL1 – 5	18.08.2021	442	300	45	3.96	3.66	19.69	21.38	5.36	9.62
					4.40		20.33		12.00	
					2.64		24.14		11.49	
AL1 - 6	20.08.2021	360	299	88	3.08	3.22	17.78	16.51	10.47	6.13
					4.40		21.60		5.36	
					2.20		10.16		2.55	
AL1 - 7	25.08.2021	340	290	72	2.64	2.64	13.34	18.00	14.81	11.57
					3.52		22.23		10.47	
					1.76		18.42		9.45	
AL1 – 8	27.08.2021	471	299	63	3.08	2.93	27.31	26.25	10.98	7.83
					1.76		30.49		5.62	
					3.96		20.96		6.89	
Monthly Average		495	262	71		3.76		20.96		10.74
Standard Deviation		171	46	14		1.83		3.96		3.08

NS: Not Specified

Table 1B : Results of Air Pollutant Concentration at Marine Bhavan					
Parameter	**Date**	**C_6H_6 [µg/m^3]**	**HC* ppm**	**CO [mg/m^3]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m^3**	**NS**	**4.0 mg/m^3**	**NS**
AL1 – 1	04.08.2021	1.06	BDL	1.86	488
AL1 – 2	06.08.2021	1.22	BDL	1.74	496
AL1 – 3	11.08.2021	1.28	BDL	1.7	499
AL1 – 4	13.08.2021	1.2	BDL	1.68	501
AL1 – 5	18.08.2021	1.21	BDL	1.72	490
AL1 - 6	20.08.2021	1.06	BDL	1.62	497
AL1 – 7	25.08.2021	1.12	BDL	1.52	488
AL1 – 8	27.08.2021	1.06	BDL	1.72	496
Monthly Average		**1.15**	**-**	**1.70**	**494**
Standard Deviation		**0.09**	**-**	**0.10**	**5**

* NMHC- Non- Methane Hydrocarbons

BDL- Below Detection Limit (Detection Limit – NMHC: 0.5ppm)

NS -Not Specified

At Marine Bhavan, the overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_X and NH_3 is attributed mainly by motor vehicle emission produced from various types of automobiles (both diesel and petrol driven). Moreover, the loading and unloading of Food Grains and Timber at Jetty no. 1 and 2 also contributes to the high levels of TSPM and PM_{10}. The mean TSPM value at Marine Bhavan was 495 µg/m^3, The mean PM_{10} values were 262.0 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were slightly above the permissible limit (mean = 71 µg/m^3). The average values of SO_2, NO_x and NH_3 were within the permissible limit. The average values of SO_2, NO_x and NH3 were 3.76 µg/ m^3, 20.96 µg/ m^3 & 10.74 µg/ m^3 respectively. These were within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Marine Bhavan. The mean Benzene concentration was 1.15 µg/m^3,well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.70 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 2: Oil Jetty (AL2)

Table 2 : Results of Air Pollutant Concentration at Oil Jetty										
Parameters	**Date**	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period	-	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit	-	**NS**	**100 µg/m3**	**60 µg/m3**	-	**80 µg/m3**	-	**80 µg/m3**	-	**400 µg/m3**
AL2 – 1	04.08.2021	299	222	55	3.52	3.81	18.42	16.30	13.53	14.81
					4.84		12.70		14.81	
					3.08		17.78		16.08	
AL2 – 2	06.08.2021	837	394	89	1.32	3.08	12.07	12.28	7.40	10.47
					3.08		10.80		11.74	
					4.84		13.97		12.25	
AL2 – 3	11.08.2021	403	350	49	8.35	9.38	33.66	25.62	4.08	6.89
					8.79		19.05		6.89	
					10.99		24.14		9.70	
AL2 – 4	13.08.2021	511	327	82	3.08	2.05	17.78	16.30	7.15	9.10
					1.76		15.88		10.72	
					1.32		15.24		9.45	
AL2 – 5	18.08.2021	567	281	75	3.08	2.20	17.15	18.63	9.70	7.83
					1.32		26.04		5.36	
					2.20		12.70		8.42	
AL2 – 6	20.08.2021	728	490	90	6.15	5.86	22.87	15.88	5.36	8.00
					7.91		8.89		8.42	
					3.52		15.88		10.21	
AL2 – 7	25.08.2021	344	237	67	0.88	1.17	24.14	20.75	9.96	10.38
					0.88		15.88		12.76	
					1.76		22.23		8.42	
AL2 – 8	27.08.2021	475	278	76	1.32	2.20	15.88	17.78	5.87	8.51
					1.76		24.14		9.19	
					3.52		13.34		10.47	
Monthly Average		520	322	73		3.72		17.94		9.50
Standard Deviation		186	88	15		2.70		3.95		2.47

NS: Not Specified

Table 2B : Results of Air Pollutant Concentration at Oil Jetty					
Parameter	**Date**	**C_6H_6 [µg/m^3]**	**HC* ppm**	**CO [mg/m^3]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m^3**	**NS**	**4.0 mg/m^3**	**NS**
AL2 -1	04.08.2021	1.22	BDL	1.86	492
AL2 -2	06.08.2021	1.06	BDL	1.72	496
AL2 -3	11.08.2021	1.26	BDL	1.76	489
AL2 -4	13.08.2021	1.23	BDL	1.66	500
AL2 – 5	18.08.2021	1.2	BDL	1.84	496
AL2 – 6	20.08.2021	1.16	BDL	1.74	489
AL2 -7	25.08.2021	1.18	BDL	1.76	476
AL2 – 8	27.08.2021	1.23	BDL	1.7	490
Monthly Average		**1.19**	**-**	**1.76**	**491**
Standard Deviation		**0.06**	**-**	**0.07**	**7**

* NMHC- Non- Methane Hydrocarbons

BDL- Below Detection Limit (Detection Limit – NMHC : 0.5ppm)

NS- Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Oil Jetty area was mainly by motor vehicle emission produced from various types of vehicles Oil Jetty Area. The mean TSPM values at Oil Jetty were 520 µg/m^3 .The mean PM_{10} values were 322 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were slightly above the permissible limit (mean = 73 µg/m^3).The average values of SO_2, NO_x and NH_3 were within the permissible limit; The mean concentration of SO_2, NO_x and NH3 were 3.72 µg/m^3, 17.94 µg/m^3 and 9.50 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 1.19 µg/m^3 .Well below the permissible limit of 5.0 µg/m^3. , HC's were below the detectable limit and Carbon Monoxide concentration was 1.76 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

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

Table 3 : Results of Air Pollutant Concentration at Estate Office											
Parameters	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period	-	24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit	-	NS	100 µg/m3	60 µg/m3	-	80 µg/m3	-	80 µg/m3	-	400 µg/m3
AL3 – 1	04.08.2021	159	97	35	1.32	2.05	25.41	23.92	14.04	16.68
					2.20		33.66		17.36	
					2.64		12.70		18.64	
AL3 – 2	06.08.2021	473	176	60	3.96	9.96	12.70	13.13	8.68	7.40
					21.98		10.80		7.15	
					3.96		15.88		6.38	
AL3 – 3	11.08.2021	379	253	74	3.96	4.25	15.24	20.75	8.42	6.47
					5.28		20.96		7.15	
					3.52		26.04		3.83	
AL3 – 4	13.08.2021	652	331	67	4.84	2.49	9.53	9.32	12.76	9.62
					1.76		9.53		9.70	
					0.88		8.89		6.38	
AL3 – 5	18.08.2021	643	457	92	4.84	3.52	24.14	24.77	9.70	38.21
					3.52		34.30		10.47	
					2.20		15.88		94.45	
AL3 – 6	20.08.2021	721	389	75	4.84	4.25	20.96	20.96	10.21	8.25
					2.20		15.88		9.45	
					5.71		26.04		5.11	
AL3 – 7	25.08.2021	298	208	68	4.40	3.22	22.23	19.05	12.00	11.66
					3.52		17.78		12.00	
					1.76		17.15		10.98	
AL3 – 8	27.08.2021	574	300	96	2.64	2.93	16.51	17.57	11.49	8.76
					4.40		17.15		9.45	
					1.76		19.05		5.36	
Monthly Average		488	276	71		4.08		18.68		13.38
Standard Deviation		196	117	19		2.50		5.26		10.53

NS: Not Specified

Table 3B : Results of Air Pollutant Concentration at Kandla Port Colony					
Parameter	**Date**	**C_6H_6 [µg/m^3]**	**HC***	**CO [mg/m^3]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m^3**	**NS**	**4.0 mg/m^3**	**NS**
AL3 -1	04.08.2021	1.12	BDL	1.84	480
AL3 -2	06.08.2021	1.16	BDL	1.76	488
AL3 -3	11.08.2021	1.22	BDL	1.8	496
AL3 -4	13.08.2021	1.26	BDL	1.74	490
AL3 – 5	18.08.2021	1.2	BDL	1.79	496
AL3 – 6	20.08.2021	1.06	BDL	1.82	499
AL3 – 7	25.08.2021	1.11	BDL	1.8	500
AL3 – 8	27.08.2021	1.07	BDL	1.76	490
Monthly Average		**1.15**	**-**	**1.79**	**492**
Standard Deviation		**0.07**	**-**	**0.03**	**7**

* NMHC- Non- Methane Hydrocarbons

BDL- Below Detection Limit (Detection Limit – NMHC : 0.5 ppm)

NS- Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Kandla Port Colony was attributed by vehicle emission produced from trucks and heavy duty vehicles that pass through the road outside Kandla Port Colony. The mean TSPM values at Oil Jetty were 488 µg/m^3, The mean PM_{10} values were 276 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were slightly above the permissible limit (mean = 71 µg/m^3). The average values of SO_2, NO_x and NH3 were 4.08 µg/m^3, 18.68 µg/m^3 and 13.38 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Kandla Port Colony. The mean Benzene concentration was 1.15 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.79 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 4: Gopalpuri Hospital (AL-4)

Table 4 : Results of Air Pollutant Concentration at Gopalpuri Hospital										
Parameter	**Date**	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period	-	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit	-	**NS**	**100 µg/m3**	**60 µg/m3**	-	**80 µg/m3**	-	**80 µg/m3**	-	**400 µg/m3**
AL4 -1	04.08.2021	128	77	28	3.08	3.08	7.62	12.70	9.70	8.76
					2.64		17.15		10.21	
					3.52		13.34		6.38	
AL4 -2	06.08.2021	180	115	38	3.52	2.05	6.35	10.16	5.36	5.02
					0.88		11.43		5.11	
					1.76		12.70		4.60	
AL4 -3	11.08.2021	228	110	48	1.76	3.08	11.43	9.95	4.34	4.85
					3.96		6.35		5.36	
					3.52		12.07		4.85	
AL4 -4	13.08.2021	327	260	60	3.08	3.08	11.43	9.74	7.15	5.62
					3.52		10.80		4.08	
					2.64		6.99		5.62	
AL4 – 5	18.08.2021	269	156	70	2.20	3.08	15.88	14.61	5.36	6.89
					3.96		8.89		8.93	
					3.08		19.05		6.38	
AL4 – 6	20.08.2021	228	113	86	3.52	2.34	13.97	12.91	5.36	9.02
					2.20		8.89		9.70	
					1.32		15.88		12.00	
AL4 – 7	25.08.2021	222	116	49	2.20	2.78	19.05	17.15	6.89	6.72
					3.52		14.61		8.42	
					2.64		17.78		4.85	
AL4 – 8	27.08.2021	249	119	30	2.64	3.08	12.07	12.07	7.91	8.93
					3.08		12.70		9.19	
					3.52		11.43		9.70	
Monthly Average		229	133	51		2.82		12.41		6.98
Standard Deviation		59	56	20		0.41		2.56		1.75

NS: Not Specified

Table 4B : Results of Air Pollutant Concentration at Gopalpuri Hospital					
Parameter	**Date**	**C_6H_6 [µg/m^3]**	**HC***	**CO [mg/m^3]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m^3**	**NS**	**4.0 mg/m^3**	**NS**
AL4 -1	04.08.2021	1.12	BDL	1.88	490
AL4 -2	06.08.2021	1.18	BDL	1.76	488
AL4 -3	11.08.2021	1.26	BDL	1.72	496
AL4 -4	13.08.2021	1.21	BDL	1.8	500
AL4 – 5	18.08.2021	1.28	BDL	1.79	482
AL4 – 6	20.08.2021	1.2	BDL	1.84	493
AL4 – 7	25.08.2021	1.18	BDL	1.86	498
AL4 – 8	27.08.2021	1.16	BDL	1.8	490
Monthly Average		**1.20**	**-**	**1.81**	**492**
Standard Deviation		**0.05**	**-**	**0.05**	**6**

* NMHC- Non- Methane Hydrocarbons

BDL- Below Detection Limit (Detection Limit – NMHC: 0.5 ppm)

NS-Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Gopalpuri Hospital was attributed by vehicle emission produced from light motor vehicles of the colony residents. The mean TSPMvalues at Oil Jetty were 229 µg/m^3, The mean PM_{10} values were 133 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were slightly above the permissible limit (mean= 51 µg/m^3). The average values of SO_2, NO_x and NH_3 were 2.82 µg/m^3, 12.41 µg/m^3 and 6.98 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Gopalpuri Hospital. The mean Benzene concentration was 1.20 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.81 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 5: Coal Storage Area (AL-5)

Table 5 : Results of Air Pollutant Concentration at Coal Storage Area

Parameters	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period	-	24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit	-	NS	100 µg/m3	60 µg/m3	-	80 µg/m3	-	80 µg/m3	-	400 µg/m3
AL5 – 1	04.08.2021	312	167	69	3.08	3.66	22.23	22.23	9.45	9.53
					3.52		23.50		7.15	
					4.40		20.96		12.00	
AL5 – 2	06.08.2021	530	333	77	9.23	6.15	20.96	20.11	16.59	17.02
					5.71		24.77		17.87	
					3.52		14.61		16.59	
AL5 – 3	11.08.2021	759	394	92	10.99	9.23	24.14	27.74	8.42	7.74
					7.47		25.41		7.15	
					9.23		33.66		7.66	
AL5 – 4	13.08.2021	813	435	94	1.76	1.61	17.78	18.84	13.02	10.30
					1.32		19.05		8.93	
					1.76		19.69		8.93	
AL5 – 5	18.08.2021	700	471	79	4.40	3.96	21.60	22.02	12.00	11.66
					4.40		19.05		10.47	
					3.08		25.41		12.51	
AL5 – 6	20.08.2021	566	427	80	3.08	3.96	16.51	18.00	16.85	15.66
					3.52		15.24		16.34	
					5.28		22.23		13.79	
AL5 – 7	25.08.2021	456	224	76	3.96	4.10	13.97	17.15	10.47	7.04
					4.40		19.69		9.70	
					3.96		17.78		0.94	
AL5 – 8	27.08.2021	249	164	70	4.40	3.66	23.50	27.52	11.49	13.44
					3.52		28.58		14.04	
					3.08		30.49		14.81	
Monthly Average		548	327	80		4.54		21.70		11.55
Standard Deviation		204	125	9		2.26		4.07		3.60

NS: Not Specified

Table 5B : Results of Air Pollutant Concentration at Coal Storage Area					
Parameter	Date	C_6H_6 [µg/m³]	HC*	CO [mg/m³]	CO_2 [ppm]
Sampling Period		8 hr	Grab Sampling	Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m³	NS	4.0 mg/m³	NS
AL5 – 1	04.08.2021	1.06	BDL	1.96	460
AL5 – 2	06.08.2021	1.11	BDL	1.88	458
AL5 – 3	11.08.2021	1.26	BDL	1.9	456
AL5 – 4	13.08.2021	1.3	BDL	1.82	460
AL5 – 5	18.08.2021	1.26	BDL	1.96	456
AL5 – 6	20.08.2021	1.22	BDL	1.93	474
AL5 – 7	25.08.2021	1.38	BDL	1.89	470
AL5 – 8	27.08.2021	1.30	BDL	1.9	468
Monthly Average		**1.24**	**-**	**1.91**	**463**
Standard Deviation		**0.11**	**-**	**0.05**	**7**

* NMHC- Non- Methane Hydrocarbons

BDL- Below Detection Limit (Detection Limit – NMHC: 0.5 ppm)

NS-Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Coal Storage Area was comparatively highest among all the locations of Air Quality monitoring in Kandla Port. High values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_X at this location was due to lifting of coal with grab and other coal handling processes near Berth no. 6 & 7. Moreover, the traffic was also heavy around this place for transport of coal thus emissions produced from heavy vehicles. The mean TSPM values at Coal storage were 548 µg/m³. The mean PM_{10} values were 327 µg/m³, which is well above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean = 80 µg/m³). The average values of SO_2, NO_x and NH_3 were 4.54 µg/m³, 21.70 µg/m³ and 11.55 µg/m³ respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Coal Storage Area. The mean Benzene concentration was 1.24 µg/m³, well below the permissible limit of 5.0 µg/m³. HC's were below the detectable limit and Carbon Monoxide concentration was 1.91 mg/m³, well below the permissible limit of 4.0 mg/m³.

Location 6: Tuna Port (AL-6)

Table 6 : Results of Air Pollutant Concentration at Tuna Port											
Parameters	**Date**	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period	-	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit	-	**NS**	**100 µg/m3**	**60 µg/m3**	-	**80 µg/m3**	-	**80 µg/m3**	-	**400 µg/m3**
AL6 -1	04.08.2021	133	75	26	3.96	2.93	22.23	15.46	15.06	12.17
					2.64		13.34		12.25	
					2.20		10.80		9.19	
AL6 – 2	06.08.2021	203	149	67	2.20	2.05	8.26	9.10	5.87	6.81
					2.20		10.16		6.38	
					1.76		8.89		8.17	
AL6 – 3	11.08.2021	316	166	44	5.28	4.40	17.78	18.63	6.89	6.47
					4.84		22.23		4.60	
					3.08		15.88		7.91	
AL6 – 4	13.08.2021	530	342	83	3.08	2.05	5.72	7.83	5.36	6.55
					1.32		9.53		7.91	
					1.76		8.26		6.38	
AL6 – 5	18.08.2021	468	291	84	0.88	2.05	20.96	17.15	12.76	12.08
					1.76		12.70		12.25	
					3.52		17.78		11.23	
AL6 – 6	20.08.2021	319	181	63	4.40	3.08	33.03	28.58	10.47	12.93
					1.32		22.87		15.57	
					3.52		29.85		12.76	
AL6 – 7	25.08.2021	256	156	58	3.08	3.22	15.88	17.15	9.96	10.21
					2.64		17.78		9.45	
					3.96		17.78		11.23	
AL6 – 8	27.08.2021	554	375	80	2.64	3.08	17.15	16.30	10.47	9.96
					3.08		12.07		8.42	
					3.52		19.69		10.98	
Monthly Average		347	217	63		2.86		16.28		9.65
Standard Deviation		155	106	20		0.81		6.35		2.71

NS: Not Specified

Table 6B : Results of Air Pollutant Concentration at Tuna Port					
Parameter	Date	C_6H_6 [µg/m^3]	HC*	CO [mg/m^3]	CO_2 [ppm]
Sampling Period		8 hr	Grab Sampling	Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m^3	NS	4.0 mg/m^3	NS
AL6 -1	04.08.2021	1.11	BDL	1.74	460
AL6 – 2	06.08.2021	1.26	BDL	1.89	470
AL6 – 3	11.08.2021	1.2	BDL	1.88	472
AL6 – 4	13.08.2021	1.16	BDL	1.9	466
AL6 – 5	18.08.2021	1.07	BDL	1.97	460
AL6 – 6	20.08.2021	1.11	BDL	1.89	451
AL6 – 7	25.08.2021	1.2	BDL	1.8	460
AL6 – 8	27.08.2021	1.21	BDL	1.82	470
Monthly Average		**1.17**	**-**	**1.86**	**464**
Standard Deviation		**0.06**	**-**	**0.07**	**7**

* NMHC- Non- Methane Hydrocarbons

BDL- Below Detection Limit (Detection Limit – NMHC : 0.5 ppm)

NS- Not Specified

The mean TSPM values at Tuna Port were 347 µg/m^3, The mean PM_{10} values were 217 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were slightly the permissible limit (mean = 63 µg/m^3). The average values of SO_2, NO_x and NH_3 were 2.86 µg/m^3, 16.28 µg/m^3 and 9.65 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Tuna Port. The mean Benzene concentration was 1.17 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.86 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

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

Table 7 : Results of Air Pollutant Concentration at Signal Building										
Parameters	**Date**	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period	**-**	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit	**-**	**NS**	**100 µg/m3**	**60 µg/m3**	**-**	**80 µg/m3**	**-**	**80 µg/m3**	**-**	**400 µg/m3**
AL7 -1	04.08.2021	144	97	30	3.08	3.08	7.62	11.86	7.66	5.53
					2.64		14.61		5.36	
					3.52		13.34		3.57	
AL7 -2	06.08.2021	180	120	38	3.96	4.98	28.58	17.78	4.60	6.55
					4.84		14.61		10.47	
					6.15		10.16		4.60	
AL7 -3	11.08.2021	148	85	29	2.20	2.34	8.89	16.51	5.36	8.68
					3.08		26.04		11.49	
					1.76		14.61		9.19	
AL7 -4	13.08.2021	165	115	32	2.64	2.07	20.33	14.19	9.19	6.47
					0.48		13.34		3.57	
					3.08		8.89		6.64	
AL7 -5	18.08.2021	151	99	35	4.84	3.96	14.61	16.30	8.93	7.49
					3.08		21.60		6.38	
					3.96		12.70		7.15	
AL7 -6	20.08.2021	173	104	64	3.96	3.81	9.53	11.22	4.85	4.68
					3.08		8.89		3.57	
					4.40		15.24		5.62	
AL7 -7	25.08.2021	168	114	44	3.96	1.67	13.34	13.55	16.85	10.89
					0.44		6.99		12.00	
					0.62		20.33		3.83	
AL7 -8	27.08.2021	113	54	37	6.15	2.78	7.62	12.70	9.70	8.76
					1.76		17.15		9.45	
					0.44		13.34		7.15	
Monthly Average		155	98	39		3.1		14.3		7.4
Standard Deviation		21	21	11		1.1		2.4		2.0

NS: Not Specified

Table 7B : Results of Air Pollutant Concentration at Signal Building					
Parameter	Date	C_6H_6 [µg/m³]	HC*	CO [mg/m³]	CO_2 [ppm]
Sampling Period		8 hr	Grab Sampling	Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m³	NS	4.0 mg/m³	NS
AL7 -1	04.08.2021	1.11	BDL	1.9	460
AL7 – 2	06.08.2021	1.2	BDL	1.86	472
AL7 – 3	11.08.2021	1.18	BDL	1.79	460
AL7 – 4	13.08.2021	1.08	BDL	1.86	461
AL7 – 5	18.08.2021	1.12	BDL	1.96	456
AL7 – 6	20.08.2021	1.2	BDL	1.9	460
AL7 – 7	25.08.2021	1.18	BDL	1.88	470
AL7 – 8	27.08.2021	1.1	BDL	1.82	465
Monthly Average		**1.15**	**-**	**1.87**	**463**
Standard Deviation		**0.05**	**-**	**0.05**	**6**

* NMHC- Non- Methane Hydrocarbons
BDL- Below Detection Limit (Detection Limit – NMHC : 0.5 ppm)
NS_ Not Specified

The mean TSPM values at Vadinar Port were 155 µg/m³. The mean PM_{10} values were 98 µg/m³, which is below the permissible limit. $PM_{2.5}$ values were also within the permissible limit (mean = 39 µg/m³). The average values of SO_2, NO_x and NH_3 were 3.1 µg/m³, 14.3 µg/m³ and 7.4 µg/m³ respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Vadinar Port. The mean Benzene concentration was 1.15 µg/m³, well below the permissible limit of 5.0 µg/m³. HC's were below the detectable limit and Carbon Monoxide concentration was 1.87 mg/m³, well below the permissible limit of 4.0 mg/m³.

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

Table 8 : Results of Air Pollutant Concentration at Admin Building										
Parameters	**Date**	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period	-	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit	-	**NS**	**100 µg/m3**	**60 µg/m3**	-	**80 µg/m3**	-	**80 µg/m3**	-	**400 µg/m3**
AL8 -1	04.08.2021	119	55	28	4.84	3.52	19.05	18.42	7.15	6.30
					2.64		22.87		6.64	
					3.08		13.34		5.11	
AL8 -2	06.08.2021	111	56	47	17.58	6.30	17.78	16.73	7.91	8.00
					0.44		19.05		5.62	
					0.88		13.34		10.47	
AL8 -3	11.08.2021	180	100	56	1.76	2.78	15.24	15.24	4.34	5.19
					3.52		22.87		4.85	
					3.08		7.62		6.38	
AL8 -4	13.08.2021	130	77	42	3.96	4.54	13.97	11.86	8.17	7.15
					6.15		10.16		10.47	
					3.52		11.43		2.81	
AL8 -5	18.08.2021	100	68	29	3.96	2.64	7.62	8.89	7.40	7.40
					0.88		8.89		9.45	
					3.08		10.16		5.36	
AL8 -6	20.08.2021	160	97	58	3.52	4.98	12.70	12.70	8.93	8.42
					5.28		10.80		9.19	
					6.15		14.61		7.15	
AL8 -5	25.08.2021	143	65	49	3.52	3.96	6.99	12.49	12.00	8.42
					3.96		17.15		4.34	
					4.40		13.34		8.93	
AL8-6	27.08.2021	160	100	53	2.20	2.93	7.62	11.43	8.17	6.30
					3.08		19.05		4.60	
					3.52		7.62		6.13	
Monthly Average		138	77	45		4.0		13.5		7.1
Standard Deviation		28	19	12		1.3		3.1		1.2

NS: Not Specified

Table 8B : Results of Air Pollutant Concentration at Admin Building					
Parameter	Date	C_6H_6 [µg/m^3]	HC*	CO [mg/m^3]	CO_2 [ppm]
Sampling Period		8 hr	Grab Sampling	Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m^3	NS	4.0 mg/m^3	NS
AL8 -1	04.08.2021	1.12	BDL	1.96	460
AL8-2	06.08.2021	1.06	BDL	1.86	456
AL8 -3	11.08.2021	1.11	BDL	1.88	466
AL8-4	13.08.2021	1.18	BDL	1.9	470
AL8 -5	18.08.2021	1.26	BDL	1.92	466
AL8-6	20.08.2021	1.16	BDL	1.96	460
AL8-7	25.08.2021	1.2	BDL	1.86	456
AL8-8	27.08.2021	1.26	BDL	1.8	462
Monthly Average		**1.17**	**-**	**1.89**	**462**
Standard Deviation		**0.07**	**-**	**0.05**	**5**

* NMHC- Non- Methane Hydrocarbons

BDL- Below Detection Limit (Detection Limit – NMHC: 0.5 ppm)

NS-Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Admin Building Vadinar was comparatively low among all the locations of Air Quality monitoring in Kandla Port and Vadinar Port. The mean TSPM values at Vadinar Port were 138 µg/m^3. The mean PM_{10} values were 77 µg/m^3, which is below the permissible limit. $PM_{2.5}$ values were also within the permissible limit (mean = 45.0 µg/m^3). The average values of SO_2, NO_x and NH_3 were 4.0µg/m^3, 13.5 µg/m^3 and 7.1 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Admin Building, Vadinar Port. The mean Benzene concentration was 1.17 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.89 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

1.4 Observations and Conclusion

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

2. Drinking Water Quality Monitoring

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

2.1 Drinking Water Monitoring Methodology

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

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

2.2 Results

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

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

Sr. No.	Parameter	Unit	Nirman Building 1	P & C building	Main Gate North	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.4	7.3	7.2	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	930	1250	890	500	2000
3	Turbidity	NTU	0	1	0	1.0	5.0
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	1850	2460	1700	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2	<2	<2	NS*	NS*
8	Chloride as Cl	mg/l	626	656	541	250.0	1000.0
9	Ca as Ca	mg/l	68.14	60.12	76.15	75.0	200.0
10	Mg as Mg	mg/l	58.32	72.90	68.04	30.0	100.0
11	Total Hardness	mg/l	390	410	430	200.0	600.0
12	Iron as Fe	mg/l	<0.01	<0.01	<0.01	0.3	No Relaxation
13	Fluorides as F	mg/l	0.34	0.41	0.13	1.0	1.5
14	Sulphate as SO4	mg/l	290.4	175.2	200.4	200.0	400
15	Nitrite as NO2	mg/l	<0.01	<0.01	<0.01	NS*	NS*
16	Nitrate as NO3	mg/l	6.27	8.10	13.38	45.0	No Relaxation
17	Salinity	%	1.13	1.19	0.98	NS*	NS*
18	Sodium as Na	mg/l	160	178	150	NS*	NS*
19	Potassium as K	mg/l	2.2	2.3	2.8	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Sr. No.	Parameter	Unit	Canteen	West Gate – I	Wharf Area	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.6	7.3	7.2	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1320	990	1030	500	2000
3	Turbidity	NTU	0	0	1	1.0	5.0
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	2590	1890	2010	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2	<2	<2	NS*	NS*
8	Chloride as Cl	mg/l	717	596	616	250.0	1000.0
9	Ca as Ca	mg/l	64.13	60.12	56.11	75.0	200.0
10	Mg as Mg	mg/l	72.90	70.47	68.04	30.0	100.0
11	Total Hardness	mg/l	390	360	390	200.0	600.0
12	Iron as Fe	mg/l	<0.01	<0.01	<0.01	0.3	No Relaxation
13	Fluorides as F	mg/l	0.44	0.49	0.51	1.0	1.5
14	Sulphate as SO4	mg/l	190.8	198	289.2	200.0	400
15	Nitrite as NO2	mg/l	<0.01	<0.01	<0.01	NS*	NS*
16	Nitrate as NO3	mg/l	8.80	10.42	9.50	45.0	No Relaxation
17	Salinity	%	1.29	1.08	1.11	NS*	NS*
18	Sodium as Na	mg/l	130	168	158	NS*	NS*
19	Potassium as K	mg/l	3	2.2	2.4	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Sr. No.	Parameter	Unit	SewaSadan – 3	Workshop	Custom Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.3	7.8	7.4	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	950	1050	1100	500	2000
3	Turbidity	NTU	1	1	0	1.0	5.0
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	1890	2080	2150	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2	<2	<2	NS*	NS*
8	Chloride	mg/l	742	692	576	250.0	1000.0
9	Ca as Ca	mg/l	76.15	60.12	52.10	75.0	200.0
10	Mg as Mg	mg/l	58.32	68.04	68.04	30.0	100.0
11	Total Hardness	mg/l	400	400	380	200.0	600.0
12	Iron as Fe	mg/l	<0.01	<0.01	<0.01	0.3	No Relaxation
13	Fluorides	mg/l	0.88	0.59	0.59	1.0	1.5
14	Sulphate	mg/l	219.6	207.6	174	200.0	400
15	Nitrite	mg/l	<0.01	<0.01	<0.01	NS*	NS*
16	Nitrate	mg/l	13.73	10.21	12.88	45.0	No Relaxation
17	Salinity	%	1.34	1.25	1.04	NS*	NS*
18	Sodium as Na	mg/l	148	150	166	NS*	NS*
19	Potassium as K	mg/l	2.3	2.4	2.8	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Sr. No.	Parameter	Unit	Port Colony Kandla	Hospital Kandla	A.O. Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.5	7.4	7.1	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1080	1350	950	500	2000
3	Turbidity	NTU	0	0	1	1.0	5.0
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	2100	2670	1890	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2	<2	<2	NS*	NS*
8	Chloride	mg/l	767	712	641	250.0	1000.0
9	Ca as Ca	mg/l	60.12	64.13	56.11	75.0	200.0
10	Mg as Mg	mg/l	70.47	72.90	82.62	30.0	100.0
11	Total Hardness	mg/l	370	410	430	200.0	600.0
12	Iron as Fe	mg/l	<0.01	<0.01	<0.01	0.3	No Relaxation
13	Fluorides	mg/l	0.85	0.65	0.93	1.0	1.5
14	Sulphate	mg/l	178.8	202.8	207.6	200.0	400
15	Nitrite	mg/l	<0.01	<0.01	<0.01	NS*	NS*
16	Nitrate	mg/l	9.50	10.21	11.62	45.0	No Relaxation
17	Salinity	%	1.39	1.29	1.16	NS*	NS*
18	Sodium as Na	mg/l	170	164	178	NS*	NS*
19	Potassium as K	mg/l	2.7	2.3	2.8	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Sr. No.	Parameter	Unit	School Gopalpuri	Guest House	E - Type Quarter	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.5	7.5	7.4	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1010	1350	1080	500	2000
3	Turbidity	NTU	1	0	1	1.0	5.0
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	1990	2670	2120	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2	<2	<2	NS*	NS*
8	Chloride	mg/l	697	496	586	250.0	1000.0
9	Ca as Ca	mg/l	56.11	64.13	72.14	75.0	200.0
10	Mg as Mg	mg/l	70.47	53.46	58.32	30.0	100.0
11	Total Hardness	mg/l	380	360	390	200.0	600.0
12	Iron as Fe	mg/l	<0.01	<0.01	<0.01	0.3	No Relaxation
13	Fluorides	mg/l	0.58	0.80	1.05	1.0	1.5
14	Sulphate	mg/l	175.2	170.4	165.6	200.0	400
15	Nitrite	mg/l	<0.01	<0.01	<0.01	NS*	NS*
16	Nitrate	mg/l	9.50	10.70	9.50	45.0	No Relaxation
17	Salinity	%	1.26	0.90	1.06	NS*	NS*
18	Sodium as Na	mg/l	190	186	189	NS*	NS*
19	Potassium as K	mg/l	2.4	2.3	2.6	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Sr. No.	Parameter	Unit	F - Type Quarter	Hospital Gopalpuri	Tuna Port	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.7	7.5	7.32	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1050	1080	1020	500	2000
3	Turbidity	NTU	0	1	0	1.0	5.0
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Unit	Colorless	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	1990	2150	2000	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2	<2	<2	NS*	NS*
8	Chloride	mg/l	626	641	604	250.0	1000.0
9	Ca as Ca	mg/l	76.15	80.16	80.16	75.0	200.0
10	Mg as Mg	mg/l	51.03	60.75	60.75	30.0	100.0
11	Total Hardness	mg/l	430	360	330	200.0	600.0
12	Iron as Fe+3	mg/l	<0.01	<0.01	<0.01	0.3	No Relaxation
13	Fluorides	mg/l	1.05	0.92	0.46	1.0	1.5
14	Sulphate	mg/l	138	190.8	180	200.0	400
15	Nitrite	mg/l	<0.01	<0.01	<0.01	NS*	NS*
16	Nitrate	mg/l	10.00	7.96	8.2	45.0	No Relaxation
17	Salinity	%	1.13	1.16	1.09	NS*	NS*
18	Sodium as Na	mg/l	190	186	188	NS*	NS*
19	Potassium as K	mg/l	2.5	2.4	2.6	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Sr. No.	Parameter	Unit	Vadinar Jetty	Port Colony Vadinar	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.6	7.4	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1010	990	500	2000
3	Turbidity	NTU	ND	ND	1.0	5.0
4	Odor	-	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	210.0	990.0	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2	<2	NS*	NS*
8	Chloride	mg/l	476	491	250.0	1000.0
9	Ca as Ca	mg/l	64.13	56.11	75.0	200.0
10	Mg as Mg	mg/l	75.33	68.04	30.0	100.0
11	Total Hardness	mg/l	470	420	200.0	600.0
12	Iron as Fe+3	mg/l	<0.01	<0.01	0.3	No Relaxation
13	Fluorides	mg/l	0.99	0.94	1.0	1.5
14	Sulphate	mg/l	16.80	17.64	200.0	400
15	Nitrite	mg/l	<0.01	<0.01	NS*	NS*
16	Nitrate	mg/l	11.48	9.50	45.0	No Relaxation
17	Salinity	%	0.86	0.89	NS*	NS*
18	Sodium as Na	mg/l	140.0	146.0	NS*	NS*
19	Potassium as K	mg/l	2.2	2.3	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent

*NS: Not Specified

2.3 Results & Discussion

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

pH

The limit of pH value for drinking water is specified as 6.5 to 8.5. pH value in the studied area varied from 7.0 to 8.0 pH unit. All the sampling points showed pH values within the prescribed limit by Indian Standards.

Total Dissolved Solids (TDS)

TDS values in the studied area varied between 600 -1800 mg/l. None of the sampling points showed higher TDS values than the prescribed limit by Indian standards .

Conductivity

Electrical Conductivity is the ability of a solution to transfer (conduct) electric current. Conductivity is used to measure the concentration of dissolved solids which have been ionized in a polar solution such as water. The conductivity in the samples collected during the month of August ranged from 1000-3300 µs/cm. Electrical conductivity standards do not appear in BIS standards for drinking water.

BOD

BOD value in the studied area was less than 2.0 mg/L. Indian standards does not show any standard values for BOD in drinking water.

Chlorides

Excessive chloride concentration increase rates of corrosion of metals in the distribution system. This can lead to increased concentration of metals in the supply. Chloride value in the studied area varied between 400-800 mg/l and is found to be within the Permissible limit of the Drinking Water Standard.

Calcium

Calcium value in the studied area varied between 45 - 80 mg/l and is found to be within the Permissible limit of the Drinking Water Standard. If calcium is present beyond the maximum acceptable limit, it causes incrustation of pipes.

Magnesium

Magnesium value in the studied area varied between 30 – 85 mg/l. All the locations had Magnesium within the prescribed limits of 30-100 mg/L.

Total Hardness

Hardness value in the studied area varied between 330-470 mg/l and is found to be within the Permissible limit of the Drinking Water Standard. The prescribed limit by Indian Standards is 200-600 mg/L.

Iron

Iron value in the studied area was below 0.01mg/L and hence well below the permissible limit as per Indian Standards is 0.3 mg/L. The excess amount of iron causes slight toxicity; gives stringent taste to water.

Fluoride

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

Sulphates

Sulphate value in the studied area varied between 10 – 300 mg/l. All the sampling points showed sulphate values within the prescribed limits by Indian Standards (200-400 mg/L). Sulphate content in drinking water exceeding the 400 mg/L imparts bitter taste.

Nitrites (NO_2) and Nitrates (NO_3)

Nitrite values in all the water samples were <0.1. There are no specified standard values for Nitrites in Drinking water. The mean Nitrate values in drinking water of KPT was 6.27 mg/l which is well within the permissible limit of the Drinking water Standard.

Salinity

Salinity in drinking water in the present samples collected ranged from 0.8 to 1.3 %. There are no prescribed Indian standards for salinity in Drinking water.

Sodium and Potassium Salts

Sodium values in the samples collected ranged from 100 - 2000 mg/l and Potassium salts ranged from 2.2 to 3.0 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 permissible limits prescribed by the Indian Standards.

Bacteriological Study

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

2.4 Conclusions

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

3. Noise Level Monitoring

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

3.1 Method of Monitoring

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

3.2 Results

Table 16: Noise Monitoring data for ten locations of Deendayal Port and two 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	52.0	48.9
2	Nirman Building 1	52.7	46.9
3	Tuna Port	56.2	49.8
4	Main Gate North	66.8	60.7
5	West Gate I	70.4	63.0
6	Canteen Area	54.8	44.7
7	Main Road	65.9	51.1
8	ATM Building	66.4	56.6
9	Wharf Area /Jetty Area	72.2	67.7
10	Port & Custom Office	51.5	46.3
	Vadinar Port		
11	Entrance Gate of Vadinar Port	66.8	53.7
12	Nr. Port Colony, Vadinar	60.4	52.8
13	Nr. Vadinar Jetty	72.5	63.7

3.3 Conclusions- Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. The Day Time Average Noise Level (SPL)in all ten locations at Deendayal Port ranged from 52.0 dB(A) to 72.2 dB(A) and it was within the permissible limits of 75 dB(A) for the industrial area for the daytime. The Night Time Average Noise Level (SPL) in all ten locations of Deendayal Port ranged from 44.7 dB to 67.7 dB(A) and it was within the permissible limits of 70 dB(A) for the industrial area for the night time.

4. Soil Monitoring

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

4.1 Methodology

The soil samples were collected in the month of August 2021. The samples collected from the all locations are homogeneous representative of each location. At random locations were identified at each location and soil was dug from 30 cm below the surface. It was uniformly mixed before homogenizing the soil samples. The samples were filled in polythene bags, labeled in the field with number and site name and sent to laboratory for analysis.

4.2 Results

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

Sr. No.	Parameter	Unit	Station Name					
			SL1	SL2	SL3	SL4	SL5	SL6
			Tuna Port	IFFCO Plant	Khori Creek	Nakti Creek	KPT Admin Site	KPT Colony
			Near main gate of Port	10 m away from main gate	Sand from creek at low tide		Vadinar	
1	Texture		Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	pH	-	8.60	8.10	8.42	8.30	8.09	8.32
3	Electrical Conductivity	µs/cm	23,400.0	20,420.0	23,700.0	17,200.0	510.0	400.0
4	Moisture	%	20.42	21.16	23.22	20.12	9.04	8.22
5	Total Organic Carbon	%	0.18	0.18	0.25	0.11	0.21	0.16
6	Alkalinity	mg/kg	60.06	140.04	140.04	60.06	100.10	80.04
7	Total Nitrogen	%	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
8	Chloride	mg/kg	4,010.0	4,324.0	5,982.0	4,001.0	42.2	67.8
9	Sulphate	mg/kg	188.0	179.2	110.0	100.0	14.0	16.2
10	Phosphorus	mg/kg	0.90	0.86	1.04	1.62	0.78	0.88
11	Potassium	mg/kg	786.0	656.0	1,162.0	780.0	130.0	182.0
12	Sodium	mg/kg	2,341.0	3,618.0	4,220.0	3,122.0	1,224.0	1,400.0
13	Calcium	mg/kg	160.00	130.00	170.00	220.00	110.00	68.00
14	Copper as Cu	mg/kg	32.2	58.2	42.2	23.4	17.4	23
15	Lead as Pb	mg/kg	3.8	3.8	3.6	4.1	BQL	BQL
16	Nickel as Ni	mg/kg	37.2	32.4	41.2	24.5	19.3	20.4
17	Zinc as Zn	mg/kg	59.36	38.32	53.4	48.50	49.20	40.40
18	Cadmium as Cd	mg/kg	ND	ND	ND	ND	ND	ND

4.3 Discussion

- The data shows that value of pH ranges from 8.42 at Nakti Creek to 8.60 at Tuna Creek indicating that all soil samples are neutral to slight basic. Tuna port samples showed maximum conductivity of 23,400µmhos/cm, while Nakti Creek location showed minimum conductivity of 17,200 µmhos/cm. Conductivity at Vadinar Port was 510 and 400 µmhos/cm at Admin site and Vadinar Port colony respectively.
- Total organic Carbon ranged from 0.1 % to 0.3 at Deendayal Port. At Vadinar Port, organic carbon content ranged from 0.1 % to 0.2 %.
- The concentration of Phosphorus and Potassium in the soil samples varies from 0.8 to 1.62 mg/kg and 600.0 to 1170 mg/kg respectively at Deendayal Port. The mean concentration of Phosphorous at Vadinar site was 0.80 mg/kg and mean concentration of Potassium at Vadinar site was 156 mg/kg.

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

Heavy Metals in the Soil

Traces of Copper, Lead, Nickel and Zinc were observed in the soil samples collected from all the four locations of Deendayal Port and two locations of Vadinar Port. Cadmium metal was not detected in the Soil.

4.4 Conclusion

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

5. Sewage Treatment Plant Monitoring

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

5.1 Methodology for STP Monitoring

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

5.2 Results

- **Kandla STP**

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

Date of Sampling	05.08.2021

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	7.9	7.5
2	Total Suspended Solids	mg/l	107	101
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	334	108
5	BOD @ 27 °C	mg/l	118.0	27.0
Aeration Tank				
6	MLSS	mg/l	12.0	
7	MLVSS	%	88.0	

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

Date of Sampling	12.08.2021

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	7.6	7.68
2	Total Suspended Solids	mg/l	193	101
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	414	104
5	BOD @ 27 °C	mg/l	136.0	27.0
Aeration Tank				
6	MLSS	mg/l	9.0	
7	MLVSS	%	97.0	

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

Date of Sampling	19.08.2021

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	7.86	7.48
2	Total Suspended Solids	mg/l	204	104
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	261	70
5	BOD @ 27 °C	mg/l	87.0	20.0
Aeration Tank				
6	MLSS	mg/l	10.0	
7	MLVSS	%	90.0	

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

Date of Sampling	23.08.2021

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	7.43	7.16
2	Total Suspended Solids	mg/l	403.3	150.4
3	Residual Chlorine	mg/l	<1.0	<1.0
4	COD	mg/l	313.1	151.5
5	BOD @ 27 °C	mg/l	106.0	52.0
6.	Fecal Coliform	MPN Index / 100 ml	-	>1600
Aeration Tank				
7.	MLSS	mg/l	33.0	
8	MLVSS	%	81.0	

- **Gopalpuri Colony STP**

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

Date of Sampling	05.08.2021

Sr. No.	Parameters	Unit	Results	
			Gopalpuri STP I/L	Gopalpuri STP O/L
1	pH	pH unit	7.76	7.34
2	Total Suspended Solids	mg/l	98.1	62.4
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	324	102
5	BOD @ 27 °C	mg/l	110.0	28.0
Aeration Tank				
6	MLSS	mg/l	12.0	
7	MLVSS	%	92.0	

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

Date of Sampling	12.08.2021

Sr. No.	Parameters	Unit	Results	
			Gopalpuri STP I/L	Gopalpuri STP O/L
1	pH	pH unit	7.72	7.37
2	Total Suspended Solids	mg/l	406	107
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	320	103
5	BOD @ 27 °C	mg/l	110.0	26.0
Aeration Tank				
6	MLSS	mg/l	14.0	
7	MLVSS	%	90.0	

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

Date of Sampling	19.08.2021

Sr. No.	Parameters	Unit	Results	
			Gopalpuri STP I/L	Gopalpuri STP O/L
1	pH	pH unit	7.71	7.34
2	Total Suspended Solids	mg/l	404	107
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	351	101
5	BOD @ 27 °C	mg/l	115.0	23.0
Aeration Tank				
6	MLSS	mg/l	16.0	
7	MLVSS	%	88.0	

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

Date of Sampling	23.08.2021

Sr. No.	Parameters	Unit	Results	
			Gopalpuri STP I/L	Gopalpuri STP O/L
1	pH	pH unit	7.7	7.35
2	Total Suspended Solids	mg/l	405	107
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	242	101
5	BOD @ 27 °C	mg/l	80.0	23.0
6.	Fecal Coliform	MPN Index / 100 ml	-	>1600
Aeration Tank				
7.	MLSS	mg/l	18.0	
8.	MLVSS	%	88.0	

- **Vadinar STP**

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

Date of Sampling	05.08.2021

Sr. No.	Parameters	Unit	Results	
			Vadinar STP I/L	Vadinar O/L
1	pH	pH unit	7.23	NOT WORKING
2	Total Suspended Solids	mg/l	18	
3	Residual Chlorine	mg/l	<1.0	
4	COD	mg/l	89.0	
5	BOD @ 27 °C	mg/l	28.0	

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

Date of Sampling	12.08.2021

Sr. No.	Parameters	Unit	Results	
			Vadinar STP I/L	Vadinar O/L
1	pH	pH unit	7.28	NOT WORKING
2	Total Suspended Solids	mg/l	60	
3	Residual Chlorine	mg/l	<1.0	
4	COD	mg/l	78.0	
5	BOD @ 27 °C	mg/l	28.0	

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

Date of Sampling	19.08.2021

Sr. No.	Parameters	Unit	Results	
			Vadinar STP I/L	Vadinar O/L
1	pH	pH unit	7.32	NOT WORKING
2	Total Suspended Solids	mg/l	60	
3	Residual Chlorine	mg/l	<1.0	
4	COD	mg/l	80.0	
5	BOD @ 27 °C	mg/l	26.0	

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

Date of Sampling	23.08.2021

Sr. No.	Parameters	Unit	Results	
			Vadinar STP I/L	Vadinar O/L
1	pH	pH unit	7.18	NOT WORKING
2	Total Suspended Solids	mg/l	72	
3	Residual Chlorine	mg/l	<1.0	
4	COD	mg/l	80.0	
5	BOD @ 27 °C	mg/l	26.0	

5.3 Conclusions:

The GPCB standards of BOD, TSS and Residual Chlorine for STP outlet are 20 mg/lit, 30 mg/lit & 0.5 mg/lit respectively. It is suggested to do treatment on regular basis to avoid flow of contaminated/polluted water into the sea. Also, the STP at Vadinar is also non-functional and thus, steps should be taken to commission the STP at Vadinar Port. Hence, currently only inlet samples are collected and analysed.

6. Marine Water Monitoring

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

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

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

Marine Environment

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

Sampling Stations

The monitoring of marine environment for the study of biological and ecological parameters was carried out on 9th& 10th August-2021 in harbor regions of KPT and on 9th August-2021 at Vadinar during spring tide period of New moon phase of Lunar Cycle. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 16th& 17th August 2021 in harbor regions of KPT. 16th August -2021 in Vadinar during Neap tide period first quarter of Lunar Cycle..

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

Sampling Locations

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

6.1 Marine Water Quality

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

The results of marine water quality and Marine sediments are as below;

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

Sr. No.	Parameters	Unit	Kandla Creek Near KPT colony (1) 23°0'58"N 70°13'22."E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.16	7.14	7.3	7.26
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	32.2	32.0	32.0	31.8
5	Turbidity	NTU	39	28	32	29
6	Total Dissolved Solids	mg/l	42660	41056	37802.0	43665.0
7	Total Suspended Solids	mg/l	675	979	614.2	372.4
8	Total Solids	mg/l	46346	44350	46346.0	44369.4
9	DO	mg/l	4.5	3.9	4.6	5.1
10	COD	mg/l	80.0	78.0	78.0	80.0
11	BOD	mg/l	<2.0	<2.0	<2.0	<2.0
12	Silica	mg/l	7.82	6.09	0.49	0.73
13	Phosphate	mg/l	0.57	0.14	0.16	0.17
14	Sulphate	mg/l	2628	1656	2352	2076
15	Nitrate	mg/l	2.22	2.03	2.53	3.77
16	Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05
17	Calcium	mg/l	1322.64	1242.48	601.2	480.96
18	Magnesium	mg/l	1239.3	1336.5	1749.6	1773.9
19	Sodium	mg/l	11012.0	10828.0	11022.0	10202.0
20	Potassium	mg/l	340.0	300.0	320.0	302.0
21	Iron	mg/l	1.32	1.40	1.20	1.30
22	Chromium	mg/l	0.16	0.14	0.12	0.11
23	Copper	mg/l	0.06	0.07	0.14	0.18
24	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01
25	Cadmium	mg/l	0.05	0.06	0.07	0.06
26	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001
27	Lead	mg/l	0.11	0.12	0.18	0.19
28	Zinc	mg/l	0.08	0.06	0.07	0.06

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

Sr. No.	Parameters	Unit	Near passenger Jetty One (2) 23° 0'18 "N 70°13'31"E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.28	7.25	7.39	7.42
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31.7	32.6	32.0	32.2
5	Turbidity	NTU	37	27	42	47
6	Total Dissolved Solids	mg/l	41612	45181	41735.0	36900.0
7	Total Suspended Solids	mg/l	717	808	414	432.9
8	Total Solids	mg/l	47224	44028	37224.0	44028.0
9	DO	mg/l	4.4	4.1	5.4	4.8
10	COD	mg/l	90.0	86.0	86.0	82.0
11	BOD	mg/l	<2.0	<2.0	<2.0	<2.0
12	Silica	mg/l	9.44	7.84	0.53	0.64
13	Phosphate	mg/l	0.06	0.11	0.18	0.19
14	Sulphate	mg/l	2760	1572	2652	2616
15	Nitrate	mg/l	2.36	2.25	3.45	4.29
16	Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05
17	Calcium	mg/l	1202.40	1122.24	561.12	480.96
18	Magnesium	mg/l	1336.5	1385.1	1798.2	1749.6
19	Sodium	mg/l	11752.0	10652.0	11120.0	12120.0
20	Potassium	mg/l	306.0	290.0	289.0	322.0
21	Iron	mg/l	1.56	1.66	1.50	1.40
22	Chromium	mg/l	0.13	0.12	0.10	0.12
23	Copper	mg/l	0.08	0.09	0.15	0.16
24	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01
25	Cadmium	mg/l	0.06	0.07	0.07	0.08
26	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001
27	Lead	mg/l	0.10	0.09	0.18	0.17
28	Zinc	mg/l	0.07	0.06	0.08	0.06

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

Sr. No.	Parameters	Unit	Near Coal Berth			
			22°59'12"N 70°13'40"E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.30	7.51	7.53	7.32
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	32.0	32.5	32.0	31.8
5	Turbidity	NTU	33	25	37	45
6	Total Dissolved Solids	mg/l	48590	39430	45812.0	35363.0
7	Total Suspended Solids	mg/l	555	809	587.3	591.2
8	Total Solids	mg/l	45108	41100	41720.0	40200.0
9	DO	mg/l	3.8	4	4.9	5.1
10	COD	mg/l	88.0	90.0	90.0	82.0
11	BOD	mg/l	<2.0	<2.0	<2.0	<2.0
12	Silica	mg/l	5.98	3.98	0.42	0.85
13	Phosphate	mg/l	0.10	0.08	0.15	0.19
14	Sulphate	mg/l	2856	2988	2736	2208
15	Nitrate	mg/l	2.73	2.33	4.75	3.79
16	Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05
17	Calcium	mg/l	1362.72	1322.64	480.96	601.2
18	Magnesium	mg/l	1190.7	1239.3	1822.5	1846.8
19	Sodium	mg/l	11452.0	10890.0	11125.0	10890.0
20	Potassium	mg/l	311.0	269.0	345.0	400.0
21	Iron	mg/l	1.80	1.92	1.30	2.01
22	Chromium	mg/l	0.11	0.12	0.18	0.19
23	Copper	mg/l	0.07	0.06	0.18	0.16
24	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01
25	Cadmium	mg/l	0.05	0.06	0.06	0.07
26	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001
27	Lead	mg/l	0.10	0.11	0.20	0.19
28	Zinc	mg/l	0.08	0.06	0.07	0.06

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

Sr. No.	Parameters	Unit	KPT 4			
			Near 15/16 Berth			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.37	7.42	7.26	7.22
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	32.6	31.6	31.8	31.6
5	Turbidity	NTU	45	37	52	28
6	Total Dissolved Solids	mg/l	42420	38440	33550.0	33133.0
7	Total Suspended Solids	mg/l	654	624	701.5	490.4
8	Total Solids	mg/l	44940	40080	44940.0	40080.0
9	DO	mg/l	4.4	4.3	5.3	5.9
10	COD	mg/l	92.0	88.0	88.0	92.0
11	BOD	mg/l	<2.0	<2.0	<2.0	<2.0
12	Silica	mg/l	2.45	7.45	0.69	0.51
13	Phosphate	mg/l	0.10	0.02	0.24	0.16
14	Sulphate	mg/l	1668	2268	2616	2580
15	Nitrate	mg/l	1.96	1.53	3.34	4.86
16	Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05
17	Calcium	mg/l	1242.48	1282.56	521.04	480.96
18	Magnesium	mg/l	1287.9	1336.5	1725.3	1725.3
19	Sodium	mg/l	12152.0	13020.0	12162.0	11782.0
20	Potassium	mg/l	288.0	316.0	389.0	380.0
21	Iron	mg/l	1.60	1.55	1.48	1.38
22	Chromium	mg/l	0.15	0.16	0.20	0.18
23	Copper	mg/l	0.08	0.10	0.15	0.11
24	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01
25	Cadmium	mg/l	0.08	0.06	0.08	0.07
26	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001
27	Lead	mg/l	0.09	0.11	0.18	0.17
28	Zinc	mg/l	0.07	0.05	0.08	0.06

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

Sr. No.	Parameters	Unit	Nakti Creek Near Tuna Port 22°57'49."N 70° 7'0.67"E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.18	7.30	7.3	7.37
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31.6	33.0	31.8	31.6
5	Turbidity	NTU	36	48	36	28
6	Total Dissolved Solids	mg/l	47540	37880	38200.0	37205.0
7	Total Suspended Solids	mg/l	885	852	332.5	474
8	Total Solids	mg/l	46280	38780	38280.0	49040.0
9	DO	mg/l	4.2	4.3	5.3	5.2
10	COD	mg/l	76.0	78.0	90.0	92.0
11	BOD	mg/l	<2.0	<2.0	<2.0	<2.0
12	Silica	mg/l	4.33	2.45	0.91	0.73
13	Phosphate	mg/l	0.08	0.10	0.18	0.18
14	Sulphate	mg/l	2052	4500	2628	2268
15	Nitrate	mg/l	2.17	2.47	5.14	5.70
16	Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05
17	Calcium	mg/l	1362.72	1282.56	561.12	561.12
18	Magnesium	mg/l	1215	1239.3	1773.9	1773.9
19	Sodium	mg/l	11582.0	11262.0	10589.0	10110.0
20	Potassium	mg/l	326.0	366.0	347.0	311.0
21	Iron	mg/l	2.02	2.00	1.60	1.58
22	Chromium	mg/l	0.20	0.19	0.16	0.15
23	Copper	mg/l	0.10	0.08	0.12	0.10
24	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01
25	Cadmium	mg/l	0.06	0.07	0.08	0.06
26	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001
27	Lead	mg/l	0.11	0.12	0.32	0.62
28	Zinc	mg/l	0.06	0.07	0.07	0.06

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

Sr. No.	Parameters	Unit	Nakti Creek Near NH-8A			
			23° 02'01"N 70° 09'31"E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.39	Sampling not possible during Low Tide	7.39	Sampling not possible during Low Tide
2	Color	-	Colorless		Colorless	
3	Odor	-	Odorless		Odorless	
4	Salinity	ppt	32.9		31.8	
5	Turbidity	NTU	36		35	
6	Total Dissolved Solids	mg/l	36020		35465.0	
7	Total Suspended Solids	mg/l	666		380.3	
8	Total Solids	mg/l	44660		46002.0	
9	DO	mg/l	4.7		5.5	
10	COD	mg/l	80.0		88.0	
11	BOD	mg/l	<2.0		<2.0	
12	Silica	mg/l	7.73		0.45	
13	Phosphate	mg/l	0.08		0.17	
14	Sulphate	mg/l	3660		2280	
15	Nitrate	mg/l	2.74		4.15	
16	Nitrite	mg/l	<0.05		<0.05	
17	Calcium	mg/l	1402.80		561.12	
18	Magnesium	mg/l	1190.7		1773.9	
19	Sodium	mg/l	13030.0		11120.0	
20	Potassium	mg/l	348.0		320.0	
21	Iron	mg/l	1.89		1.50	
22	Chromium	mg/l	0.17		0.17	
23	Copper	mg/l	0.09		0.11	
24	Arsenic	mg/l	<0.01		<0.01	
25	Cadmium	mg/l	0.08		0.07	
26	Mercury	mg/l	<0.001		<0.001	
27	Lead	mg/l	0.09		0.2	
28	Zinc	mg/l	0.08		0.08	

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

Sr. No.	Parameters	Unit	Nr.Vadinar Jetty 22°26'25.26"N 69°40'20.41"E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.60	7.90	7.38	7.25
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	33.0	32.5	32.0	32.0
5	Turbidity	NTU	48	37	47	40
6	Total Dissolved Solids	mg/l	38810	36220	37902.0	35080.0
7	Total Suspended Solids	mg/l	405	380	456.9	395.5
8	Total Solids	mg/l	42180	42020	38990.0	38620.0
9	DO	mg/l	4.3	4.7	4.5	4.9
10	COD	mg/l	90.0	88.0	82.0	78.0
11	BOD	mg/l	<2.0	<2.0	<2.0	<2.0
12	Silica	mg/l	6.00	7.65	0.76	0.93
13	Phosphate	mg/l	0.56	0.68	0.20	0.17
14	Sulphate	mg/l	2628	2268	2520	2376
15	Nitrate	mg/l	2.05	2.15	3.03	3.04
16	Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05
17	Calcium	mg/l	1242.48	1362.72	641.28	521.04
18	Magnesium	mg/l	1239.3	1239.3	1798.2	1798.2
19	Sodium	mg/l	14025.0	13879.0	11012.0	11212.0
20	Potassium	mg/l	326.0	300.0	342.0	333.0
21	Iron	mg/l	1.88	1.79	1.60	1.30
22	Chromium	mg/l	0.18	0.18	0.18	0.12
23	Copper	mg/l	0.08	0.08	0.18	0.20
24	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01
25	Cadmium	mg/l	0.06	0.07	0.06	0.07
26	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001
27	Lead	mg/l	0.10	0.09	0.16	0.2
28	Zinc	mg/l	0.06	0.06	0.06	0.07

6.1.1 Marine Sediments

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

6.2 Results

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

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

Sr. No.	Parameters	Unit	KPT - 1	KPT - 2	KPT – 3	KPT - 5	Jetty
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	1.20	1.08	1.20	1.86	1.46
3	Organic Carbon	mg/kg	0.70	0.96	0.87	0.65	0.68
4	Inorganic Phosphate	mg/kg	120.0	132.0	142.0	162.0	160.0
5	Moisture	%	20.20	23.10	21.88	21.2	23.80
6	Aluminium	mg/kg	ND	ND	ND	ND	ND
7	Silica	mg/kg	28.0	21.0	24.0	36.0	23.0
8	Phosphate	mg/kg	10.50	11.20	9.80	9.60	10.20
9	Sulphate	mg/kg	210.0	242.0	160.0	170.0	140.0
10	Nitrite	mg/kg	0.11	0.12	0.1	0.11	0.12
11	Nitrate	mg/kg	9.80	7.44	10.80	9.20	8.40
12	Calcium	mg/kg	342.0	270.0	325.0	309.0	322.0
13	Magnesium	mg/kg	186.0	145.0	178.0	152.0	202.0
14	Sodium	mg/kg	8824.0	7242.0	9452.0	7122.0	8777.0
15	Potassium	mg/kg	396.0	388.0	460.0	680.0	780.0
16	Chromium	mg/kg	88	60	72.2	68.8	70.2
17	Nickel	mg/kg	20.4	30.4	19.5	21.3	30
18	Copper	mg/kg	60	34	21.5	18.2	23.4
19	Zinc	mg/kg	30.20	32.50	33.20	40.00	28.00
20	Cadmium	mg/kg	ND	ND	ND	ND	ND
21	Lead	mg/kg	2.8	2.4	3.9	5.2	3.8
22	Mercury	mg/kg	ND	ND	ND	ND	ND
23	Arsenic	mg/kg	ND	ND	ND	ND	ND

*Grab samples could not be collected due high current at KPT 3, Natki Creek Near Tuna port & Vadinar SBM

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

Sr. No.	Parameters	Unit	KPT - 1	KPT - 2	KPT - 3	KPT - 4	KPT - 5	Jetty
1	Texture	-	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam
2	Organic Matter	mg/kg	1.20	1.12	1.20	1.80	1.62	1.10
3	Organic Carbon	mg/kg	0.69	0.65	0.69	1.04	0.94	0.64
4	Inorganic Phosphate	mg/kg	120.0	142.0	116.0	136.0	142.0	152.0
5	Moisture	%	20.08	21.52	23.05	24.55	28.88	22.02
6	Aluminium	mg/kg	ND	ND	ND	ND	ND	ND
7	Silica	mg/kg	21.20	18.88	21.0	18.8	16.20	13.60
8	Phosphate	mg/kg	8.8	8.9	7.70	8.20	8.40	6.2
9	Sulphate	mg/kg	180.0	196.0	142.0	166.0	120.0	210.0
10	Nitrite	mg/kg	0.1	0.11	0.1	0.12	0.11	0.13
11	Nitrate	mg/kg	9.80	6.89	8.99	8.80	7.93	10
12	Calcium	mg/kg	322.0	266.0	320.0	296.0	300.0	288.0
13	Magnesium	mg/kg	180.0	145.0	180.0	142.0	212.0	196.0
14	Sodium	mg/kg	8242.0	7002.0	8942.0	6641.0	8041.0	9424.0
15	Potassium	mg/kg	380.0	396.0	422.0	644.0	621.0	386.0
16	Chromium	mg/kg	79	54	74.2	64.7	58.4	66
17	Nickel	mg/kg	18.2	28.2	20.6	19.4	28.4	18.8
18	Copper	mg/kg	54	20	22.5	16.8	18.6	74.2
19	Zinc	mg/kg	28.20	18.80	28.40	34.50	18.60	75.00
20	Cadmium	mg/kg	ND	ND	ND	ND	ND	ND
21	Lead	mg/kg	2	2.1	2.8	3.8	2.4	ND
22	Mercury	mg/kg	ND	ND	ND	ND	ND	ND
23	Arsenic	mg/kg	ND	ND	ND	ND	ND	ND

REPORT

ON

ECOLOGICAL MONITORING

OF MARINE ENVIRONMENT

IN

DPTHARBOURAREA, NEAR BY CREEKS

For

DEENDAYAL PORT TRUST

AUGUST,2021

Sampling Stations:

The monitoring of marine environment for the study of biological and ecological Parameters was carried out on9th August, 2021 in harbour region of DPT, and on 10thAugust,2021 in creeks near by the port during spring tide. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 15thAugust, 2021 in harbour region of DPT and on 16thAugust, 2021 in creeks near by the port during neap tidal condition.

Plankton samples from sub surface layer was collected both during high tide period and low tide period from 3 water quality monitoring stations of DPT harbour area andone 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. Collected water samples were processed for estimation of Chlorophyll- a, Pheophytin- a, qualitative &quantitative evaluation of phytoplankton, qualitative &quantitative evaluation zooplanktons(density and their population).

TABLE #1 SAMPLING LOCATIONS

monitoring requirement	Number of locations
Kandla creek Nakti creek Khori Creek	3 in Kandla creek 2 in Nakti creek 1 in Khori creek
Total Number of locations	**6**

Sampling methodology adopted:

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

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

Samples Processing for chlorophyll estimation:

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

PLANKTON:

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

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

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

Phytoplankton in the marine environment:

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

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

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

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

Zooplankton in the marine environment:

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

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

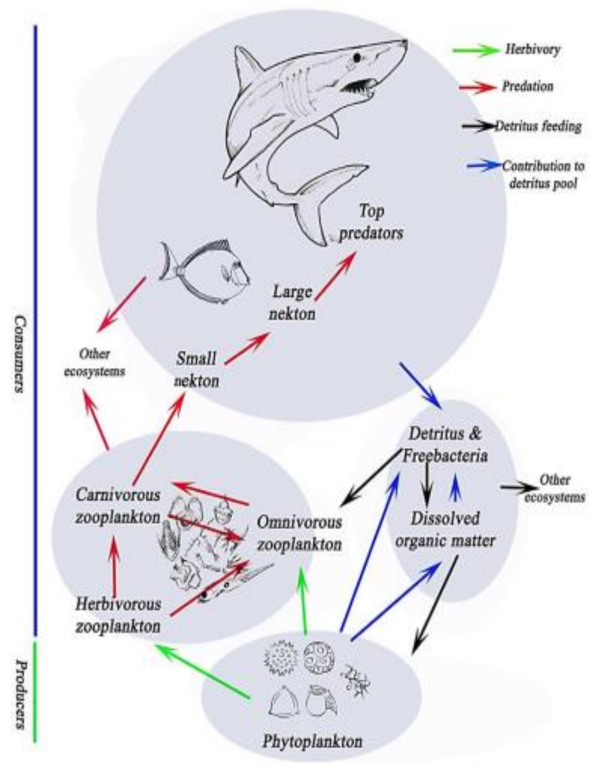
Based on the duration of planktonic life, zooplankton are categorised into Holoplankton (organisms which complete their entire lifecycle as plankton) and Meroplankton (organisms which are planktonic during the early part of their lives such as the larval stages of benthic and nektonic organisms). Tychoplankton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

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

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

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

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



Simplified marine food web

Spatial distribution of Plankton:

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

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

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

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

Methodology adopted for Plankton sampling:

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

Preservation and storage:

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

Sample concentration:

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

Taxonomic evaluation:

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

Cell counts by drop count method:

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

plankton, total number of plankton in the original volume of sample filtered was calculated as units/L.

BENTHIC ORGANISMS:

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

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

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

SAMPLING METHODOLOGY ADOPTED FOR SUB TIDAL REGION:

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

Sample sieving:

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

Sample staining:

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

DIVERSITY INDICES:

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

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

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

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

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

Simpson's diversity index

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

The formula for calculating D is presented as:

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

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

N = the total number of organisms of all species

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

Low species diversity suggests:

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

High species diversity suggests:

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

Species richness indices

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

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

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

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

Shannon-Wiener's index:

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

Shannon and Weiner index represents entropy. It is a diversity index taking into account the number of individuals as well as the number of taxa. It varies from 0 for communities with only single taxa to high values for community with many taxa each with few individuals. This index can also determine the pollution status of a water body. Normal values range from 0 to 4. This index is a combination of species present and the evenness of the species. Examining the diversity in the range of polluted and unpolluted ecosystems, Wilham and Dorris (1968) concluded that the values of the index greater than 3 indicate clean water, values in the range of 1 to 3 are characterized by moderate pollution and values less than 1 are characterized as heavily polluted

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

RESULTS:

CHLOROPHYLL-a:

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

In the sub surface water chlorophyll-a was varying from 0.305 -0.543mg/m^3.in harbour region of DPT during sampling done in spring tide period of August, 2021. In the nearby creeks chlorophyll-a was varying from 0.290-0.732 mg/m^3.Pheophytin –a level was below detectable limit- the all the sampling stations during springtide in the harbour region of DPT.

In the sub surface water chlorophyll-a was varying from 0.220 -0.748mg/m^3.in harbour region of DPT during sampling done in neap tide period of August, 2021 . In the nearby creeks chlorophyll-a was varying from BDL-0.862 mg/m^3.·Pheophytin –a level was below detectable limit- the all the sampling stations during neap tide in the harbour region of DPT.

TABLE #2 VARIATIONS IN CHLOROPHYLL –a PHEOPHYTIN- a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS DURING SPRING TIDE IN AUGUST,2021

Sr. No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPTHARBOUR AREA					
1	KPT1	High tide	0.425	BDL	28.48
		Low tide	0.307	BDL	20.57
2	KPT 2	High tide	0.305	BDL	20.43
		Low tide	0.543	BDL	36.38
3	KPT 3	High tide	0.527	BDL	35.31
		Low tide	0.425	BDL	28.47
CREEKS					
4	KPT-4 Khori-I	High tide	0.543	BDL	36.38
		Low tide	0.527	BDL	35.31
5	KPT-5 Nakti-I	High tide	0.409	BDL	27.40
		Low tide	0.732	BDL	49.04
6	KPT-5 Nakti-II	High tide	0.290	BDL	19.43

BDL: Below Detectable Limit.

TABLE #3 VARIATIONS IN CHLOROPHYLL –a PHEOPHYTIN- a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS DURING NEAP TIDE IN AUGUST,2021

Sr. No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPTHARBOUR AREA					
1	KPT1	High tide	0.220	BDL	14.74
		Low tide	0.308	BDL	20.64
2	KPT 2	High tide	0.748	BDL	50.11
		Low tide	0.731	BDL	48.98
3	KPT 3	High tide	0.307	BDL	20.56
		Low tide	0.221	BDL	14.81
CREEKS					
4	KPT-4 Khori-I	High tide	0.543	BDL	36.38
		Low tide	0.221	BDL	14.81
5	KPT-5 Nakti-I	High tide	0.862	BDL	57.75
		Low tide	0.216	BDL	14.47
6	KPT-5 Nakti-II	High tide	BDL	BDL	-

BDL: Below Detectable Limit.

PHYTOPLANKTON POPULATION:

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

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by,Diatoms blue green algae and dinoflagellates during spring tide period.Diatoms were represented by 14genera. Blue green were represented by threegenera and two genera of Dinoflagellates during the sampling conducted in spring tide in August,2021. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 98-226 units/ L during high tide period and 191-259 units/ L during low tide of Spring Tide.

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by Diatoms ,Blue green algae and Dinoflagellates duringNeap tide period.Diatoms were represented by 15genera and Blue green algae were represented two genera and Dinoflagellates were represented by three genera during the sampling conducted in Neap tide in August, 2021. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from65-307units/ L during high tide period and 238-281 units/ L during low tide of Neap Tide.

Species Richness Indices and Diversity Indices:

Margalef's diversity index (Species Richness)S

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

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations was varying from 1.527-3.091 with an average of 2.420during the sampling conducted in High tide period of spring tide.While Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla Harbour region and nearby creeks was varying from 1.679-2.621 with an average of 2.225 during the consecutive low tide period.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations was varying from 2.344 -3.188 with an average of 2.887 during the sampling conducted in High tide period of Neaptide While .Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla Harbour region and nearby creeks was varying from. 2.526-3. 246with an average of 2.887 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 0.728 -0.860 (H'(log10)) between selected sampling stations with an average value of 0.807 during high tide period of spring tide .Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.726-0.836 (H'(log10)) between selected sampling stations with an average value of 0.773 during consecutive lowtide. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.880-0.959 (H'(log10)) between selected sampling stations with an average value of 0.909 during high tide period of neap tide. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.819-0.911 (H'(log10)) between selected sampling stations with an average value of 0.887 during consecutive low tide. Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon-Wiener's index increases as both the richness and the evenness of the community increase. This result indicates that diversity of phytoplankton of Kandla Harbour region and nearby creeks is less but with abundant population of few, with relatively few ecological niches and only very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson's diversity index:

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

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks, which was varying from 0.785- 0.823 between selected sampling stations with an average of 0.801 during high tide period of spring tide . Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks, which was varying from 0.770- 0.820 between selected sampling stations with an average of 0.787 during consecutive low tide . Low species diversity suggests a relatively few successful species in this habitat. The environment is quite stressful with relatively few ecological niches and only a few organisms are really well adapted to that environment. Any change in the environment would probably have quite serious effects.

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in Kandla Harbour region and nearby creeks, during high tide period and low tide period during neap tide also, which was varying from 0.811-0.886 with an average value of 0.836 between selected sampling stations during high tide period and varying from 0.774-0.826 with an average value of 0.813 between selected sampling stations during consecutive low tide period Low species diversity suggests a relatively few successful species in this habitat.

Table # 4PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS DURING SPRING TIDE IN AUGUST,2021

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	210	14/19	73.68	2.431	0.7923	0.7938
	2	177	17/19	89.47	3.091	0.8603	0.8182
	3	226	12/19	63.16	2.029	0.7883	0.7853
	4	221	17/19	89.47	2.964	0.8243	0.7993
	5	190	14/19	73.68	2.478	0.8531	0.8227
	6	98	8/19	42.11	1.527	0.7279	0.7886
LOW TIDE	1	191	13/19	68.42	2.285	0.7812	0.7901
	2	233	13/19	68.42	2.201	0.7658	0.7795
	3	209	15/19	78.94	2.621	0.8367	0.8208
	4	213	10/19	52.63	1.679	0.7264	0.7732
	5	259	14/19	73.68	2.339	0.7547	0.7702

Table # 5 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS DURING NEAP TIDE IN AUGUST,2021

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	221	18/20	90	3.149	0.9462	0.8522
	2	283	19/20	95	3.188	0.8844	0.811
	3	268	17/20	85	2.862	0.899	0.8255
	4	256	14/20	70	2.344	0.8803	0.8328
	5	307	19/20	95	3.143	0.8857	0.8113
	6	65	12/20	60	2.635	0.9594	0.8861
LOW TIDE	1	238	15/20	75	2.558	0.8192	0.7738
	2	281	19/20	95	3.192	0.9106	0.8188
	3	256	19/20	95	3.246	0.9023	0.8241
	4	242	17/20	85	2.915	0.9102	0.8263
	5	255	15/20	75	2.526	0.8939	0.824

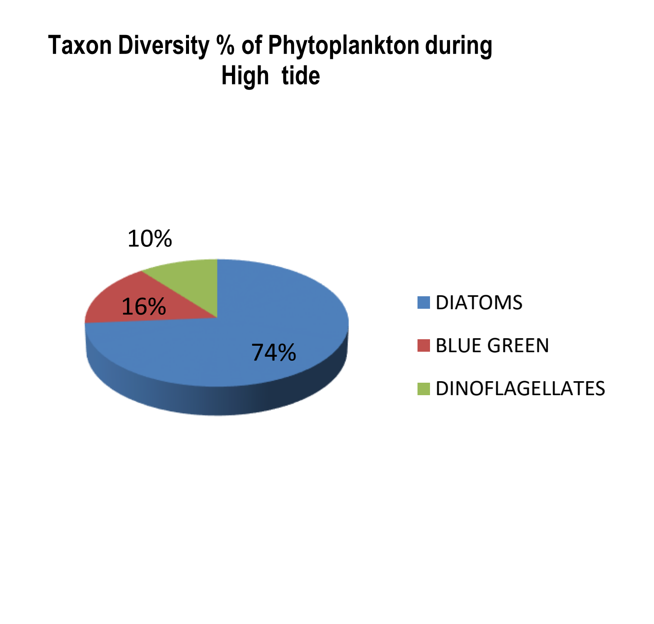
Table # 6 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA, NEAR BY CREEKS DURING SPRING TIDEIN AUGUST, 2021

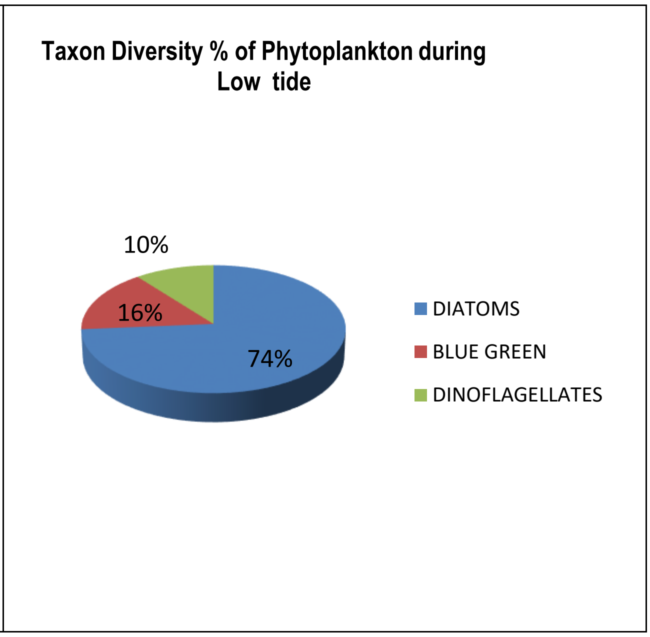
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	DIATOMS	94-215	14/19	73.68
			BLUE GREEN	4-13	3/19	15.79
			DINOFLAGELLATES	0-1	2/19	10.53
			TOTAL PHYTO PLANKTON	98-226	19	-
LOW TIDE	Sub surface	5	DIATOMS	182-250	14/19	73.68
			BLUE GREEN	8-12	3/19	15.79
			DINOFLAGELLATES	0-1	2/19	10.53
			TOTAL PHYTO PLANKTON	191-259	19	-

Table # 7 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA, NEAR BY CREEKS DURING NEAP TIDE IN AUGUST,2021

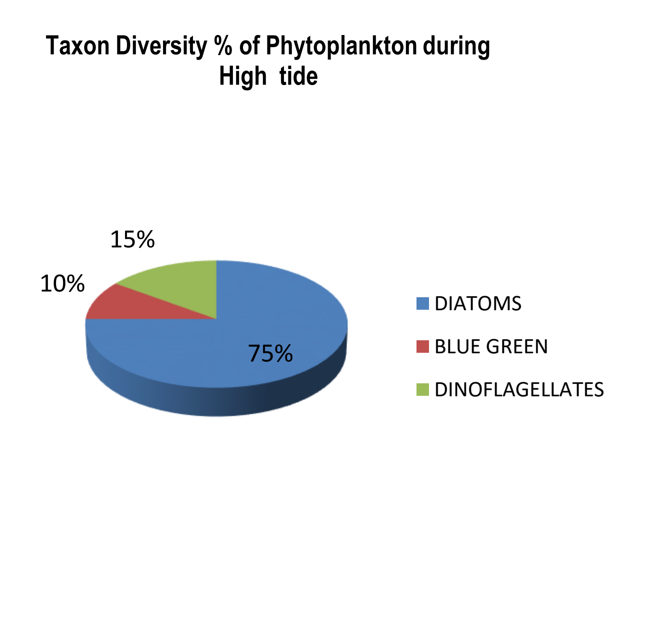
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	DIATOMS	64-298	15/20	75
			BLUE GREEN	0-6	2/20	10
			DINOFLAGELLATES	0-5	3/20	15
			TOTAL PHYTO PLANKTON	65-307	20	-
LOW TIDE	Sub surface	5	DIATOMS	236-274	15/20	75
			BLUE GREEN	1-5	2/20	10
			DINOFLAGELLATES	0-4	3/20	15
			TOTAL PHYTO PLANKTON	238-281	20	-

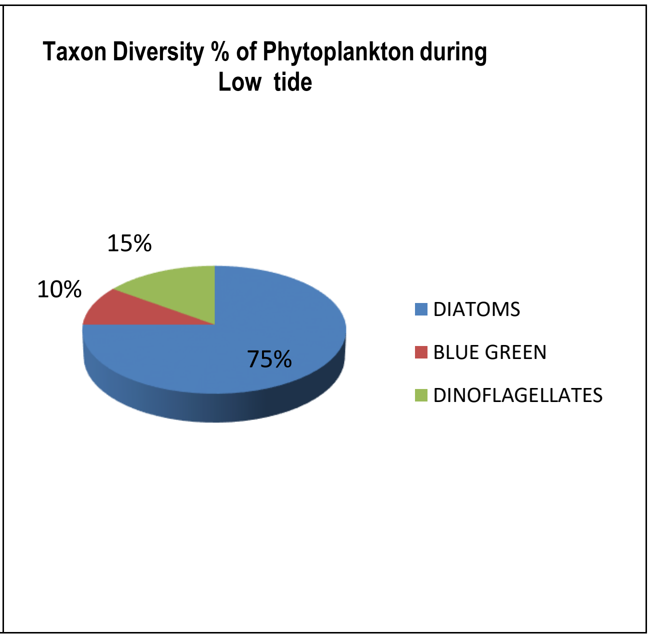
Taxon Diversity % of Phytoplankton during High tide and Low tide period during spring tide





Taxon Diversity % of Phytoplankton during High tide and Low tide period during Neap tide





ZOOPLANKTON POPULATION:

For the evaluation of the Zooplankton population in DPT harbour area and within the immediate surroundings of the port sampling was conducted from 6 sampling locations (3 in harbour area and two in Nakti creek and one in Khoricreek) during high tide period and low tide period of spring tide and Neap tide in August,2021. The Zooplankton community of the sub surface water in the harbour and nearby creeks during spring tide was represented by mainly five groups, Tintinids, Copepods, Ciliates Foraminiferans and larval forms of Crustacea, Molluscans and Polychaetes. The Zooplankton community of the sub surface water in the harbour and nearby creeks during neap tide was represented by mainly four groups, Tintinids, Copepods, Mysids and larval forms of Crustaceans , Molluscansand Polychaetes,.

Zooplankton of the sampling stations at sub surface layer in the DPT harbour area and nearby creek was varying from 34-109x10^3 N/ m^3 during high tide and 109-123 x10^3 N/ m^3during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPT harbour area and nearby creek was varying from 23-109 x10^3 N/ m^3 during high tide and86-103x10^3 N/ m^3during low tide of Neap Tide period.

Species Richness Indices and Diversity Indices:

Margalef's diversity index (Species Richness)S

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

Margalef's diversity index (Species Richness) S of Zooplankton communities in the stations Kandla Harbour region and nearby creeks was varying from 2.269-3.505 with an average of 3.009 during the sampling conducted in High tide period.Margalef's diversity index (Species Richness) S of Zooplankton communities varying from.2.701-3.354 with an average of 3.033 during the sampling conducted in low tide period during Spring tide.

Margalef's diversity index (Species Richness) S of Zooplankton communities in the Kandla Harbour region and nearby creeks sampling stations was varying from1.914- 3.962 with an average of 2.754 during the sampling conducted in high tide and varying from. 1.972-3.236 with an average of 2.640 during the sampling conducted in low tide during Neap 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 0.813-1.052 (H'(log10)) between selected sampling stations with an average value of 0.995 (H'(log10)) during high tide period of spring tide . Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.991-1.067(H'(log10)) between selected sampling stations with an average value of 1.035 (H'(log10)) during consecutive low tide period .

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.696-1.007 (H'(log10)) between selected sampling stations with an average value of 0.897 (H'(log10)) during high tide period of Neap tide. Shannon-

Wiener’s Index (H) of Zooplankton communities in the samplingstations in Kandla Harbour region and nearby creeks was in the range of 0.785-0.983 (H'(log10)) between selected sampling stations with an average value of 0.883 (H'(log10)) during 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 Zooplankton of Kandla Harbour region and nearby creeks stations is slightly high with very minimum diverse population but very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson’s diversity index:

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

Simpson diversity index (1-D) of Zooplankton communities was below 0.9 most of sampling stations in the Kandla Harbour region and nearby creeksduring high tide and low tide of spring tide period, which was varying from 0.839-0.899between selected sampling stations with an average of 0.884 during high tide period and was varying from 0.887- 0.908 with an average value of 0.897 between selected sampling stations during low tide

Simpson diversity index (1-D) of Zooplankton communities was below 0.9 at all sampling stationsin the Kandla Harbour region and nearby creeks during high tide and low tide period except few, which was varying from 0.771-0.869 between selected sampling stations with an average of 0.833 during high tide period and was varying from 0.787- 0.863with an average value of 0.826 between selected sampling stations during consecutive low tide

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

Table # 8 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS DURING SPRING TIDE IN AUGUST,2021

Tide	Sampling Station	Abundance In No / 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	93 $X10^3$	16/19	84.21	3.309	1.052	0.8955
	2	96 $X10^3$	17/19	89.47	3.505	1.032	0.8899
	3	105 $X10^3$	15/19	78.95	3.008	1.031	0.8958
	4	109 $X10^3$	15/19	78.95	2.984	1.037	0.8991
	5	109 $X10^3$	15/19	78.95	2.984	1.008	0.8865
	6	34 $X10^3$	9/19	47.37	2.269	0.8131	0.8396
LOW TIDE	1	110 $X10^3$	15/19	78.95	2.978	1.001	0.8881
	2	118 $X10^3$	17/19	89.47	3.354	1.067	0.8984
	3	123 $X10^3$	14/19	73.68	2.701	0.9911	0.887
	4	117 $X10^3$	16/19	84.21	3.15	1.065	0.9088
	5	109 $X10^3$	15/19	78.95	2.984	1.051	0.904

Table # 9 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS DURING NEAP TIDE IN AUGUST,2021

Tide	Sampling Station	Abundance In No / 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	99 $X10^3$	14/20	70	2.829	0.9755	0.8695
	2	94 $X10^3$	19/20	95	3.962	1.007	0.8646
	3	91 $X10^3$	13/20	65	2.66	0.9544	0.8698
	4	101 $X10^3$	14/20	70	2.817	0.8993	0.8176
	5	109 $X10^3$	12/20	60	2.345	0.8501	0.8089
	6	23 $X10^3$	7/20	35	1.914	0.6965	0.7708
LOW TIDE	1	89 $X10^3$	11/20	55	2.228	0.8172	0.7878
	2	103 $X10^3$	16/20	80	3.236	0.9831	0.8633
	3	96 $X10^3$	14/20	70	2.848	0.92	0.8412
	4	86 $X10^3$	14/20	70	2.918	0.9071	0.8375
	5	96 $X10^3$	10/20	50	1.972	0.7875	0.7987

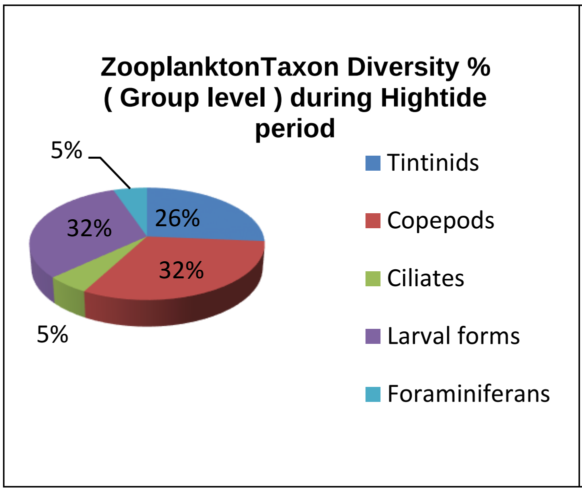
Table # 10 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS DURING SPRING TIDE IN AUGUST,2021

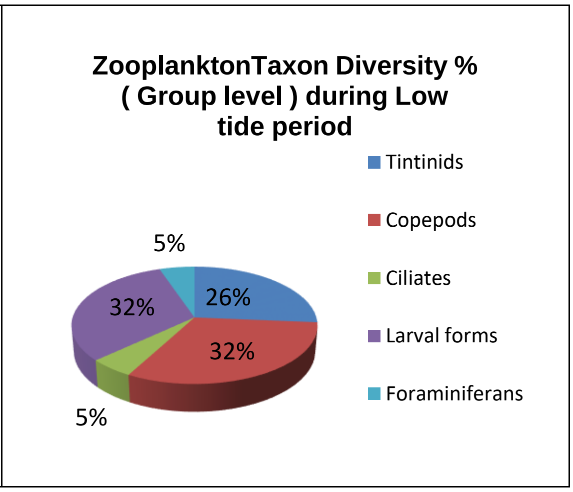
Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^3$ Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinids	1-28	5/19	26.32
			Copepods	17-49	6/19	31.58
			Ciliates	1-6	1/19	5.26
			Larval forms	9-46	6/19	31.58
			Foraminiferans	0-2	1/19	5.26
			TOTAL ZOOPLANKTON NO/L	**34-109**	**19**	
LOW TIDE	Sub surface	5	Tintinids	20-27	5/19	26.32
			Copepods	39-55	6/19	31.58
			Ciliates	1-7	1/19	5.26
			Larval forms	40-46	6/19	31.58
			Foraminiferans	0-1	1/19	5.26
			TOTAL ZOOPLANKTON NO/L	**109-123**	**19**	

Table # 11 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA , NEAR BY CREEKS DURING NEAPTIDE IN AUGUST,2021

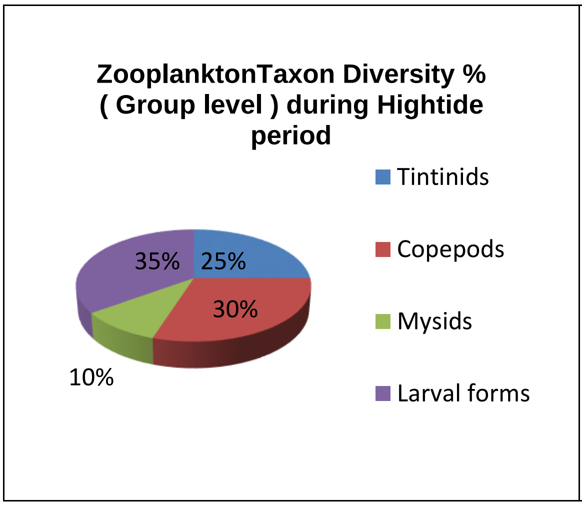
Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^3$ Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinids	1-11	5/20	25
			Copepods	7-26	6/20	30
			Mysids	0-6	2/20	10
			Larval forms	15-84	7/20	35
			TOTAL ZOOPLANKTON NO/L	**23-109**	**20**	-
LOW TIDE	Sub surface	5	Tintinids	6-12	5/20	25
			Copepods	5-23	6/20	30
			Mysids	1-4	2/20	10
			Larval forms	57-74	7/20	35
			TOTAL ZOOPLANKTON NO/L	**86-103**	**20**	-

Taxon Diversity % of Zooplankton during High tide and Low tide period of Spring tide





Taxon Diversity % of Zooplankton during High tide and Low tide period of Neap tide



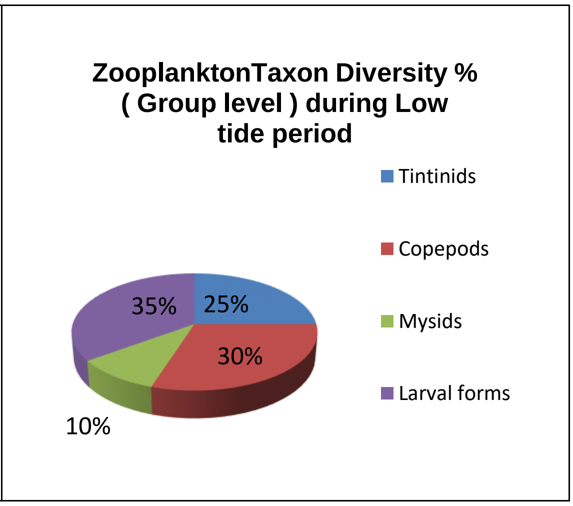


TABLE # 12 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPT HARBOUR AREA AND NEARBY CREEKS DURINGSPRING TIDE OF AUGUST, 2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAE	Cyanophyta	Cyanophyceae	Nostocales	Oscillatoriaceae	*Arthospira*sp.	B1	Rare
					Lyngbya sp.	B2	Rare
			Stigonematales	Stigonemataceae	*Stigonema sp.*	B3	Occasional
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Thalassiosirales	Thalassiosiraceae	*Planktoniella*sp	D1	Rare
			Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D2	Abundant
			Triceratiales	Triceratiaceae	*Odontella*sp	D3	Occasional
					*Triceratium*sp.	D4	Rare
			Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D5	Dominant
			Hemiaulales	Bellerocheaceae	*Bellerochea*sp	D6	Rare
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros*sp	D7	Occasional
			Lithodesmiales	Lithodesmiaceae	*Ditylum*sp	D8	Abundant
		Bacillariophyceae	Naviculales	Pleurosigmataceae	*Pleurosigma*sp	D9	Rare
		Fragilariophyceae	Thalassionematales	Thalassionemataceae	*Thalassiothrix sp.*	D10	Abundant
					Thalassionema sp.	D11	Rare
			Fragilariales	Fragilariaceae	*Asterionelopsis sp..*	D12	Rare
					*Fragilaria*sp	D13	Occasional
					*Synedra*sp	D14	Rare
DINO FLAGELLATES	Dinoflagellata / Dinozoa	Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Rare
			Gonyaulacales	Ceratiaceae	*Ceratiumfurca*	DF2	Rare

TABLE # 12 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPT HARBOUR AREA AND NEARBY CREEKS DURING AND NEAP TIDE OF AUGUST,2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAE	Cyanophyta	Cyanophyceae	Nostocales	Oscillatoriaceae	*Oscillatoria* sp.	B1	Rare
			Stigonematales	Stigonemataceae	*Stigonema sp.*	B2	Rare
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D1	Dominant
			Triceratiales	Triceratiaceae	*Odontellasp*	D2	Occasional
					Triceratiumsp.	D3	Rare
			Biddulphiales	Biddulphiaceae	*Biddulphiasp*	D4	Abundant
			Hemiaulales	Bellerocheaceae	*Bellerocheasp*	D5	Rare
			Chaetocerotales	Chaetocerotaceae	*Chaetocerossp*	D6	Occasional
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D7	Occasional
			Lithodesmiales	Lithodesmiaceae	*Ditylumsp*	D8	Abundant
		Bacillariophyceae	Naviculales	Pleurosigmataceae	*Pleurosigma*sp	D9	Occasional
				Pinnulariaceae	*Pinnulariasp*	D10	Rare
		Fragilariophyceae	Thalassionematales	Thalassionemataceae	*Thalassiothrix sp.*	D11	Dominant
					Thalassionema sp.	D12	Rare
			Fragilariales	Fragilariaceae	*Asterionella sp.*	D13	Occasional
					Fragilariasp	D14	Frequent
					Synedrasp	D15	Rare
DINO FLAGELLATES	Dinoflagellata / Dinozoa	Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Rare
			Gonyaulacales	Ceratiaceae	*Ceratiumfurca*	DF2	Rare
					Ceratiumtripos	DF3	Rare

TABLE #13 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS IN DPT HARBOUR AREA, AND NEAR BY CREEKS DURING SPRING TIDE OF AUGUST,2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnussp.*	T1	Frequent
				Codonellidae	*Tintinnopsisaccuminata*	T2	Rare
					Tintinnopsisfailakkaensis	T3	Rare
					Tintinnopsisgracilis	T4	Occasional
					Tintinnopsis radix	T5	Rare
COPEPODS	ATHROPODA	Crustacea Sub class copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Frequent
				Temoridae	*Temora sp.*	C2	Rare
			Cyclopoida	Oithonidae	*Oithona sp.*	C3	Frequent
			Harpacticoida	Ectinosomatidae	*Microsetella*sp.	C4	Abundant
				Euterpinidae	*Euterpina sp.*	C5	Rare
			Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C6	Rare
CILIATES	CILIOPHORA	Oligohymenophorea	Sessilida	Zoothamniidae	*Zoothamniumsp.*	CI1	Occasional
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of Copepods	L1	Dominant
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of Bivalves	L2	Occasional
POLYCHAETE LARVA	ANNELIDA	Polychaeta			Trochophore larvae	L3	Occasional
BARNACLE LARVAE	ATHROPODA CRUSTACEA	Maxillopoda Thecostraca			Cirripede larvae	L4	Rare
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L5	Occasional
BRYOZOA					Cyphonautes larvae	L6	Occasional
FORAMINIFERA	FORAMINIFERA	Globothalamea	Rotaliida	Rotalliidae	*Rotalia* sp.	F1	Rare

TABLE # 13 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS IN DPT HARBOUR AREA, AND NEAR BY CREEKS DURING NEAP TIDE OF AUGUST,2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnussp.*	T1	Occasional
				Codonellidae	*Tintinnopsisaccuminata*	T2	Rare
					Tintinnopsisfailakkaensis	T3	Rare
					Tintinnopsisgracilis	T4	Occasional
					Tintinnopsis radix	T5	Rare
COPEPODS	ATHROPODA	Crustacea Sub class copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Frequent
				Temoridae	*Temora sp.*	C2	Rare
			Cyclopoida	Oithonidae	*Oithona sp.*	C3	Occasional
			Harpacticoida	Ectinosomatidae	*Microsetella*sp.	C4	Occasional
				Euterpinidae	*Euterpina sp.*	C5	Rare
			Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C6	Rare
MYSIDS	ATHROPODA CRUSTACEA	Malacostraca	Mysida, Decapoda	Solenoceridae	*Solenocerasp.*	M1	Rare
				Penaeidae	*Metapenaeussp.*	M2	Rare
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of Copepods	L1	Dominant
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of Bivalves	L2	Occasional
POLYCHAETE LARVA	ANNELIDA	Polychaeta			Trochophore larvae	L3	Occasional
BARNACLE LARVAE	ATHROPODA CRUSTACEA	Maxillopoda Thecostraca			Cirripede larvae	L4	Rare
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L5	Abundant
CYPHONAUTES LARVAE	BRYOZOA				Cyphonautes larvae	L6	Occasional
ECHINODERMATA larave	ECHINODERMATA	Ophiuroidea			Ophiopluetus larvae	L7	Rare

BENTHIC ORGANISMS:

Few Benthic organisms were observed in the collected sediments by using the Van-veen grabs during the sampling conducted during spring tide period and Neap tide period from DPT harbour region and nearby creek.The benthic organisms during spring tide were represented by Polychaetes, Nematodes and Amphipods. The polychaetes were represented by *Syllis sp.* *Polydorasp* , and*Pondodorasp,* during spring tide sampling. The benthic organisms in the collected samples were varying from 0-300 N/M ^{2} during spring tide and 10-140 NO/M ^{2} during neap tide sampling

Table # 14 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPT HARBOUR AREA CREEKS DURING NEAP TIDE IN AUGUST ,2021

Benthic fauna	ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS REPRESENTATION BY GROUP						
	DPT HARBOUR			CREEKS			
POLYCHATES	KPT-1	KPT-2	KPT-3	KPT-4	KPT-5	KPT-6	
Family : Iospilidae *Pondodora sp.*	0	70	0	0	0	NS	
Family : Spionidae *Polydora sp..*	10	10	0	20	0	NS	
Family : Syllidae *Syllis sp*.	0	10	0	10	0	NS	
Total Polychates N/M^2	10	90	0	30	0	NS	
Un identified Nematode worms	40	200	0	10	30	NS	
Amhipods	0	10	0	10	0	NS	
TOTAL Benthic Fauna NUMBER/ M^2	50	300	0	50	30	NS	

NS : No sample

Table # 15BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPT HARBOUR AREA CREEKS DURING NEAP TIDE IN AUGUST ,2021

Benthic fauna	ABUNDANCE IN NO/M^2 DIFFERENT SAMPLING STATIONS REPRESENTATION BY GROUP						
	DPT HARBOUR			CREEKS			
POLYCHATES	KPT-1	KPT-2	KPT-3	KPT-4	KPT-5	KPT-6	
Family : Spionidae *Polydora sp..*	20	10	0	40	20	NS	
Family : Syllidae *Syllis sp*.	10	10	0	20	60	NS	
Total Polychates N/M^2	30	20	0	60	80	NS	
Un identified Nematode worms	40	30	10	40	40	NS	
Amhipods	10	10	0	10	20	NS	
TOTAL Benthic Fauna NUMBER/ M^2	80	60	10	110	140	NS	

NS : No sample

7. Meteorological Data

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

Temperature

The mean day time temperature for Deendayal Port was 30.5 °C. The day-time maximum temperature was 34.1 °C. The mean night time temperature was 27.4 °C. The minimum mean night time temperature recorded was 26.1 °C.

Air Pressure

The mean absolute air pressure for the month of August was 1004.7 hpa, whereas the mean relative pressure was 1001.2 hpa. The maximum absolute air pressure recorded for the month of August was 1008.3 hpa.

Heat Index

The mean day-time heat index for the month of August was 34.7 ^{o}C. The maximum heat index recorded was 42^{o}C.

Solar Radiation

The mean Solar Radiation in August was 232.4 w/m^2. The maximum solar radiation recorded in the month of August was 682.8 w/m^2.

Humidity

The mean day-time humidity was 73.0 % for the month of August and mean night time humidity was 83.2%. Maximum humidity recorded during day-time was 88.0 % and maximum humidity recorded during night-time was 90.0%.

Wind Velocity and Wind Direction

The mean wind velocity for the entire month of August was 10.8 km/hour. Maximum wind velocity recorded was 34.9 Km/hr . The wind direction was mostly S to SW.

Conclusive Summary and Remedial measures Suggested

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

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

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

- The sewage treated water of Deendayal Port Colony (Gopalpuri) was in line with the standards set by the Gujarat Pollution Control Board. The STP at Deendayal Port is not fully operational and STP at Vadinar Port was found non-operational.

Reasons for higher Values of PM_{10}

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

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

Remedial Measures

The values of PM_{10} during the month of August, 2021 were observed beyond the permissible limit at four locations mentioned above. Given below are the remedial measures suggest to minimize the Air pollution at Deendayal Port.

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

- Sewage Treatment Plan at Vadinar Port is not working. Hence, it is recommended to commission the sewage treatment plant at Vadinar immediately.

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

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ENVIRONMENTAL MONITORING REPORT
FOR
DEENDAYAL PORT TRUST

REPORT NO.	:	DCPL/DPT/20-21/17
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Introduction

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

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

1. Ambient Air Quality Monitoring

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

1.1 Air Quality Monitoring Methodology

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

The AAQ samples are collected twice a week from all the eight locations as per the EMP.

1.2 Results

The ambient air quality monitoring data for six stations, viz. Marine Bhavan, Oil Jetty, Port Colony,Gopalpuri Hospital,Tuna Port and Nr. Coal Storage Area for the month of September 2021 are given in Tables 1A to 6B. The ambient air quality monitoring data for two stations at Vadinar (Nr. Admin Building &Nr. Signal Building) are given in Tables 7A to 8B.

Location 1: Marine Bhavan (AL1)

Table 1 : Results of Air Pollutant Concentration at Marine Bhavan

Parameter	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period	-	24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit	-	NS	100 µg/m3	60 µg/m3		80 µg/m3		80 µg/m3		400 µg/m3
AL1 – 1	03.09.2021	412	314	76	3.96	5.13	10.80	29.22	5.36	9.53
					6.59		32.39		13.02	
					4.84		44.46		10.21	
AL1 – 2	08.09.2021	673	579	50	3.52	3.81	13.34	26.25	12.25	12.85
					3.08		49.54		12.76	
					4.84		15.88		13.53	
AL1 – 3	10.09.2021	706	552	53	3.08	4.25	11.43	17.78	15.32	16.17
					6.15		17.15		14.55	
					3.52		24.77		18.64	
AL1 – 4	15.09.2021	357	260	82	6.15	4.84	17.78	39.80	18.12	15.06
					3.52		52.72		16.34	
					4.84		48.91		10.72	
AL1 – 5	17.09.2021	297	178	89	1.76	4.40	17.78	28.58	16.34	15.49
					5.28		24.77		15.57	
					6.15		43.19		14.55	
AL1 - 6	22.09.2021	387	309	72	3.52	3.08	40.02	38.53	5.36	9.53
					3.96		45.10		11.23	
					1.76		30.49		12.00	
AL1 - 7	24.09.2021	288	176	67	3.08	3.52	12.70	19.27	20.42	21.95
					4.84		23.50		22.46	
					2.64		21.60		22.98	
AL1 – 8	28.09.2021	471	299	163	17.14	13.48	27.95	27.31	20.68	21.53
					18.90		33.66		19.66	
					4.40		20.33		24.25	
Monthly Average		449	333	81		5.31		28.34		15.26
Standard Deviation		160	153	36		3.37		7.89		4.73

NS: Not Specified

Table 1B : Results of Air Pollutant Concentration at Marine Bhavan					
Parameter	**Date**	**C_6H_6 [µg/m^3]**	**HC* ppm**	**CO [mg/m^3]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m^3**	**NS**	**4.0 mg/m^3**	**NS**
AL1 – 1	03.09.2021	1.11	BDL	1.89	492
AL1 – 2	08.09.2021	1.2	BDL	1.92	499
AL1 – 3	10.09.2021	1.3	BDL	1.9	486
AL1 – 4	15.09.2021	1.22	BDL	1.86	496
AL1 – 5	17.09.2021	1.27	BDL	1.88	501
AL1 - 6	22.09.2021	1.16	BDL	1.79	492
AL1 – 7	24.09.2021	1.18	BDL	1.86	496
AL1 – 8	28.09.2021	1.22	BDL	1.92	488
Monthly Average		**1.21**	**-**	**1.88**	**494**
Standard Deviation		**0.06**	**-**	**0.04**	**5**

* NMHC- Non- Methane Hydrocarbons

BDL- Below Detection Limit (Detection Limit – NMHC: 0.5ppm)

NS -Not Specified

At Marine Bhavan, the overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_X and NH_3 is attributed mainly by motor vehicle emission produced from various types of automobiles (both diesel and petrol driven). Moreover, the loading and unloading of Food Grains and Timber at Jetty no. 1 and 2 also contributes to the high levels of TSPM and PM_{10}. The mean TSPM value at Marine Bhavan was 449 µg/m^3, The mean PM_{10} values were 333.0 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean = 81 µg/m^3). The average values of SO_2, NO_x and NH_3 were within the permissible limit. The average values of SO_2, NO_x and NH3 were 5.31 µg/ m^3, 28.34 µg/ m^3 & 15.26 µg/ m^3 respectively. These were within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Marine Bhavan. The mean Benzene concentration was 1.21 µg/m^3,well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.88 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 2: Oil Jetty (AL2)

Table 2 : Results of Air Pollutant Concentration at Oil Jetty											
Parameters	**Date**	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**		
Sampling Period	**-**	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	
NAAQMS limit	**-**	**NS**	**100 µg/m3**	**60 µg/m3**	**-**	**80 µg/m3**	**-**	**80 µg/m3**	**-**	**400 µg/m3**	
AL2 – 1	03.09.2021	645	423	158	6.15	4.84	23.50	16.30	17.87	14.72	
					3.52		13.34		16.08		
					4.84		12.07		10.21		
AL2 – 2	08.09.2021	697	594	45	4.40	4.40	12.07	37.26	13.53	13.87	
					5.28		45.73		10.21		
					3.52		53.99		17.87		
AL2 – 3	10.09.2021	673	561	62	3.52	4.25	28.58	18.84	9.45	10.81	
					4.40		21.60		13.02		
					4.84		6.35		9.96		
AL2 – 4	15.09.2021	604	481	103	2.20	3.52	28.58	42.56	16.59	16.93	
					3.08		46.37		17.87		
					5.28		52.72		16.34		
AL2 – 5	17.09.2021	616	571	38	6.15	3.81	46.37	38.53	11.74	8.34	
					3.08		55.89		6.13		
					2.20		13.34		7.15		
AL2 – 6	22.09.2021	673	563	102	2.20	4.54	57.16	51.66	10.47	9.02	
					5.28		45.10		9.70		
					6.15		52.72		6.89		
AL2 – 7	24.09.2021	245	159	71	6.15	3.52	23.50	38.11	10.47	14.81	
					3.08		50.81		15.32		
					1.32		40.02		18.64		
AL2 – 8	28.09.2021	280	178	82	4.40	8.94	15.88	18.42	13.02	15.06	
					8.79		13.34		8.42		
					13.63		26.04		23.74		
Monthly Average		554	442	83		4.73		32.71		12.94	
Standard Deviation		183	177	39		1.77		13.12		3.14	

NS: Not Specified

Table 2B : Results of Air Pollutant Concentration at Oil Jetty					
Parameter	**Date**	**C_6H_6 [µg/m³]**	**HC* ppm**	**CO [mg/m³]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m³**	**NS**	**4.0 mg/m³**	**NS**
AL2 -1	03.09.2021	1.12	BDL	1.56	490
AL2 -2	08.09.2021	1.16	BDL	1.62	488
AL2 -3	10.09.2021	1.06	BDL	1.66	496
AL2 -4	15.09.2021	1.13	BDL	1.72	501
AL2 – 5	17.09.2021	1.23	BDL	1.76	490
AL2 – 6	22.09.2021	1.06	BDL	1.7	488
AL2 -7	24.09.2021	1.19	BDL	1.68	486
AL2 – 8	28.09.2021	1.22	BDL	1.74	493
Monthly Average		**1.15**	**-**	**1.68**	**492**
Standard Deviation		**0.07**	**-**	**0.07**	**5**

* NMHC- Non- Methane Hydrocarbons
BDL- Below Detection Limit (Detection Limit – NMHC : 0.5ppm)

NS- Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Oil Jetty area was mainly by motor vehicle emission produced from various types of vehicles Oil Jetty Area. The mean TSPM values at Oil Jetty were 554 µg/m³ .The mean PM_{10} values were 442 µg/m³, which is above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean = 83 µg/m³).The average values of SO_2, NO_x and NH_3 were within the permissible limit; The mean concentration of SO_2, NO_x and NH3 were 4.73 µg/m³, 32.71 µg/m³ and 12.94 µg/m³ respectively.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Oil Jetty. The mean Benzene concentration was 1.15 µg/m³ .Well below the permissible limit of 5.0 µg/m³. , HC's were below the detectable limit and Carbon Monoxide concentration was 1.68 mg/m³, well below the permissible limit of 4.0 mg/m³.

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

Table 3 : Results of Air Pollutant Concentration at Estate Office

Parameters	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period	-	24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit	-	NS	100 µg/m3	60 µg/m3	-	80 µg/m3	-	80 µg/m3	-	400 µg/m3
AL3 – 1	03.09.2021	239	162	61	3.96	4.54	41.29	37.69	9.45	11.49
					4.40		38.11		11.49	
					5.28		33.66		13.53	
AL3 – 2	08.09.2021	412	288	97	2.64	3.37	20.96	35.36	12.00	12.59
					4.40		40.02		15.57	
					3.08		45.10		10.21	
AL3 – 3	10.09.2021	248	121	41	5.28	4.69	17.78	23.08	15.06	15.57
					5.71		28.58		16.08	
					3.08		22.87		15.57	
AL3 – 4	15.09.2021	195	123	68	4.40	3.08	15.88	17.15	12.00	9.36
					1.76		11.43		7.15	
					3.08		24.14		8.93	
AL3 – 5	17.09.2021	256	194	55	3.08	3.22	32.39	31.55	16.59	14.81
					2.20		30.49		16.85	
					4.40		31.76		10.98	
AL3 – 6	22.09.2021	554	153	39	3.52	3.52	24.14	35.78	18.12	15.06
					3.08		40.02		12.25	
					3.96		43.19		14.81	
AL3 – 7	24.09.2021	467	399	52	2.64	3.08	27.31	34.72	5.36	6.72
					1.76		32.39		6.38	
					4.84		44.46		8.42	
AL3 – 8	28.09.2021	355	253	64	8.79	16.41	7.62	14.19	14.04	10.55
					34.73		14.61		6.13	
					5.71		20.33		11.49	
Monthly Average		341	211	60		5.24		28.69		12.02
Standard Deviation		128	96	18		4.56		9.22		3.11

NS: Not Specified

Table 3B : Results of Air Pollutant Concentration at Kandla Port Colony					
Parameter	**Date**	**C_6H_6 [µg/m^3]**	**HC***	**CO [mg/m^3]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m^3**	**NS**	**4.0 mg/m^3**	**NS**
AL3 -1	03.09.2021	1.1	BDL	1.77	492
AL3 -2	08.09.2021	1.06	BDL	1.82	480
AL3 -3	10.09.2021	1.11	BDL	1.86	479
AL3 -4	15.09.2021	1.16	BDL	1.8	482
AL3 – 5	17.09.2021	1.18	BDL	1.92	477
AL3 – 6	22.09.2021	1.26	BDL	1.96	486
AL3 – 7	24.09.2021	1.22	BDL	1.86	478
AL3 – 8	28.09.2021	1.21	BDL	1.78	482
Monthly Average		**1.16**	**-**	**1.85**	**482**
Standard Deviation		**0.07**	**-**	**0.07**	**5**

* NMHC- Non- Methane Hydrocarbons

BDL- Below Detection Limit (Detection Limit – NMHC : 0.5 ppm)

NS- Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Kandla Port Colony was attributed by vehicle emission produced from trucks and heavy duty vehicles that pass through the road outside Kandla Port Colony. The mean TSPM values at Oil Jetty were 341 µg/m^3, The mean PM_{10} values were 211 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values within the permissible limit (mean = 60 µg/m^3). The average values of SO_2, NO_x and NH3 were 5.24 µg/m^3, 28.69 µg/m^3 and 12.02 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Kandla Port Colony. The mean Benzene concentration was 1.16 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC’s were below the detectable limit and Carbon Monoxide concentration was 1.85 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 4: Gopalpuri Hospital (AL-4)

Table 4 : Results of Air Pollutant Concentration at Gopalpuri Hospital										
Parameter	**Date**	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period	-	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit	-	**NS**	**100 µg/m3**	**60 µg/m3**	-	**80 µg/m3**	-	**80 µg/m3**	-	**400 µg/m3**
AL4 -1	03.09.2021	167	118	37	4.40	3.52	13.34	14.40	8.42	6.30
					2.64		23.50		5.36	
					3.52		6.35		5.11	
AL4 -2	08.09.2021	256	178	63	3.08	3.66	13.34	21.17	8.42	8.85
					1.76		36.84		5.36	
					6.15		13.34		12.76	
AL4 -3	10.09.2021	165	122	26	1.32	2.34	30.49	30.06	12.25	9.36
					3.96		36.20		8.17	
					1.76		23.50		7.66	
AL4 -4	15.09.2021	189	124	54	3.08	4.54	48.91	41.29	5.62	8.59
					4.40		40.02		9.45	
					6.15		34.93		10.72	
AL4 – 5	17.09.2021	185	104	48	2.20	4.40	11.43	24.56	12.00	11.15
					6.15		22.23		7.91	
					4.84		40.02		13.53	
AL4 – 6	22.09.2021	249	101	45	1.76	3.08	17.15	14.40	9.19	8.59
					3.08		12.07		6.89	
					4.40		13.97		9.70	
AL4 – 7	24.09.2021	167	116	43	2.20	2.49	24.14	16.94	9.70	11.83
					0.88		15.88		13.53	
					4.40		10.80		12.25	
AL4 – 8	28.09.2021	177	122	48	0.88	0.88	5.08	6.14	5.87	5.87
					1.32		5.72		7.15	
					0.44		7.62		4.60	
Monthly Average		194	123	46		3.11		21.12		8.82
Standard Deviation		37	24	11		1.20		10.89		2.07

NS: Not Specified

Table 4B : Results of Air Pollutant Concentration at Gopalpuri Hospital					
Parameter	**Date**	**C_6H_6 [µg/m^3]**	**HC***	**CO [mg/m^3]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m^3**	**NS**	**4.0 mg/m^3**	**NS**
AL4 -1	03.09.2021	1.01	BDL	1.76	485
AL4 -2	08.09.2021	1.1	BDL	1.62	480
AL4 -3	10.09.2021	1.06	BDL	1.7	490
AL4 -4	15.09.2021	1.11	BDL	1.59	494
AL4 – 5	17.09.2021	1.18	BDL	1.7	486
AL4 – 6	22.09.2021	1.16	BDL	1.81	490
AL4 – 7	24.09.2021	1.08	BDL	1.79	487
AL4 – 8	28.09.2021	1.06	BDL	1.73	497
Monthly Average		**1.10**	**-**	**1.71**	**489**
Standard Deviation		**0.06**	**-**	**0.08**	**5**

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

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Gopalpuri Hospital was attributed by vehicle emission produced from light motor vehicles of the colony residents. The mean TSPM values at Oil Jetty were 194 µg/m^3, The mean PM_{10} values were 123 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were in within the permissible limit (mean= 46 µg/m^3). The average values of SO_2, NO_x and NH_3 were 3.11 µg/m^3, 21.12 µg/m^3 and 8.82 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Gopalpuri Hospital. The mean Benzene concentration was 1.10 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC’s were below the detectable limit and Carbon Monoxide concentration was 1.71 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 5: Coal Storage Area (AL-5)

Table 5 : Results of Air Pollutant Concentration at Coal Storage Area

Parameters	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period	-	24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit	-	NS	100 µg/m3	60 µg/m3	-	80 µg/m3	-	80 µg/m3	-	400 µg/m3
AL5 – 1	03.09.2021	380	115	86	3.52	4.10	32.39	30.28	13.79	14.30
					3.96		37.47		12.25	
					4.84		20.96		16.85	
AL5 – 2	08.09.2021	275	176	80	2.64	4.40	18.42	30.06	6.38	5.79
					6.59		33.66		5.11	
					3.96		38.11		5.87	
AL5 – 3	10.09.2021	302	225	74	2.20	3.66	52.72	48.91	9.45	10.64
					4.84		31.12		6.38	
					3.96		62.88		16.08	
AL5 – 4	15.09.2021	378	242	97	3.08	4.98	13.34	31.33	9.70	10.72
					5.28		50.81		12.76	
					6.59		29.85		9.70	
AL5 – 5	17.09.2021	210	138	70	4.84	4.10	12.07	27.31	9.70	10.98
					3.52		48.91		10.21	
					3.96		20.96		13.02	
AL5 – 6	22.09.2021	402	305	92	5.28	5.71	19.05	28.37	14.55	12.08
					6.15		26.04		12.25	
					5.71		40.02		9.45	
AL5 – 7	24.09.2021	268	151	73	2.64	4.69	32.39	33.66	18.64	17.61
					4.84		31.76		16.08	
					6.59		36.84		18.12	
AL5 – 8	28.09.2021	375	248	70	5.71	6.15	26.04	18.00	15.32	16.00
					6.15		5.72		19.91	
					6.59		22.23		12.76	
Monthly Average		324	200	80		4.73		30.99		12.26
Standard Deviation		69	65	10		0.96		8.61		3.69

NS: Not Specified

Table 5B : Results of Air Pollutant Concentration at Coal Storage Area					
Parameter	**Date**	**C_6H_6 [µg/m^3]**	**HC***	**CO [mg/m^3]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m^3**	**NS**	**4.0 mg/m^3**	**NS**
AL5 – 1	03.09.2021	1.22	BDL	1.9	489
AL5 – 2	08.09.2021	1.26	BDL	1.86	499
AL5 – 3	10.09.2021	1.3	BDL	1.79	501
AL5 – 4	15.09.2021	1.22	BDL	1.88	486
AL5 – 5	17.09.2021	1.21	BDL	1.86	488
AL5 – 6	22.09.2021	1.35	BDL	1.8	492
AL5 – 7	24.09.2021	1.34	BDL	1.92	496
AL5 – 8	28.09.2021	1.30	BDL	1.93	502
Monthly Average		**1.28**	**-**	**1.87**	**494**
Standard Deviation		**0.06**	**-**	**0.05**	**6**

* NMHC- Non- Methane Hydrocarbons

BDL- Below Detection Limit (Detection Limit – NMHC: 0.5 ppm)

NS-Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Coal Storage Area was comparatively highest among all the locations of Air Quality monitoring in Kandla Port. High values of TSPM, $PM_{10,}$ $PM_{2.5}$, SO_2, NO_X at this location was due to lifting of coal with grab and other coal handling processes near Berth no. 6 & 7. Moreover, the traffic was also heavy around this place for transport of coal thus emissions produced from heavy vehicles. The mean TSPM values at Coal storage were 324 µg/m^3. The mean PM_{10} values were 200 µg/m^3, which is well above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean = 80 µg/m^3). The average values of SO_2, NO_x and NH_3 were 4.73 µg/m^3, 30.99 µg/m^3 and 12.26 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Coal Storage Area. The mean Benzene concentration was 1.28 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.87 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 6: Tuna Port (AL-6)

Table 6 : Results of Air Pollutant Concentration at Tuna Port

Parameters	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period	-	24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit	-	NS	100 µg/m3	60 µg/m3	-	80 µg/m3	-	80 µg/m3	-	400 µg/m3
AL6 -1	03.09.2021	186	104	52	7.03	5.13	12.70	38.11	14.30	16.34
					4.40		57.16		16.85	
					3.96		44.46		17.87	
AL6 – 2	08.09.2021	253	123	75	4.40	4.69	11.43	17.36	6.38	10.64
					6.15		18.42		14.04	
					3.52		22.23		11.49	
AL6 – 3	10.09.2021	214	128	57	3.52	3.66	25.41	23.29	9.96	13.87
					5.28		32.39		21.70	
					2.20		12.07		9.96	
AL6 – 4	15.09.2021	166	108	49	2.20	4.54	30.49	20.96	9.70	9.70
					4.84		19.05		9.19	
					6.59		13.34		10.21	
AL6 – 5	17.09.2021	253	177	50	3.08	4.69	52.72	45.52	12.25	12.51
					4.84		45.10		15.57	
					6.15		38.74		9.70	
AL6 – 6	22.09.2021	441	135	49	1.32	3.22	27.31	31.97	13.02	13.79
					3.08		38.74		15.57	
					5.28		29.85		12.76	
AL6 – 7	24.09.2021	216	130	46	3.08	3.81	33.66	40.44	16.08	12.00
					5.28		44.46		10.47	
					3.08		43.19		9.45	
AL6 – 8	28.09.2021	179	106	62	1.76	3.37	13.34	7.20	5.87	7.23
					3.96		4.45		5.36	
					4.40		3.81		10.47	
Monthly Average		238	126	55		4.14		28.11		12.01
Standard Deviation		88	24	10		0.71		13.08		2.82

NS: Not Specified

Table 6B : Results of Air Pollutant Concentration at Tuna Port					
Parameter	**Date**	**C_6H_6 [µg/m³]**	**HC***	**CO [mg/m³]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m³**	**NS**	**4.0 mg/m³**	**NS**
AL6 -1	03.09.2021	1.19	BDL	1.86	478
AL6 – 2	08.09.2021	1.16	BDL	1.92	492
AL6 – 3	10.09.2021	1.21	BDL	1.78	486
AL6 – 4	15.09.2021	1.06	BDL	1.92	482
AL6 – 5	17.09.2021	1.1	BDL	1.86	478
AL6 – 6	22.09.2021	1.02	BDL	1.8	492
AL6 – 7	24.09.2021	1.21	BDL	1.79	488
AL6 – 8	28.09.2021	1.2	BDL	1.86	478
Monthly Average		**1.14**	**-**	**1.85**	**484**
Standard Deviation		**0.07**	**-**	**0.05**	**6**

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

The mean TSPM values at Tuna Port were 238 µg/m³, The mean PM_{10} values were 126 µg/m³, which is above the permissible limit. $PM_{2.5}$ values were within the permissible limit (mean = 55 µg/m³). The average values of SO_2, NO_x and NH_3 were 4.14 µg/m³, 28.11 µg/m³ and 12.01 µg/m³ respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Tuna Port. The mean Benzene concentration was 1.14 µg/m³, well below the permissible limit of 5.0 µg/m³. HC's were below the detectable limit and Carbon Monoxide concentration was 1.85 mg/m³, well below the permissible limit of 4.0 mg/m³.

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

Table 7 : Results of Air Pollutant Concentration at Signal Building

Parameters	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period	-	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit	-	**NS**	**100 µg/m3**	**60 µg/m3**	-	**80 µg/m3**	-	**80 µg/m3**	-	**400 µg/m3**
AL7 -1	03.09.2021	158	88	43	3.96	12.60	9.53	10.80	5.62	6.21
					30.77		8.89		4.60	
					3.08		13.97		8.42	
AL7 -2	08.09.2021	158	93	59	3.96	3.52	13.97	14.61	9.96	9.28
					4.40		17.78		6.64	
					2.20		12.07		11.23	
AL7 -3	10.09.2021	180	108	53	3.08	3.22	19.05	12.28	5.62	4.51
					3.52		10.80		4.85	
					3.08		6.99		3.06	
AL7 -4	15.09.2021	169	102	33	5.28	4.25	13.97	12.70	6.13	8.85
					3.52		10.16		9.96	
					3.96		13.97		10.47	
AL7 -5	17.09.2021	160	87	27	5.28	3.66	10.80	9.74	8.42	5.87
					2.64		8.26		5.62	
					3.08		10.16		3.57	
AL7 -6	22.09.2021	177	95	64	3.52	4.40	13.97	8.79	10.47	9.87
					3.96		10.80		9.96	
					5.71		1.59		9.19	
AL7 -7	24.09.2021	139	94	32	2.20	3.52	13.97	12.91	6.38	6.72
					4.40		12.70		8.42	
					3.96		12.07		5.36	
AL7 -8	28.09.2021	168	107	43	2.64	3.08	14.61	12.49	8.68	7.40
					3.08		8.89		6.13	
					3.52		13.97		7.40	
Monthly Average		164	97	44		5		12		7
Standard Deviation		13	8	13		3		2		2

NS: Not Specified

Table 7B : Results of Air Pollutant Concentration at Signal Building					
Parameter	Date	C_6H_6 [µg/m^3]	HC*	CO [mg/m^3]	CO_2 [ppm]
Sampling Period		8 hr	Grab Sampling	Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m^3	NS	4.0 mg/m^3	NS
AL7 -1	03.09.2021	1.12	BDL	1.8	456
AL7 – 2	08.09.2021	1.06	BDL	1.78	462
AL7 – 3	10.09.2021	1.11	BDL	1.86	470
AL7 – 4	15.09.2021	1.18	BDL	1.8	455
AL7 – 5	17.09.2021	1.25	BDL	1.72	469
AL7 – 6	22.09.2021	1.16	BDL	1.68	460
AL7 – 7	24.09.2021	1.2	BDL	1.77	463
AL7 – 8	28.09.2021	1.26	BDL	1.7	460
Monthly Average		**1.17**	**-**	**1.76**	**462**
Standard Deviation		**0.07**	**-**	**0.06**	**5**

* NMHC- Non- Methane Hydrocarbons
BDL- Below Detection Limit (Detection Limit – NMHC : 0.5 ppm)
NS_ Not Specified

The mean TSPM values at Vadinar Port were 164 µg/m^3. The mean PM_{10} values were 97 µg/m^3, which is below the permissible limit. $PM_{2.5}$ values were also within the permissible limit (mean = 44 µg/m^3). The average values of SO_2, NO_x and NH_3 were 5.0 µg/m^3, 12.0 µg/m^3 and 7.0 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Vadinar Port. The mean Benzene concentration was 1.17 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.76 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

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

Table 8 : Results of Air Pollutant Concentration at Admin Building

Parameters	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period	-	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit	-	**NS**	**100 µg/m3**	**60 µg/m3**	-	**80 µg/m3**	-	**80 µg/m3**	-	**400 µg/m3**
AL8 -1	03.09.2021	164	83	24	3.96	4.25	13.34	12.28	5.87	4.77
					3.96		12.07		5.87	
					4.84		11.43		2.55	
AL8 -2	08.09.2021	198	130	35	4.40	5.28	20.96	20.54	5.11	5.70
					6.15		17.78		4.85	
					5.28		22.87		7.15	
AL8 -3	10.09.2021	177	86	64	2.64	3.81	8.89	12.91	8.42	8.34
					3.96		13.97		9.19	
					4.84		15.88		7.40	
AL8 -4	15.09.2021	150	78	25	2.64	2.07	20.96	16.94	8.42	6.98
					3.08		17.78		4.08	
					0.48		12.07		8.42	
AL8 -5	17.09.2021	156	84	46	2.20	3.52	247.71	91.46	5.62	6.72
					3.96		12.70		6.89	
					4.40		13.97		7.66	
AL8 -6	22.09.2021	198	123	55	3.52	4.10	11.43	13.97	4.60	4.85
					4.40		14.61		4.34	
					4.40		15.88		5.62	
AL8 -5	24.09.2021	172	101	54	3.08	2.34	9.53	9.10	8.68	7.83
					3.52		6.99		11.23	
					0.44		10.80		3.57	
AL8-6	28.09.2021	135	79	34	4.84	5.57	7.62	9.95	3.57	6.30
					5.71		9.53		5.62	
					6.15		12.70		9.70	
Monthly Average		169	95	42		4		23		6
Standard Deviation		22	20	15		1		28		1

NS: Not Specified

Table 8B : Results of Air Pollutant Concentration at Admin Building					
Parameter	**Date**	**C_6H_6 [µg/m³]**	**HC***	**CO [mg/m³]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m³**	**NS**	**4.0 mg/m³**	**NS**
AL8 -1	03.09.2021	1.06	BDL	1.78	460
AL8-2	08.09.2021	1.1	BDL	1.8	472
AL8 -3	10.09.2021	1.02	BDL	1.68	460
AL8-4	15.09.2021	1.1	BDL	1.72	461
AL8 -5	17.09.2021	1.17	BDL	1.81	452
AL8-6	22.09.2021	1.06	BDL	1.76	460
AL8-7	24.09.2021	1.1	BDL	1.66	470
AL8-8	28.09.2021	1.11	BDL	1.6	465
Monthly Average		**1.09**	**-**	**1.73**	**463**
Standard Deviation		**0.04**	**-**	**0.07**	**6**

* NMHC- Non- Methane Hydrocarbons

BDL- Below Detection Limit (Detection Limit – NMHC: 0.5 ppm)

NS-Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Admin Building Vadinar was comparatively low among all the locations of Air Quality monitoring in Kandla Port and Vadinar Port. The mean TSPM values at Vadinar Port were 169 µg/m³. The mean PM_{10} values were 95 µg/m³, which is below the permissible limit. $PM_{2.5}$ values were also within the permissible limit (mean = 42.0 µg/m³). The average values of SO_2, NO_x and NH_3 were 4.0 µg/m³, 23.0 µg/m³ and 6.0 µg/m³ respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Admin Building, Vadinar Port. The mean Benzene concentration was 1.09 µg/m³, well below the permissible limit of 5.0 µg/m³. HC's were below the detectable limit and Carbon Monoxide concentration was 1.73 mg/m³, well below the permissible limit of 4.0 mg/m³.

1.4 Observations and Conclusion

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

2. Drinking Water Quality Monitoring

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

2.1 Drinking Water Monitoring Methodology

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

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

2.2 Results

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

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

Sr. No.	Parameter	Unit	Nirman Building 1	P & C building	Main Gate North	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.36	7.31	7.4	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1343	1312	1350	500	2000
3	Turbidity	NTU	0	1	1	1.0	5.0
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	2630	2600	2690	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2	<2	<2	NS*	NS*
8	Chloride as Cl	mg/l	420.94	365.81	370.82	250.0	1000.0
9	Ca as Ca	mg/l	72.14	56.11	52.10	75.0	200.0
10	Mg as Mg	mg/l	85.05	72.90	65.61	30.0	100.0
11	Total Hardness	mg/l	350	300	270	200.0	600.0
12	Iron as Fe	mg/l	<0.01	<0.01	<0.01	0.3	No Relaxation
13	Fluorides as F	mg/l	0.35	0.54	0.21	1.0	1.5
14	Sulphate as SO4	mg/l	228	210	258	200.0	400
15	Nitrite as NO2	mg/l	<0.01	<0.01	<0.01	NS*	NS*
16	Nitrate as NO3	mg/l	6.27	8.10	13.38	45.0	No Relaxation
17	Salinity	%	0.76	0.66	0.67	NS*	NS*
18	Sodium as Na	mg/l	301	243	265	NS*	NS*
19	Potassium as K	mg/l	3.24	3.68	3.51	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Sr. No.	Parameter	Unit	Canteen	West Gate – I	Wharf Area	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.55	7.6	7.83	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1390	1360	1500	500	2000
3	Turbidity	NTU	0	0	1	1.0	5.0
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	2700	2680	2950	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2	<2	<2	NS*	NS*
8	Chloride as Cl	mg/l	430.96	360.80	380.85	250.0	1000.0
9	Ca as Ca	mg/l	60.12	56.11	60.12	75.0	200.0
10	Mg as Mg	mg/l	63.18	80.19	85.05	30.0	100.0
11	Total Hardness	mg/l	260	330	350	200.0	600.0
12	Iron as Fe	mg/l	<0.01	<0.01	<0.01	0.3	No Relaxation
13	Fluorides as F	mg/l	0.58	0.79	0.25	1.0	1.5
14	Sulphate as SO4	mg/l	164.4	282	276	200.0	400
15	Nitrite as NO2	mg/l	<0.01	<0.01	<0.01	NS*	NS*
16	Nitrate as NO3	mg/l	8.80	10.42	9.50	45.0	No Relaxation
17	Salinity	%	0.78	0.65	0.69	NS*	NS*
18	Sodium as Na	mg/l	274	251	263	NS*	NS*
19	Potassium as K	mg/l	4.23	3.88	4.21	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Sr. No.	Parameter	Unit	SewaSadan – 3	Workshop	Custom Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.61	7.57	7.45	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1326	1320	1520	500	2000
3	Turbidity	NTU	2	1	0	1.0	5.0
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	2650	2610	3010	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2	<2	<2	NS*	NS*
8	Chloride	mg/l	410.91	320.71	425.95	250.0	1000.0
9	Ca as Ca	mg/l	48.10	56.11	48.10	75.0	200.0
10	Mg as Mg	mg/l	77.76	82.62	77.76	30.0	100.0
11	Total Hardness	mg/l	320	340	320	200.0	600.0
12	Iron as Fe	mg/l	<0.01	<0.01	<0.01	0.3	No Relaxation
13	Fluorides	mg/l	0.16	0.20	0.77	1.0	1.5
14	Sulphate	mg/l	213.6	195.6	276	200.0	400
15	Nitrite	mg/l	<0.01	<0.01	<0.01	NS*	NS*
16	Nitrate	mg/l	13.73	10.21	12.88	45.0	No Relaxation
17	Salinity	%	0.74	0.58	0.77	NS*	NS*
18	Sodium as Na	mg/l	215	206	166	NS*	NS*
19	Potassium as K	mg/l	3.87	3.73	3.56	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Sr. No.	Parameter	Unit	Port Colony Kandla	Hospital Kandla	A.O. Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.53	7.56	7.59	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1370	1350	1450	500	2000
3	Turbidity	NTU	0	0	1	1.0	5.0
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	2690	2700	2990	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2	<2	<2	NS*	NS*
8	Chloride	mg/l	335.75	375.84	821.83	250.0	1000.0
9	Ca as Ca	mg/l	76.15	52.10	72.14	75.0	200.0
10	Mg as Mg	mg/l	87.48	70.47	92.34	30.0	100.0
11	Total Hardness	mg/l	360	290	380	200.0	600.0
12	Iron as Fe	mg/l	<0.01	<0.01	<0.01	0.3	No Relaxation
13	Fluorides	mg/l	0.48	0.14	0.81	1.0	1.5
14	Sulphate	mg/l	336	228	237.6	200.0	400
15	Nitrite	mg/l	<0.01	<0.01	<0.01	NS*	NS*
16	Nitrate	mg/l	9.50	10.21	11.62	45.0	No Relaxation
17	Salinity	%	0.61	0.68	1.48	NS*	NS*
18	Sodium as Na	mg/l	211	196	202	NS*	NS*
19	Potassium as K	mg/l	4.08	4.01	3.99	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Sr. No.	Parameter	Unit	School Gopalpuri	Guest House	E - Type Quarter	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.64	7.61	7.69	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1400	1850	1190	500	2000
3	Turbidity	NTU	2	0	1	1.0	5.0
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	2780	3670	2310	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2	<2	<2	NS*	NS*
8	Chloride	mg/l	410.91	471.05	385.86	250.0	1000.0
9	Ca as Ca	mg/l	64.13	76.15	44.09	75.0	200.0
10	Mg as Mg	mg/l	85.05	99.63	80.19	30.0	100.0
11	Total Hardness	mg/l	350	410	330	200.0	600.0
12	Iron as Fe	mg/l	<0.01	<0.01	<0.01	0.3	No Relaxation
13	Fluorides	mg/l	0.34	0.22	0.48	1.0	1.5
14	Sulphate	mg/l	252	284.4	303.6	200.0	400
15	Nitrite	mg/l	<0.01	<0.01	<0.01	NS*	NS*
16	Nitrate	mg/l	9.50	10.70	9.50	45.0	No Relaxation
17	Salinity	%	0.74	0.85	0.70	NS*	NS*
18	Sodium as Na	mg/l	202	184	192	NS*	NS*
19	Potassium as K	mg/l	3.49	3.50	3.56	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Sr. No.	Parameter	Unit	F - Type Quarter	Hospital Gopalpuri	Tuna Port	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.56	7.42	7.32	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1230	1590	1020	500	2000
3	Turbidity	NTU	1	1	0	1.0	5.0
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Unit	Colorless	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	2450	3150	2000	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2	<2	<2	NS*	NS*
8	Chloride	mg/l	375.84	511.14	604	250.0	1000.0
9	Ca as Ca	mg/l	40.08	60.12	80.16	75.0	200.0
10	Mg as Mg	mg/l	85.05	97.20	60.75	30.0	100.0
11	Total Hardness	mg/l	350	400	330	200.0	600.0
12	Iron as Fe+3	mg/l	<0.01	<0.01	<0.01	0.3	No Relaxation
13	Fluorides	mg/l	0.59	0.36	0.46	1.0	1.5
14	Sulphate	mg/l	260.4	174	180	200.0	400
15	Nitrite	mg/l	<0.01	<0.01	<0.01	NS*	NS*
16	Nitrate	mg/l	10.00	7.96	8.2	45.0	No Relaxation
17	Salinity	%	0.68	0.92	1.09	NS*	NS*
18	Sodium as Na	mg/l	162	206	210	NS*	NS*
19	Potassium as K	mg/l	2.18	4.01	2.6	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Sr. No.	Parameter	Unit	Vadinar Jetty	Port Colony Vadinar	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.5	7.4	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1160	1150	500	2000
3	Turbidity	NTU	ND	ND	1.0	5.0
4	Odor	-	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	2390	2300	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2	<2	NS*	NS*
8	Chloride	mg/l	425.95	415.92	250.0	1000.0
9	Ca as Ca	mg/l	56.11	64.13	75.0	200.0
10	Mg as Mg	mg/l	75.33	70.47	30.0	100.0
11	Total Hardness	mg/l	310	290	200.0	600.0
12	Iron as Fe+3	mg/l	<0.01	<0.01	0.3	No Relaxation
13	Fluorides	mg/l	0.71	0.62	1.0	1.5
14	Sulphate	mg/l	30.60	28.80	200.0	400
15	Nitrite	mg/l	<0.01	<0.01	NS*	NS*
16	Nitrate	mg/l	9.85	9.71	45.0	No Relaxation
17	Salinity	%	0.76	0.75	NS*	NS*
18	Sodium as Na	mg/l	192.0	183.0	NS*	NS*
19	Potassium as K	mg/l	2.2	2.7	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent

*NS: Not Specified

2.3 Results & Discussion

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

pH

The limit of pH value for drinking water is specified as 6.5 to 8.5. pH value in the studied area varied from 7.0 to 8.0 pH unit. All the sampling points showed pH values within the prescribed limit by Indian Standards.

Total Dissolved Solids (TDS)

TDS values in the studied area varied between 1000 -1800 mg/l. None of the sampling points showed higher TDS values than the prescribed limit by Indian standards .

Conductivity

Electrical Conductivity is the ability of a solution to transfer (conduct) electric current. Conductivity is used to measure the concentration of dissolved solids which have been ionized in a polar solution such as water. The conductivity in the samples collected during the month of September ranged from 2000-3700 µs/cm. Electrical conductivity standards do not appear in BIS standards for drinking water.

BOD

BOD value in the studied area was less than 2.0 mg/L. Indian standards does not show any standard values for BOD in drinking water.

Chlorides

Excessive chloride concentration increase rates of corrosion of metals in the distribution system. This can lead to increased concentration of metals in the supply. Chloride value in the studied area varied between 400-900 mg/l and is found to be within the Permissible limit of the Drinking Water Standard.

Calcium

Calcium value in the studied area varied between 40 - 80 mg/l and is found to be within the Permissible limit of the Drinking Water Standard. If calcium is present beyond the maximum acceptable limit, it causes incrustation of pipes.

Magnesium

Magnesium value in the studied area varied between 60 – 99 mg/l. All the locations had Magnesium within the prescribed limits of 30-100 mg/L.

Total Hardness

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

Iron

Iron value in the studied area was below 0.01mg/L and hence well below the permissible limit as per Indian Standards is 0.3 mg/L. The excess amount of iron causes slight toxicity; gives stringent taste to water.

Fluoride

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

Sulphates

Sulphate value in the studied area varied between 30 – 350 mg/l. All the sampling points showed sulphate values within the prescribed limits by Indian Standards (200-400 mg/L). Sulphate content in drinking water exceeding the 400 mg/L imparts bitter taste.

Nitrites (NO_2) and Nitrates (NO_3)

Nitrite values in all the water samples were <0.1. There are no specified standard values for Nitrites in Drinking water. The mean Nitrate values in drinking water of KPT was 6.27 mg/l which is well within the permissible limit of the Drinking water Standard.

Salinity

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

Sodium and Potassium Salts

Sodium values in the samples collected ranged from 100 - 300 mg/l and Potassium salts ranged from 2.2 to 4.0 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 permissible limits prescribed by the Indian Standards.

Bacteriological Study

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

2.4 Conclusions

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

3. Noise Level Monitoring

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

3.1 Method of Monitoring

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

3.2 Results

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

Sr. No.	Location	Day Time Average Noise Level (SPL) in dB(A)	Night Time Average Noise Level (SPL) in dB(A)
	Sampling Time	**6:00 am to 10:00 PM**	**10:00PM to 6:00 AM**
1	Marine Bhavan	58.0	50.4
2	Nirman Building 1	55.3	49.1
3	Tuna Port	52.8	46.5
4	Main Gate North	60.3	55.2
5	West Gate I	67.2	60.6
6	Canteen Area	58.7	50.9
7	Main Road	70.5	59.5
8	ATM Building	69.2	62.3
9	Wharf Area /Jetty Area	73.7	65.4
10	Port & Custom Office	55.2	49.6
	Vadinar Port		
11	Entrance Gate of Vadinar Port	69.6	58.4
12	Nr. Port Colony, Vadinar	61.3	55.8
13	Nr. Vadinar Jetty	68.2	61.5

3.3 Conclusions- Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. The Day Time Average Noise Level (SPL)in all 13 locations at Deendayal Port ranged from 52.0 dB(A) to 73.7 dB(A) and it was within the permissible limits of 75 dB(A) for the industrial area for the daytime. The Night Time Average Noise Level (SPL) in all 13 locations of Deendayal Port ranged from 46.5 dB to 65.4 dB(A) and it was within the permissible limits of 70 dB(A) for the industrial area for the night time.

4. Soil Monitoring

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

4.1 Methodology

The soil samples were collected in the month of September 2021. The samples collected from the all locations are homogeneous representative of each location. At random locations were identified at each location and soil was dug from 30 cm below the surface. It was uniformly mixed before homogenizing the soil samples. The samples were filled in polythene bags, labeled in the field with number and site name and sent to laboratory for analysis.

4.2 Results

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

Sr. No.	Parameter	Unit	Station Name					
			SL1	SL2	SL3	SL4	SL5	SL6
			Tuna Port	IFFCO Plant	Khori Creek	Nakti Creek	KPT Admin Site	KPT Colony
			Near main gate of Port	10 m away from main gate	Sand from creek at low tide		Vadinar	
1	Texture		Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	pH	-	8.58	8.16	8.46	8.26	8.02	8.56
3	Electrical Conductivity	µs/cm	18,400.0	25,620.0	17,880.0	16,520.0	523.0	420.0
4	Moisture	%	21.00	22.20	24.10	18.80	8.66	9.02
5	Total Organic Carbon	%	0.48	1.24	0.48	3.93	0.18	0.21
6	Alkalinity	mg/kg	72.07	36.04	190.19	90.09	60.06	100.10
7	Total Nitrogen	%	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
8	Chloride	mg/kg	1,506.6	6,381.0	1,701.0	1,878.9	52.0	67.8
9	Sulphate	mg/kg	202.0	196.0	112.0	112.0	12.0	18.0
10	Phosphorus	mg/kg	0.89	0.92	1.05	1.10	0.78	0.86
11	Potassium	mg/kg	386.0	820.0	345.0	422.0	110.0	172.0
12	Sodium	mg/kg	1,585.0	3,386.0	2,303.0	1,990.0	990.0	810.0
13	Calcium	mg/kg	228.46	741.50	248.50	468.94	118.00	72.00
14	Copper as Cu	mg/kg	52.2	78.2	46.2	33.8	18.6	28
15	Lead as Pb	mg/kg	4.9	5.6	3.2	4.8	3.2	1.1
16	Nickel as Ni	mg/kg	46.2	28	33.2	26.1	18.2	16.2
17	Zinc as Zn	mg/kg	66.20	41.60	68	49.55	24.00	38.50
18	Cadmium as Cd	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL

4.3 Discussion

- The data shows that value of pH ranges from 8.02 at Nakti Creek to 8.58 at Tuna Creek indicating that all soil samples are neutral to slight basic. Iffco Plant samples showed maximum conductivity of 25,620µmhos/cm, while Nakti Creek location showed minimum conductivity of 16,520 µmhos/cm. Conductivity at Vadinar Port was 523 and 420 µmhos/cm at Admin site and Vadinar Port colony respectively.
- Total organic Carbon ranged from 0.1 % to 3.9 at Deendayal Port. At Vadinar Port, organic carbon content ranged from 0.1 % to 0.2 %.
- The concentration of Phosphorus and Potassium in the soil samples varies from 0.8 to 1.10 mg/kg and 300.0 to 800 mg/kg respectively at Deendayal Port. The mean concentration of Phosphorous at Vadinar site was 0.82 mg/kg and mean concentration of Potassium at Vadinar site was 145 mg/kg.

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

Heavy Metals in the Soil

Traces of Copper, Lead, Nickel and Zinc were observed in the soil samples collected from all the four locations of Deendayal Port and two locations of Vadinar Port. Cadmium metal was not detected in the Soil.

4.4 Conclusion

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

5. Sewage Treatment Plant Monitoring

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

5.1 Methodology for STP Monitoring

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

5.2 Results

- **Kandla STP**

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

Date of Sampling	04.09.2021

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	7.56	7.44
2	Total Suspended Solids	mg/l	64.2	26.6
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	424.2	103.0
5	BOD @ 27 °C	mg/l	141.0	29.0
6.	Fecal Coliform	MPN Index / 100 ml	-	20.0
Aeration Tank				
7.	MLSS	mg/l	6.0	
8.	MLVSS	%	93.0	

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

Date of Sampling	09.09.2021

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	7.6	7.2
2	Total Suspended Solids	mg/l	152.2	72.4
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	384	103.0
5	BOD @ 27 °C	mg/l	120.0	24.0
6.	Fecal Coliform	MPN Index / 100 ml	-	31.0
Aeration Tank				
7.	MLSS	mg/l	9.0	
8.	MLVSS	%	89.0	

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

Date of Sampling	16.09.2021

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	7.71	7.18
2	Total Suspended Solids	mg/l	417.8	159.8
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	383.8	102
5	BOD @ 27 °C	mg/l	128.0	23.0
6.	Fecal Coliform	MPN Index / 100 ml	-	<1.8
Aeration Tank				
7.	MLSS	mg/l	9.0	
8.	MLVSS	%	89.0	

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

Date of Sampling	21.09.2021

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	7.53	7.32
2	Total Suspended Solids	mg/l	172.4	75.9
3	Residual Chlorine	mg/l	<1.0	<1.0
4	COD	mg/l	151.5	102.0
5	BOD @ 27 °C	mg/l	106.0	52.0
6.	Fecal Coliform	MPN Index / 100 ml	-	110.0
Aeration Tank				
7.	MLSS	mg/l	16.0	
8	MLVSS	%	82.0	

- **Gopalpuri Colony STP**

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

Date of Sampling	04.09.2021

Sr. No.	Parameters	Unit	Results	
			Gopalpuri STP I/L	Gopalpuri STP O/L
1	pH	pH unit	7.35	7.21
2	Total Suspended Solids	mg/l	108.8	26
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	316.0	98.0
5	BOD @ 27 °C	mg/l	110.0	28.0
6.	Fecal Coliform	MPN Index / 100 ml	-	>1600.0
Aeration Tank				
7.	MLSS	mg/l	11.0	
8	MLVSS	%	87.0	

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

Date of Sampling	09.09.2021

Sr. No.	Parameters	Unit	Results	
			Gopalpuri STP I/L	Gopalpuri STP O/L
1	pH	pH unit	7.6	7.41
2	Total Suspended Solids	mg/l	406	107.4
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	414.1	101
5	BOD @ 27 °C	mg/l	139.0	28.0
6.	Fecal Coliform	MPN Index / 100 ml	-	>1600.0
Aeration Tank				
7.	MLSS	mg/l	14.0	
8	MLVSS	%	90.0	

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

Date of Sampling	16.09.2021

Sr. No.	Parameters	Unit	Results	
			Gopalpuri STP I/L	Gopalpuri STP O/L
1	pH	pH unit	7.7	7.36
2	Total Suspended Solids	mg/l	276.6	92.1
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	373.7	104
5	BOD @ 27 °C	mg/l	125.0	28.0
6.	Fecal Coliform	MPN Index / 100 ml	-	>1600.0
Aeration Tank				
7.	MLSS	mg/l	12.0	
8	MLVSS	%	86.0	

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

Date of Sampling	05.09.2021

Sr. No.	Parameters	Unit	Results	
			Gopalpuri STP I/L	Gopalpuri STP O/L
1	pH	pH unit	7.4	7.22
2	Total Suspended Solids	mg/l	182.4	117.8
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	171.7	101
5	BOD @ 27 °C	mg/l	80.0	23.0
6.	Fecal Coliform	MPN Index / 100 ml	-	920.0
Aeration Tank				
7.	MLSS	mg/l	12.0	
8.	MLVSS	%	88.0	

- **Vadinar STP**

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

Date of Sampling	05.09.2021

Sr. No.	Parameters	Unit	Results	
			Vadinar STP I/L	Vadinar O/L
1	pH	pH unit	7.22	7.10
2	Total Suspended Solids	mg/l	62	28.0
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	88.0	56.0
5	BOD @ 27 °C	mg/l	26.0	15.0

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

Date of Sampling	09.09.2021

Sr. No.	Parameters	Unit	Results	
			Vadinar STP I/L	Vadinar O/L
1	pH	pH unit	7.33	7.10
2	Total Suspended Solids	mg/l	72	24.0
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	88.0	60.0
5	BOD @ 27 °C	mg/l	29.0	18.0

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

Date of Sampling	16.09.2021

Sr. No.	Parameters	Unit	Results	
			Vadinar STP I/L	Vadinar O/L
1	pH	pH unit	7.32	7.12
2	Total Suspended Solids	mg/l	60	58.0
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	80.0	55.0
5	BOD @ 27 °C	mg/l	26.0	16.0

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

Date of Sampling	21.09.2021

Sr. No.	Parameters	Unit	Results	
			Vadinar STP I/L	Vadinar O/L
1	pH	pH unit	7.18	7.10
2	Total Suspended Solids	mg/l	72	42.0
3	Residual Chlorine	mg/l	<1.0	<0.5
4	COD	mg/l	80.0	58.0
5	BOD @ 27 °C	mg/l	26.0	12.0

5.3 Conclusions:

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

6. Marine Water Monitoring

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

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

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

Marine Environment

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

Sampling Stations

The monitoring of marine environment for the study of biological and ecological parameters was carried out on 7^{th}& 8^{th} September-2021 in harbor regions of KPT and on 7^{th} September-2021 at Vadinar during spring tide period of New moon phase of Lunar Cycle. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 14^{th}& 15^{th} September 2021 in harbor regions of KPT. 15^{th} September -2021 in Vadinar during Neap tide period first quarter of Lunar Cycle..

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

Sampling Locations

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

6.1 Marine Water Quality

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

The results of marine water quality and Marine sediments are as below;

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

Sr. No.	Parameters	Unit	Kandla Creek Near KPT colony (1) 23°0'58"N 70°13'22."E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.20	7.35	7.31	7.27
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31.6	32.0	31.0	31.8
5	Turbidity	NTU	37	35	32	28
6	Total Dissolved Solids	mg/l	59704	58025	34000.0	37060.0
7	Total Suspended Solids	mg/l	282	357	382	303.5
8	Total Solids	mg/l	59986	58382	34382.0	37363.5
9	DO	mg/l	4.5	4.7	4.7	5.3
10	COD	mg/l	78.0	82.0	80.0	86.0
11	BOD	mg/l	<2.0	<2.0	<2.0	<2.0
12	Silica	mg/l	6.09	7.49	0.53	0.42
13	Phosphate	mg/l	0.17	0.16	0.18	0.18
14	Sulphate	mg/l	2640	2280	2808	2568
15	Nitrate	mg/l	2.60	1.43	2.26	2.29
16	Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05
17	Calcium	mg/l	761.52	921.84	521.04	721.44
18	Magnesium	mg/l	1409.4	1263.6	1749.6	1749.6
19	Sodium	mg/l	11280.0	10920.0	11360.0	11062.0
20	Potassium	mg/l	289.0	320.0	296.0	310.0
21	Iron	mg/l	1.95	1.89	1.85	1.79
22	Chromium	mg/l	0.11	0.13	0.11	0.12
23	Copper	mg/l	0.07	0.08	0.08	0.07
24	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01
25	Cadmium	mg/l	0.04	0.05	0.04	0.05
26	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001
27	Lead	mg/l	0.17	0.18	0.13	0.14
28	Zinc	mg/l	0.05	0.06	0.05	0.07

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

Sr. No.	Parameters	Unit	Near passenger Jetty One (2)			
			23° 0'18 "N 70°13'31"E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.40	7.28	7.4	7.43
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31.8	31.6	32.5	32.0
5	Turbidity	NTU	26	27	36	27
6	Total Dissolved Solids	mg/l	55555	51116	34060.0	33780.0
7	Total Suspended Solids	mg/l	363	174	242	582.9
8	Total Solids	mg/l	55918	51290	34302.0	34362.9
9	DO	mg/l	4.9	5.2	5.5	4.6
10	COD	mg/l	96.0	90.0	90.0	88.0
11	BOD	mg/l	<2.0	<2.0	<2.0	<2.0
12	Silica	mg/l	5.16	6.84	0.67	0.71
13	Phosphate	mg/l	0.20	0.18	0.16	0.19
14	Sulphate	mg/l	2820	2376	2832	2496
15	Nitrate	mg/l	2.36	2.89	4.00	3.37
16	Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05
17	Calcium	mg/l	721.44	961.92	601.2	681.36
18	Magnesium	mg/l	1409.4	1215	1822.5	1773.9
19	Sodium	mg/l	11862.0	11060.0	11652.0	11110.0
20	Potassium	mg/l	290.0	312.0	299.0	310.0
21	Iron	mg/l	1.96	1.93	1.86	1.93
22	Chromium	mg/l	0.13	0.13	0.13	0.14
23	Copper	mg/l	0.09	0.08	0.06	0.05
24	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01
25	Cadmium	mg/l	0.06	0.05	0.06	0.04
26	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001
27	Lead	mg/l	0.19	0.16	0.17	0.18
28	Zinc	mg/l	0.08	0.08	0.07	0.06

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

Sr. No.	Parameters	Unit	Near Coal Berth			
			22°59'12"N 70°13'40"E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.19	7.38	7.53	7.34
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	32.5	32.2	32.6	31.6
5	Turbidity	NTU	35	36	34	33
6	Total Dissolved Solids	mg/l	48086	54880	41460.0	39690.0
7	Total Suspended Solids	mg/l	220	220	376.6	359.9
8	Total Solids	mg/l	48306	55100	41836.6	40049.9
9	DO	mg/l	5.0	5.1	4.8	5.2
10	COD	mg/l	89.0	92.0	81.0	78.0
11	BOD	mg/l	<2.0	<2.0	<2.0	<2.0
12	Silica	mg/l	4.67	4.95	0.47	0.71
13	Phosphate	mg/l	0.16	0.21	0.18	0.19
14	Sulphate	mg/l	2376	2964	2376	2352
15	Nitrate	mg/l	2.04	2.26	4.82	4.60
16	Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05
17	Calcium	mg/l	801.60	921.84	440.88	521.04
18	Magnesium	mg/l	1336.5	1287.9	1701	1773.9
19	Sodium	mg/l	12042.0	11910.0	12150.0	11956.0
20	Potassium	mg/l	366.0	372.0	358.0	376.0
21	Iron	mg/l	2.11	2.30	1.96	2.01
22	Chromium	mg/l	0.12	0.15	0.12	0.16
23	Copper	mg/l	0.07	0.09	0.08	0.07
24	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01
25	Cadmium	mg/l	0.04	0.07	0.05	0.07
26	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001
27	Lead	mg/l	0.19	0.19	0.17	0.2
28	Zinc	mg/l	0.07	0.07	0.05	0.07

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

Sr. No.	Parameters	Unit	KPT 4			
			Near 15/16 Berth			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.40	7.38	7.27	7.22
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	32.4	31.8	31.8	31.6
5	Turbidity	NTU	27	23	39	45
6	Total Dissolved Solids	mg/l	53390	47930	42746.0	35470.0
7	Total Suspended Solids	mg/l	262	354	561.7	520.9
8	Total Solids	mg/l	53652	48284	43307.7	35990.9
9	DO	mg/l	4.8	4.9	5.5	4.7
10	COD	mg/l	78.0	80.0	86.0	82.0
11	BOD	mg/l	<2.0	<2.0	<2.0	<2.0
12	Silica	mg/l	6.98	6.35	0.98	0.85
13	Phosphate	mg/l	0.23	0.21	0.21	0.19
14	Sulphate	mg/l	2220	2268	2412	2568
15	Nitrate	mg/l	2.87	2.03	2.81	3.32
16	Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05
17	Calcium	mg/l	801.60	881.76	601.2	480.96
18	Magnesium	mg/l	1312.2	1360.8	1773.9	1773.9
19	Sodium	mg/l	12220.0	12052.0	12012.0	12110.0
20	Potassium	mg/l	300.0	278.0	289.0	280.0
21	Iron	mg/l	2.31	2.22	1.88	2.02
22	Chromium	mg/l	0.16	0.14	0.18	0.16
23	Copper	mg/l	0.06	0.08	0.06	0.05
24	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01
25	Cadmium	mg/l	0.06	0.08	0.06	0.07
26	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001
27	Lead	mg/l	0.19	0.17	0.19	0.16
28	Zinc	mg/l	0.09	0.07	0.06	0.08

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

Sr. No.	Parameters	Unit	Nakti Creek Near Tuna Port			
			22°57'49."N 70° 7'0.67"E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.47	7.45	7.22	7.39
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31.6	31.9	32.0	31.9
5	Turbidity	NTU	35	37	36	48
6	Total Dissolved Solids	mg/l	52041	55010	35620.0	38755.0
7	Total Suspended Solids	mg/l	360	425	387.9	525.7
8	Total Solids	mg/l	52401	55435	36007.9	39280.7
9	DO	mg/l	4.5	4.7	5.4	5.1
10	COD	mg/l	86.0	82.0	92.0	90.0
11	BOD	mg/l	<2.0	<2.0	<2.0	<2.0
12	Silica	mg/l	8.67	9.40	0.82	0.53
13	Phosphate	mg/l	0.17	0.18	0.22	0.18
14	Sulphate	mg/l	2820	2844	2268	2136
15	Nitrate	mg/l	2.56	1.91	2.42	3.81
16	Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05
17	Calcium	mg/l	761.52	721.44	521.04	601.2
18	Magnesium	mg/l	1409.4	1458	1676.7	1749.6
19	Sodium	mg/l	11958.0	11628.0	11990.0	11558.0
20	Potassium	mg/l	366.0	376.0	360.0	320.0
21	Iron	mg/l	2.35	2.36	2.05	2.10
22	Chromium	mg/l	0.19	0.20	0.18	0.16
23	Copper	mg/l	0.08	0.09	0.05	0.06
24	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01
25	Cadmium	mg/l	0.06	0.08	0.05	0.08
26	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001
27	Lead	mg/l	0.19	0.21	0.17	0.18
28	Zinc	mg/l	0.09	0.08	0.07	0.08

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

Sr. No.	Parameters	Unit	Nakti Creek Near NH-8A			
			23° 02'01"N 70° 09'31"E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.36	Sampling not possible during Low Tide	7.39	Sampling not possible during Low Tide
2	Color	-	Colorless		Colorless	
3	Odor	-	Odorless		Odorless	
4	Salinity	ppt	31.6		31.8	
5	Turbidity	NTU	38		37	
6	Total Dissolved Solids	mg/l	54144		35040.0	
7	Total Suspended Solids	mg/l	394		327	
8	Total Solids	mg/l	54538		35367.0	
9	DO	mg/l	4.9		5.6	
10	COD	mg/l	78.0		90.0	
11	BOD	mg/l	<2.0		<2.0	
12	Silica	mg/l	6.96		0.67	
13	Phosphate	mg/l	0.19		0.20	
14	Sulphate	mg/l	2964		2340	
15	Nitrate	mg/l	2.21		25.70	
16	Nitrite	mg/l	<0.05		<0.05	
17	Calcium	mg/l	921.84		641.28	
18	Magnesium	mg/l	1263.6		1725.3	
19	Sodium	mg/l	13125.0		13052.0	
20	Potassium	mg/l	360.0		388.0	
21	Iron	mg/l	2.41		2.30	
22	Chromium	mg/l	0.20		0.19	
23	Copper	mg/l	0.09		0.08	
24	Arsenic	mg/l	<0.01		<0.01	
25	Cadmium	mg/l	0.08		0.07	
26	Mercury	mg/l	<0.001		<0.001	
27	Lead	mg/l	0.18		0.2	
28	Zinc	mg/l	0.09		0.05	

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

Sr. No.	Parameters	Unit	Nr.Vadinar Jetty			
			22°26'25.26"N 69°40'20.41"E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.72	7.56	7.4	7.52
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31.6	32.0	32.0	32.0
5	Turbidity	NTU	33	34	35	31
6	Total Dissolved Solids	mg/l	41457	45920	34437.0	38630.0
7	Total Suspended Solids	mg/l	299	267	512.6	396
8	Total Solids	mg/l	41756	46187	34949.6	39026.0
9	DO	mg/l	4.7	4.8	5.5	4.8
10	COD	mg/l	90.0	86.0	86.0	89.0
11	BOD	mg/l	<2.0	<2.0	<2.0	<2.0
12	Silica	mg/l	7.27	8.55	0.78	0.77
13	Phosphate	mg/l	0.17	0.18	0.19	0.20
14	Sulphate	mg/l	2316	2388	2388	2532
15	Nitrate	mg/l	3.03	3.15	3.32	2.59
16	Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05
17	Calcium	mg/l	841.68	961.92	561.12	601.2
18	Magnesium	mg/l	1385.1	1263.6	1846.8	1822.5
19	Sodium	mg/l	13820.0	13962.0	13762.0	13888.0
20	Potassium	mg/l	310.0	285.0	316.0	296.0
21	Iron	mg/l	1.96	1.99	1.89	2.00
22	Chromium	mg/l	0.19	0.21	0.17	0.16
23	Copper	mg/l	0.08	0.07	0.07	0.06
24	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01
25	Cadmium	mg/l	0.07	0.05	0.07	0.06
26	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001
27	Lead	mg/l	0.21	0.16	0.17	0.18
28	Zinc	mg/l	0.08	0.07	0.06	0.05

6.1.1 Marine Sediments

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

6.2 Results

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

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

Sr. No.	Parameters	Unit	KPT - 1	KPT - 2	KPT - 4	KPT - 5	Jetty
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	1.16	1.12	0.83	0.75	0.86
3	Organic Carbon	mg/kg	0.67	0.65	0.48	0.44	0.50
4	Inorganic Phosphate	mg/kg	111.0	126.0	132.0	142.0	175.0
5	Moisture	%	26.00	27.20	42.60	41	28.20
6	Aluminium	mg/kg	ND	ND	ND	ND	ND
7	Silica	mg/kg	18.0	16.0	13.0	16.0	20.0
8	Phosphate	mg/kg	9.20	10.60	10.66	8.40	8.60
9	Sulphate	mg/kg	219.0	253.0	189.0	211.0	186.0
10	Nitrite	mg/kg	0.12	0.13	0.11	0.12	0.13
11	Nitrate	mg/kg	10.20	8.88	9.25	8.69	9.74
12	Calcium	mg/kg	362.0	322.0	410.0	365.0	310.0
13	Magnesium	mg/kg	210.0	192.0	265.0	196.0	188.0
14	Sodium	mg/kg	3824.0	4012.0	2611.0	2978.0	3777.0
15	Potassium	mg/kg	240.0	202.0	160.0	145.0	178.0
16	Chromium	mg/kg	42.5	16	79	19.2	28.7
17	Nickel	mg/kg	24	20.4	16.9	11	19.3
18	Copper	mg/kg	31.8	36.4	34.2	16.8	31.2
19	Zinc	mg/kg	37.10	32.60	28.00	10.20	24.00
20	Cadmium	mg/kg	ND	ND	ND	ND	ND
21	Lead	mg/kg	3.2	3.9	4.8	3	ND
22	Mercury	mg/kg	ND	ND	ND	ND	ND
23	Arsenic	mg/kg	ND	ND	ND	ND	ND

*Grab samples could not be collected due high at KPT – 3 & Vadinar SBM location.

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

Sr. No.	Parameters	Unit	KPT - 1	KPT - 2	KPT - 3	KPT - 4	KPT - 5	Jetty
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	1.78	0.90	1.03	2.03	0.81	1.31
3	Organic Carbon	mg/kg	1.03	0.52	0.60	1.18	0.47	0.76
4	Inorganic Phosphate	mg/kg	116.0	136.0	142.0	146.0	149.0	166.0
5	Moisture	%	27.00	19.00	27.0	19.0	27.00	19.00
6	Aluminium	mg/kg	ND	ND	ND	ND	ND	ND
7	Silica	mg/kg	22.20	19.62	18.0	20.2	18.00	16.66
8	Phosphate	mg/kg	7.6	8.2	8.90	10.60	11.20	9.8
9	Sulphate	mg/kg	234.0	268.0	245.0	210.0	265.0	206.0
10	Nitrite	mg/kg	0.11	0.13	0.12	0.1	0.11	0.12
11	Nitrate	mg/kg	8.88	9.20	7.66	9.75	8.88	7.82
12	Calcium	mg/kg	378.0	325.0	389.0	378.0	378.0	296.0
13	Magnesium	mg/kg	216.0	206.0	233.0	186.0	210.0	198.0
14	Sodium	mg/kg	4428.0	3971.0	4554.0	2491.0	3036.0	3798.0
15	Potassium	mg/kg	221.0	152.0	167.0	149.0	116.0	160.30
16	Chromium	mg/kg	38.5	12.1	34.9	77.8	18.7	29.4
17	Nickel	mg/kg	27.3	20.4	36.9	21.6	13.1	19.3
18	Copper	mg/kg	11.8	33.5	40.7	20.2	11	41.2
19	Zinc	mg/kg	47.10	61.00	64.10	38.70	5.20	24.00
20	Cadmium	mg/kg	ND	ND	ND	ND	ND	ND
21	Lead	mg/kg	4.4	4.4	5.6	5.7	2.8	ND
22	Mercury	mg/kg	ND	ND	ND	ND	ND	ND
23	Arsenic	mg/kg	ND	ND	ND	ND	ND	ND

REPORT

ON

ECOLOGICAL MONITORING

OF MARINE ENVIRONMENT

IN

DPTHARBOURAREA, NEAR BY CREEKS

For

DEENDAYAL PORT TRUST

SEPTEMBER,2021

INTRODUCTION:

Sampling Stations:

The monitoring of marine environment for the study of biological and ecological Parameters was carried out on8thSeptember 2021 in harbour region of DPT, and on 9thSeptember2021 in creeks near by the port during spring tide. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 14thSeptember 2021 in harbour region of DPT and on 15thSeptember 2021 in creeks near by the port during neap tidal condition.

Plankton samples from sub surface layer was collected both during high tide period and low tide period from 3 water quality monitoring stations of DPT harbour area andone 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. Collected water samples were processed for estimation of Chlorophyll- a, Pheophytin- a, qualitative &quantitative evaluation of phytoplankton, qualitative &quantitative evaluation zooplanktons(density and their population).

TABLE #1 SAMPLING LOCATIONS

monitoring requirement	**Number of locations**
Kandla creek Nakti creek Khori Creek	3 in Kandla creek 2 in Nakti creek 1 in Khori creek
Total Number of locations	**6**

Sampling methodology adopted:

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

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

Samples Processing for chlorophyll estimation:

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

PLANKTON:

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

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

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

Phytoplankton in the marine environment:

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

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

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

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

Zooplankton in the marine environment:

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

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

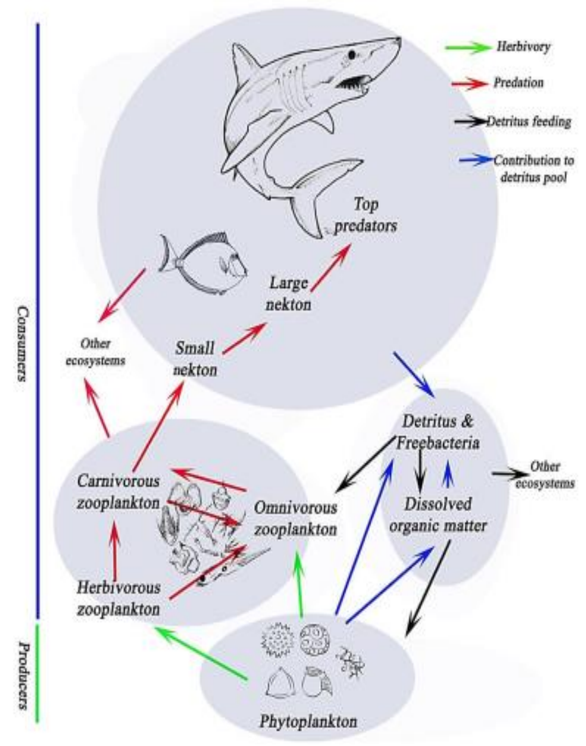
Based on the duration of planktonic life, zooplankton are categorised into Holoplankton (organisms which complete their entire lifecycle as plankton) and Meroplankton (organisms which are planktonic during the early part of their lives such as the larval stages of benthic and nektonic organisms). Tychoplankton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

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

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

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

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



Simplified marine food web

Spatial distribution of Plankton:

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

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

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

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

Methodology adopted for Plankton sampling:

Mixed plankton sample were obtained from the sub surface layer at each sampling locations by towing the net horizontally with the weight .After the tow of about 10-15 minutes, plankton net was pulled up and washed down to the tail and collected the plankton adhered to plankton net in the collection bucket at the bottom by springing outer and inner surface of the net with sea water, while the net was hanging with the mouth upward. For quantitative evaluation 50 L water samples were collected from subsurface layer and filtered through 20µm mesh size net by using bucket and filtration assembly.

Preservation and storage:

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

Sample concentration:

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

Taxonomic evaluation:

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

Cell counts by drop count method:

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

plankton, total number of plankton in the original volume of sample filtered was calculated as units/L.

BENTHIC ORGANISMS:

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

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

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

SAMPLING METHODOLOGY ADOPTED FOR SUB TIDAL REGION:

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

Sample sieving:

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

Sample staining:

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

DIVERSITY INDICES:

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

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

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

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

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

Simpson's diversity index

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

The formula for calculating D is presented as:

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

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

N = the total number of organisms of all species

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

Low species diversity suggests:

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

High species diversity suggests:

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

Species richness indices

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

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

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

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

Shannon-Wiener's index:

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

Shannon and Weiner index represents entropy. It is a diversity index taking into account the number of individuals as well as the number of taxa. It varies from 0 for communities with only single taxa to high values for community with many taxa each with few individuals. This index can also determine the pollution status of a water body. Normal values range from 0 to 4. This index is a combination of species present and the evenness of the species. Examining the diversity in the range of polluted and unpolluted ecosystems, Wilham and Dorris (1968) concluded that the values of the index greater than 3 indicate clean water, values in the range of 1 to 3 are characterized by moderate pollution and values less than 1 are characterized as heavily polluted

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

RESULTS:

CHLOROPHYLL-a:

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

In the sub surface water chlorophyll-a was varying from 0.366 -0.613mg/m^3.in harbour region of DPT during sampling done in spring tide period of September 2021. In the nearby creeks chlorophyll-a was varying from 0.101-0.851mg/m^3.Pheophytin –a level was below detectable limit- the all the sampling stations during springtide in the harbour region of DPT.

In the sub surface water chlorophyll-a was varying from 0.322 -0.645mg/m^3.in harbour region of DPT during sampling done in neap tide period of September 2021 . In the nearby creeks chlorophyll-a was varying from 0.291-0.614 mg/m^3. Pheophytin –a level was below detectable limit- the all the sampling stations during neap tide in the harbour region of DPT.

TABLE #2 VARIATIONS IN CHLOROPHYLL –a PHEOPHYTIN- a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS DURING SPRING TIDE IN SEPTEMBER,2021

Sr. No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPT HARBOUR AREA					
1	KPT1	High tide	0.410	BDL	27.47
		Low tide	0.366	BDL	24.52
2	KPT 2	High tide	0.409	BDL	27.40
		Low tide	0.467	BDL	31.29
3	KPT 3	High tide	0.512	BDL	34.30
		Low tide	0.613	BDL	41.07
CREEKS					
4	KPT-4 Khori-I	High tide	0.645	BDL	43.22
		Low tide	0.748	BDL	50.12
5	KPT-5 Nakti-I	High tide	0.818	BDL	54.81
		Low tide	0.851	BDL	57.02
6	KPT-5 Nakti-II	High tide	0.101	BDL	6.76

BDL: Below Detectable Limit.

TABLE #3 VARIATIONS IN CHLOROPHYLL –a PHEOPHYTIN- a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS DURING NEAP TIDE IN SEPTEMBER,2021

Sr. No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPT HARBOUR AREA					
1	KPT1	High tide	0.322	BDL	21.57
		Low tide	0.323	BDL	21.64
2	KPT 2	High tide	0.630	BDL	42.21
		Low tide	0.615	BDL	41.21
3	KPT 3	High tide	0.527	BDL	35.31
		Low tide	0.645	BDL	43.22
CREEKS					
4	KPT-4 Khori-I	High tide	0.511	BDL	34.24
		Low tide	0.599	BDL	40.13
5	KPT-5 Nakti-I	High tide	0.529	BDL	35.44
		Low tide	0.614	BDL	41.14
6	KPT-5 Nakti-II	High tide	0.291	BDL	19.50

BDL: Below Detectable Limit.

PHYTOPLANKTON POPULATION:

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

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by,Diatoms andblue green algae during spring tide period.Diatoms were represented by 18 genera. Blue green were represented by 3 generaduring the sampling conducted in spring tide in September,2021. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 85-116 units/ L during high tide period and103-133 units/ L during low tide of Spring Tide.

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by Diatoms andBlue green algae duringNeap tide period.Diatoms were represented by 15genera and Blue green algae were represented 3 genera during the sampling conducted in Neap tide in September, 2021. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from45 -155 units/ L during high tide period and 131-182 units/ L during low tide of Neap Tide.

Species Richness Indices and Diversity Indices:

Margalef's diversity index (Species Richness)S

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

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations was varying from 1.801-3.197 with an average of 2.642 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 Harbour region and nearby creeks was varying from 12.458-2.904 with an average of 2.697 during the consecutive low tide period .

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations was varying from 1.808-2.461 with an average of 2.087 during the sampling conducted in High tide period of Neaptide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla Harbour region and nearby creeks was varying from. 1.961-2.882 with an average of 2.371 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 0.771-0.988 (H'(log10)) between selected sampling stations with an average value of 0.934during high tide period of spring tide. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.893-0.932 (H'(log10)) between selected sampling stations with an average value of 0.916 during consecutive lowtide. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.781-0.911 (H'(log10)) between selected sampling stations with an average value of 0.862 during high tide period of neap tide. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.823-0.969 (H'(log10)) between selected sampling stations with an average value of 0.904during consecutive low tide. Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon-Wiener's index increases as both the richness and the evenness of the community increase. This result indicates that diversity of phytoplankton of Kandla Harbour region and nearby creeks is less but with abundant population of few, with relatively few ecological niches and only very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson's diversity index:

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

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks, which was varying from 0.797- 0.882 between selected sampling stations with an average of 0.862 during high tide period of spring tide . Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks, which was varying from 0.845- 0.867 between selected sampling stations with an average of 0.854during consecutive low tide . Low species diversity suggests a relatively few successful species in this habitat. The environment is quite stressful with relatively few ecological niches and only a few organisms are really well adapted to that environment. Any change in the environment would probably have quite serious effects.

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in Kandla Harbour region and nearby creeks, during high tide period and low tide period during neap tide also, which was varying from 0.821-0.857 with an average value of 0.845 between selected sampling stations during high tide period and varying from 0.824-0.870 with an average value of 0.853 between selected sampling stations during consecutive low tide period Low species diversity suggests a relatively few successful species in this habitat.

Table # 4PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS DURING SPRING TIDE IN SEPTEMBER,2021

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H ($\log_{10}$)	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	109	16/21	76.19	3.197	0.9854	0.8739
	2	110	13/21	61.90	2.553	0.9544	0.8754
	3	107	13/21	61.90	2.568	0.9737	0.8824
	4	105	14/21	66.66	2.793	0.9885	0.8811
	5	116	15/21	71.43	2.945	0.9317	0.8627
	6	85	9/21	42.86	1.801	0.7711	0.7978
LOW TIDE	1	103	13/21	61.90	2.589	0.9277	0.8667
	2	132	13/21	61.90	2.458	0.9324	0.8648
	3	124	15/21	71.43	2.904	0.91	0.8451
	4	130	14/21	66.66	2.671	0.8926	0.8458
	5	133	15/21	71.43	2.863	0.9185	0.8479

Table # 5 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS DURING NEAP TIDE IN SEPTEMBER,2021

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H ($\log_{10}$)	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	131	13/18	72.22	2.461	0.881	0.8452
	2	144	12/18	66.66	2.213	0.8693	0.8503
	3	145	10/18	55.55	1.808	0.8678	0.8511
	4	155	11/18	61.11	1.983	0.8653	0.8484
	5	153	12/18	66.66	2.187	0.911	0.8573
	6	42	8/18	44.44	1.873	0.7809	0.8211
LOW TIDE	1	131	11/18	61,11	2.051	0.8234	0.8243
	2	153	12/18	66.66	2.187	0.8951	0.8542
	3	182	16/18	88.88	2.882	0.9697	0.8703
	4	155	15/18	83.33	2.776	0.9374	0.8618
	5	164	11/18	61.11	1.961	0.8971	0.8564

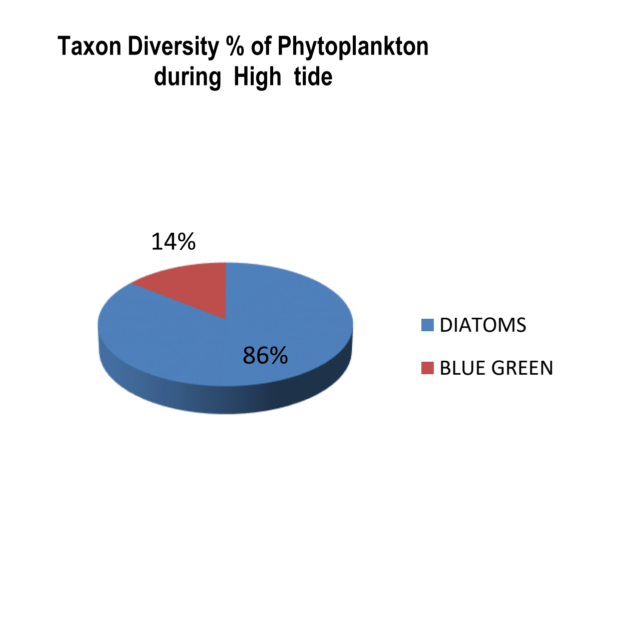
Table # 6 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA, NEAR BY CREEKS DURING SPRING TIDE IN SEPTEMBER, 2021

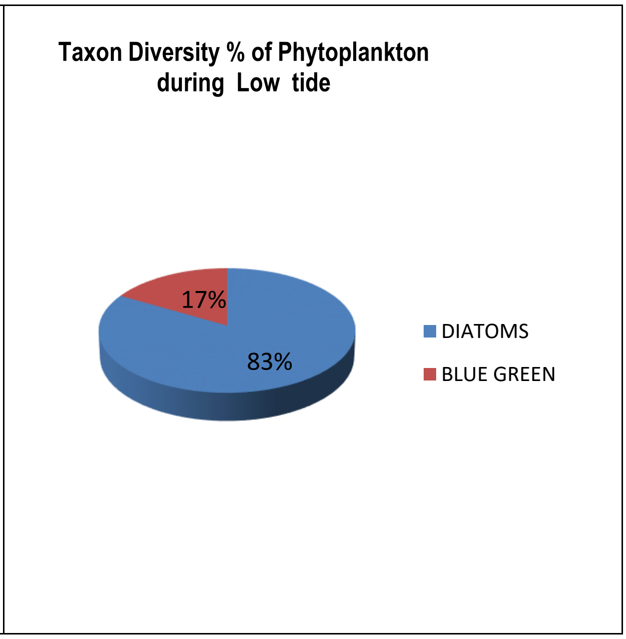
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	DIATOMS	83-110	18/21	85.71
			BLUE GREEN	2-12	3/21	14.29
			TOTAL PHYTO PLANKTON	**85-116**	**21**	-
LOW TIDE	Sub surface	5	DIATOMS	93-129	18/21	85.71
			BLUE GREEN	4-13	3/12	14.29
			TOTAL PHYTO PLANKTON	103-133	**21**	-

Table # 7 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA, NEAR BY CREEKS DURING NEAP TIDE IN SEPTEMBER,2021

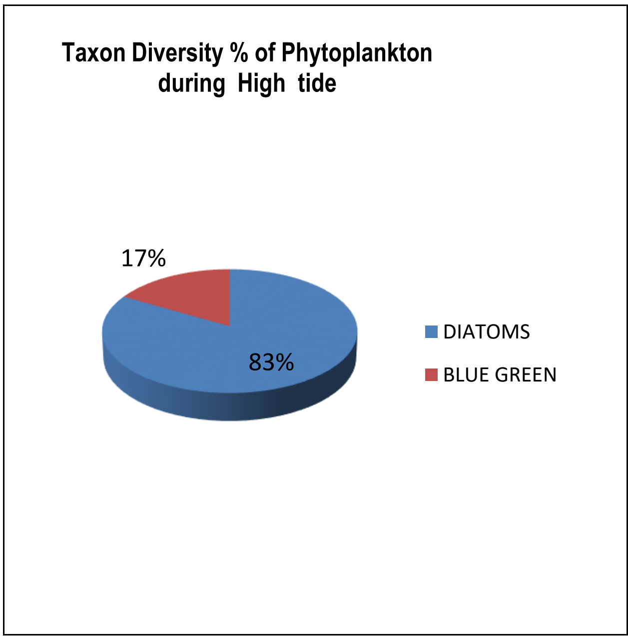
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	DIATOMS	38-154	15/18	83.33
			BLUE GREEN	1-4	3/18	16.67
			TOTAL PHYTO PLANKTON	**42-155**	**18**	-
LOW TIDE	Sub surface	5	DIATOMS	131-177	15/18	83.33
			BLUE GREEN	0-5	3/18	16.67
			TOTAL PHYTO PLANKTON	**131-182**	**18**	-

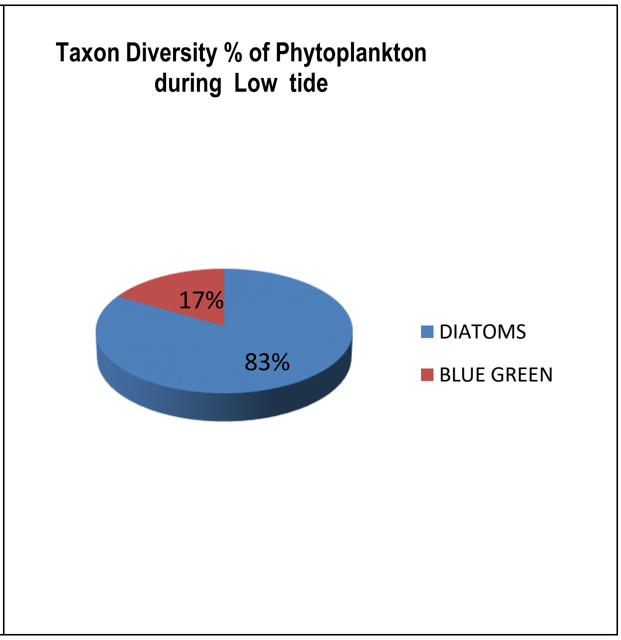
Taxon Diversity % of Phytoplankton during High tide and Low tide period during spring tide





Taxon Diversity % of Phytoplankton during High tide and Low tide period during Neap tide





ZOOPLANKTON POPULATION:

For the evaluation of the Zooplankton population in DPT harbour area and within the immediate surroundings of the port sampling was conducted from 6 sampling locations (3 in harbour area and two in Nakti creek and one in Khori creek) during high tide period and low tide period of spring tide and Neap tide in September,2021. The Zooplankton community of the sub surface water in the harbour and nearby creeks during spring tide was represented by mainly five groups, Tintinids, Copepods, Ciliates ,Foraminiferans and larval forms of Crustacea, Molluscans and Polychaetes. The Zooplankton community of the sub surface water in the harbour and nearby creeks during neap tide was represented by mainly Seven groups, Tintinids, Copepods, Arrow worms , Ciliates ,Mysids,Foraminiferans and larval forms of Crustaceans , Molluscansand Polychaetes,.

Zooplankton of the sampling stations at sub surface layer in the DPT harbour area and nearby creek was varying from 32-86x10^3 N/ m^3 during high tide and 64-100 x103 N/ m^3during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPT harbour area and nearby creek was varying from 43-173 x103 N/ m^3 during high tide and115-184x10^3 N/ m^3during low tide of Neap Tide period.

Species Richness Indices and Diversity Indices:

Margalef's diversity index (Species Richness)S

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

Margalef's diversity index (Species Richness) S of Zooplankton communities in the stations Kandla Harbour region and nearby creeks was varying from 2.825-3.507 with an average of 3.009during the sampling conducted in High tide period.Margalef's diversity index (Species Richness) S of Zooplankton communities varying from. 2.645-3.423 with an average of 3.020 during the sampling conducted in low tide period during Spring tide.

Margalef's diversity index (Species Richness) S of Zooplankton communities in the Kandla Harbour region and nearby creeks sampling stations was varying from3.722- 4.463with an average of 4.061 during the sampling conducted in high tide and varying from. 4.163-4.647 with an average of 4.458 during the sampling conducted in low tide during Neap 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 0.909-1.014 (H'(log10)) between selected sampling stations with an average value of 0.966 (H'(log10)) during high tide period of spring tide. Shannon-

Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.929-0.989(H'(log10)) between selected sampling stations with an average value of 0.963 (H'(log10)) during consecutive low tide period .

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.925-1.248 (H'(log10)) between selected sampling stations with an average value of 1.155 (H'(log10)) during high tide period of Neap tide. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 1.185-1.254 (H'(log10)) between selected sampling stations with an average value of 1.214 (H'(log10)) during 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 Zooplankton of Kandla Harbour region and nearby creeks stations is slightly high with very minimum diverse population but very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson's diversity index:

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

Simpson diversity index (1-D) of Zooplankton communities was below 0.9 most of sampling stations in the Kandla Harbour region and nearby creeksduring high tide and low tide of spring tide period, which was varying from 0.849-0.889between selected sampling stations with an average of 0.872 during high tide period and was varying from 0.845- 0.880 with an average value of 0.868 between selected sampling stations during low tide

Simpson diversity index (1-D) of Zooplankton communities was above 0.9 at all sampling stationsin the Kandla Harbour region and nearby creeks except few during high tide and low tide period, which was varying from 0.834-0.939between selected sampling stations with an average of 0.914 during high tide period and was varying from 0.920- 0.939 with an average value of 0.929 between selected sampling stations during consecutive low tide

This high species diversity suggests a relatively more number of successful species in this habitat during September ,2021 sampling.

Table # 8 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS DURING SPRING TIDE IN SEPTEMBER,2021

Tide	Sampling Station	Abundance In No / 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	72 $X10^3$	16/23	69.56	3.507	0.9864	0.8725
	2	70 $X10^3$	13/23	56.52	2.825	0.9094	0.8584
	3	81 $X10^3$	14/23	60.87	2.958	0.9324	0.8494
	4	82 $X10^3$	15/23	65.22	3.177	1.014	0.8871
	5	86 $X10^3$	14/23	60.87	2.918	1.008	0.8892
	6	32 $X10^3$	12/23	52.17	3.174	0.9456	0.875
LOW TIDE	1	80 $X10^3$	16/23	69.56	3.423	0.9692	0.8661
	2	64 $X10^3$	12/23	52.17	2.645	0.9299	0.873
	3	70 $X10^3$	13/23	56.52	2.825	0.9384	0.8451
	4	82 $X10^3$	14/23	60.87	2.95	0.9894	0.8802
	5	100 $X10^3$	16/23	69.56	3.257	0.9872	0.8772

Table # 9 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS DURING NEAP TIDE IN SEPTEMBER,2021

Tide	Sampling Station	Abundance In No / m^3	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	107 $X10^3$	21/29	72.41	4.28	1.16	0.9185
	2	123 $X10^3$	19/29	65.52	3.741	1.19	0.9315
	3	168 $X10^3$	22/29	75.86	4.098	1.205	0.9328
	4	173 $X10^3$	24/29	82.76	4.463	1.248	0.9389
	5	137 $X10^3$	21/29	72.41	4.065	1.203	0.9342
	6	43 $X10^3$	15/29	51.72	3.722	0.9255	0.8339
LOW TIDE	1	115 $X10^3$	22/29	75.86	4.426	1.185	0.9202
	2	122 $X10^3$	21/29	72.41	4.163	1.19	0.9252
	3	175 $X10^3$	25/29	86.21	4.647	1.254	0.9395
	4	184 $X10^3$	25/29	86.21	4.602	1.23	0.9342
	5	140 $X10^3$	23/29	79.31	4.452	1.21	0.9274

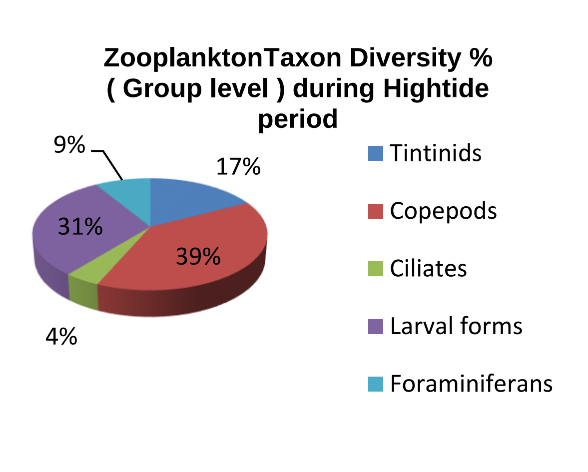
Table # 10 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS DURING SPRING TIDE IN SEPTEMBER,2021

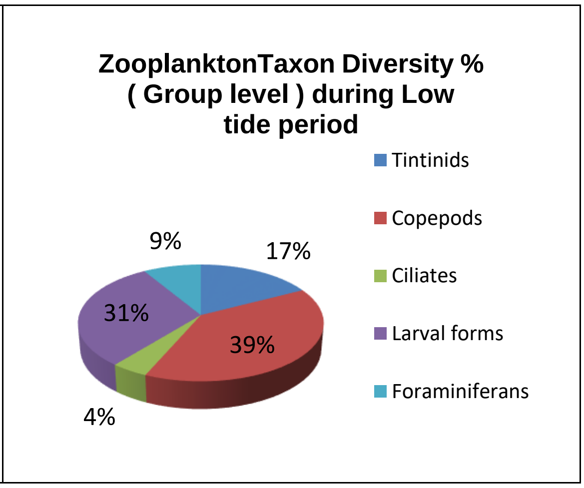
Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^3$ Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinids	0-8	4/23	17.39
			Copepods	16-51	9/23	39.13
			Ciliates	0-1	1/23	4.35
			Larval forms	14-35	7/23	30.44
			Foraminiferans	0-3	2/23	8.69
			TOTAL ZOOPLANKTON NO/L	**32-86**	**23**	**23**
LOW TIDE	Sub surface	5	Tintinids	2-6	4/23	17.39
			Copepods	29-53	9/23	39.13
			Ciliates	0-1	1/23	4.35
			Larval forms	26-39	7/23	30.44
			Foraminiferans	1-4	2/23	8.69
			TOTAL ZOOPLANKTON NO/M3	**64-100**	**23**	**23**

Table # 11 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA, NEAR BY CREEKS DURING NEAP TIDE IN SEPTEMBER, 2021

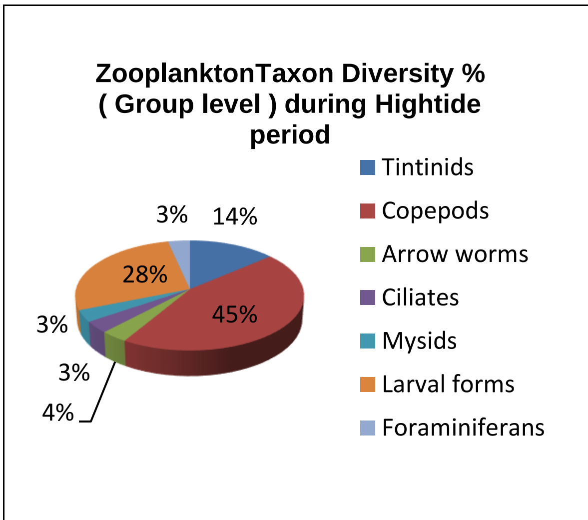
Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^3$ Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinids	1-8	4/29	13.79
			Copepods	17-71	13/29	44.83
			Arrow worms	0-1	1/29	3.45
			Ciliates	1-7	1/29	3.45
			Mysids	0-4	1/29	3.45
			Larval forms	22-87	8/29	27.58
			Foraminiferans	0-2	1/29	3.45
			TOTAL ZOOPLANKTON	**43-173**	**29**	**-**
LOW TIDE	Sub surface	5	Tintinids	2-8	4/29	13.79
			Copepods	38-70	13/29	44.83
			Arrow worms	0-1	1/29	3.45
			Ciliates	3-7	1/29	3.45
			Mysids	1-4	1/29	3.45
			Larval forms	67-106	8/29	27.58
			Foraminiferans	**0-1**	1/29	3.45
			TOTAL ZOOPLANKTON NO/M3	**115-184**	**29**	**-**

Taxon Diversity % of Zooplankton during High tide and Low tide period of Spring tide





Taxon Diversity % of Zooplankton during High tide and Low tide period of Neap tide



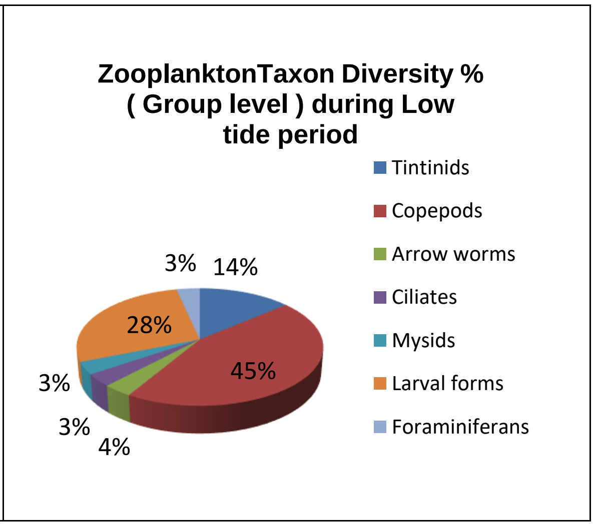


TABLE # 12 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPT HARBOUR AREA AND NEARBY CREEKS DURINGSPRING TIDE OF SEPTEMBER 2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAE	Cyanophyta	Cyanophyceae	Nostocales	Oscillatoriaceae	*Oscillatoria* sp.	B1	Occasional
					Arthrospira sp.	B2	Rare
			Stigonematales	Stigonemataceae	*Stigonema sp.*	B3	Rare
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Thalassiosirales	Thalassiosiraceae	*Planktoniella*sp	D1	Occasional
			Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D2	Abundant
			Triceratiales	Triceratiaceae	*Odontella sp*	D3	Frequent
					Triceratium sp.	D4	Rare
			Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D5	Dominant
			Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D6	Rare
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D7	Rare
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp	D8	Occasional
			Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D9	Abundant
		Bacillariophyceae	Naviculales	Pleurosigmataceae	*Pleurosigma* sp	D10	Rare
					Navicula sp	D11	Rare
			Surirellales	*Surirellaceae*	*Surirella* sp	D12	Rare
		Fragilariophyceae	Thalassionematales	Thalassionemataceae	*Thalassiothrix sp.*	D13	Frequent
					Thalassionema sp.	D14	Rare
			Fragilariales	Fragilariaceae	*Asterionellopsis sp.*	D15	Rare
					Fragilaria sp	D16	Occasional
					*Synedra*sp	D17	Rare
			Tabellariales	Tabellariaceae	*Tabellaria* sp	D18	Rare

TABLE # 13 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPT HARBOUR AREA AND NEARBY CREEKS DURING AND NEAP TIDE OF SEPTEMBER,2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAE	Cyanophyta	Cyanophyceae	Nostocales	Oscillatoriaceae	*Oscillatoria* sp.	B1	Rare
					Arthrospira sp.	B2	Rare
			Stigonematales	Stigonemataceae	*Stigonema sp.*	B3	Occasional
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Thalassiosirales	Thalassiosiraceae	*Planktoniella*sp	D1	Rare
			Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D2	Abundant
			Triceratiales	Triceratiaceae	*Odontella sp*	D3	Frequent
					Triceratium sp.	D4	Occasional
			Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D5	Dominant
			Hemiaulales	Bellerocheaceae	*Bellerochea* sp	D6	Occasional
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros* sp	D7	Rare
			Lithodesmiales	Lithodesmiaceae	*Ditylum sp*	D8	Abundant
		Bacillariophyceae	Naviculales	Pleurosigmataceae	*Pleurosigma* sp	D9	Occasional
		Fragilariophyceae	Thalassionematales	Thalassionemataceae	*Thalassiothrix sp.*	D10	Abundant
					Thalassionema sp.	D11	Rare
			Fragilariales	Fragilariaceae	*Asterionellopsis sp.*	D12	Rare
					Fragilaria sp	D13	Occasional
					*Synedra*sp	D14	Frequent
			Tabellariales	Tabellariaceae	*Tabellaria* sp	D15	Rare

TABLE #14 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS IN DPT HARBOUR AREA, AND NEAR BY CREEKS DURING SPRING TIDE OF SEPTEMBER,2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnus sp.*	T1	Rare
				Codonellidae	*Tintinnopsis gracilis*	T2	Occasional
					Tintinnopsis radix	T3	Rare
					Tintinnopsis tocantinensis	T4	Rare
COPEPODS	ATHROPODA	Crustacea Sub class copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Abundant
				Eucalanidae	*Pareucalanus sp.*	C2	Rare
				Clausocalanidae	*Clausocalanus sp.*	C3	Occasional
				Acartiidae	*Acartia sp.*	C4	Rare
				Temoridae	*Temora sp.*	C5	Occasional
			Cyclopoida	Oithonidae	*Oithona sp.*	C6	Frequent
			Harpacticoida	Ectinosomatidae	*Microsetella* sp.	C7	Frequent
				Euterpinidae	*Euterpina sp.*	C8	Rare
			Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C9	Rare
CILIATES	CILIOPHORA	Oligohymenophorea	Sessilida	Zoothamniidae	*Zoothamnium sp.*	CI1	Rare
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of Copepods	L1	Dominant
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of Bivalves	L2	Occasional
POLYCHAETE LARVAE	ANNELIDA	Polychaeta			Trochophore larvae	L3	Rare
BARNACLE LARVAE	ATHROPODA CRUSTACEA	Maxillopoda Thecostraca			Cirripede larvae	L4	Rare
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda,Streptoneura			Opisthobranchia larvae	L5	Occasional
CYPHONAUTES LARVAE	BRYOZOA				Cyphonautes larvae	L6	Rare
BRACHYURA LARVAE	ARTHROPODA (CRUSTACEA)	Malacostraca Decapoda			Brachyuran Zoea larvae	L7	Rare
FORAMINIFERA	FORAMINIFERA	Globothalamea	Rotaliida	Globigerinidae	*Globigerina* sp.	F1	Rare
				Rotalliidae	*Rotalia* sp.	F2	Rare

TABLE # 15 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS IN DPT HARBOUR AREA, AND NEAR BY CREEKS DURING NEAP TIDE OF SEPTEMBER,2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnus sp.*	T1	Rare
				Codonellidae	*Tintinnopsis gracilis*	T2	Occasional
					Tintinnopsis radix	T3	Rare
					Tintinnopsis failakkaensis	T4	Rare
COPEPODS	ATHROPODA	Crustacea Sub class copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Frequent
					Parvocalanus sp.	C2	Rare
				Eucalanidae	*Pareucalanus sp.*	C3	Rare
					Subeucalanus sp.	C4	Rare
				Clausocalanidae	*Clausocalanus sp.*	C5	Occasional
				Centropagidae	*Centropages sp.*	C6	Rare
				Tortanidae	*Tortanus sp.*	C7	Rare
				Acartiidae	*Acartia sp.*	C8	Frequent
				Temoridae	*Temora sp.*	C9	Occasional
			Cyclopoida	Oithonidae	*Oithona sp.*	C10	Abundant
			Harpacticoida	Ectinosomatidae	*Microsetella* sp.	C11	Frequent
				Euterpinidae	*Euterpina sp.*	C12	Occasional
			Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C13	Rare
ARROW WORMS	CHAETOGNATHA	Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Rare
CILIATES	CILIOPHORA	Oligohymenophorea	Sessilida	Zoothamniidae	*Zoothamnium sp.*	CI1	Occasional
MYSIDS	ATHROPODA CRUSTACEA	Malacostraca	Mysida, Decapoda	Penaeidae	*Penaeus sp.*	M1	Occasional
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of Copepods	L1	Dominant
BRACHYURA LARVAE	ARTHROPODA (CRUSTACEA)	Malacostraca Decapoda			Brachyuran Zoea larvae	L2	Abundant

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
BARNACLE LARVAE	ATHROPODA CRUSTACEA	Maxillopoda Thecostraca			Cirripede larvae	L3	Frequent
CYPHONAUTES LARVAE	BRYOZOA				Cyphonautes larvae	L4	Occasional
ECHINODERMATA LARVAE	ECHINODERMATA				Ophipluutes larvae/ Echinoplutes larvae	L5	Occasional
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L6	Occasional
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of Bivalves	L7	Frequent
POLYCHAETE LARVAE	ANNELIDA	Polychaeta			Trochophore larvae	L8	Frequent
FORAMINIFERA	FORAMINIFERA	Globothalamea	Rotaliida	Rotalliidae	*Rotalia* sp.	F1	Rare

BENTHIC ORGANISMS:

Few Benthic organismswere observed in the collected sediments by using the Van-veen grabs during the sampling conducted during spring tide period and while no benthic organisms were observed during sampling conducted in Neap tide period from DPT harbour region and nearby creek except few dead shells.The meiobenthic organisms during spring tide were represented by Polychaetes,and Nematodes. The polychaetes were represented by *Scyphoproctus sp*. and *Branchiocapitelida* sps*,*during spring tide sampling*.* The meiobenthic organisms in the collected samples were varying from 0-80N/M ^{2}.

Table # 16 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPT HARBOUR AREA CREEKS DURING SPRING TIDE IN SEPTEMBER ,2021

Benthic fauna	ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS REPRESENTATION BY GROUP						
	DPT HARBOUR			CREEKS			
POLYCHAETES	KPT-1	KPT-2	KPT-3	KPT-4	KPT-5	KPT-6	
Family : Capitellidae **Scyphoproctus** *sp.*	40	0	0	0	0	NS	
Family : Capitellidae **Branchiocapitelida** *sp.*	0	20	0	0	0		
Total Polychates N/M^2	40	20	0	00	0	NS	
Un identified Nematode worms	40	20	0	10	0	NS	
TOTAL Benthic Fauna NUMBER/ M^2	80	40	0	10	0	-	

NS : No sample

7. Meteorological Data

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

Temperature

The mean day time temperature for Deendayal Port was 29.0 °C. The day-time maximum temperature was 36.2 °C. The mean night time temperature was 26.7 °C. The minimum mean night time temperature recorded was 29.4 °C.

Air Pressure

The mean absolute air pressure for the month of September was 1003.7 hpa, whereas the mean relative pressure was 1002.3 hpa. The maximum absolute air pressure recorded for the month of September was 1010.1 hpa.

Heat Index

The mean day-time heat index for the month of September was 33.5 ^{o}C. The maximum heat index recorded was 49^{o}C.

Solar Radiation

The mean Solar Radiation in September was 136.4 w/m^2. The maximum solar radiation recorded in the month of September was 808.9 w/m^2.

Humidity

The mean day-time humidity was 83.5 % for the month of September and mean night time humidity was 98.0%. Maximum humidity recorded during day-time was 90.3 % and maximum humidity recorded during night-time was 96.0%.

Wind Velocity and Wind Direction

The mean wind velocity for the entire month of September was 6.88 km/hour. Maximum wind velocity recorded was 43.2 Km/hr . The wind direction was mostly S to SW.

Conclusive Summary and Remedial measures Suggested

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

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

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

- The sewage treated water of Deendayal Port Colony (Gopalpuri) was in line with the standards set by the Gujarat Pollution Control Board. The STP at Deendayal Port is not fully operational and STP at Vadinar Port was found non-operational.

Reasons for higher Values of PM_{10}

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

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

Remedial Measures

The values of PM_{10} during the month of September, 2021 were observed beyond the permissible limit at four locations mentioned above. Given below are the remedial measures suggest to minimize the Air pollution at Deendayal Port.

- Guidelines for Coal Handling by GPCB should be strictly followed. (http://gpcb.gov.in/pdf/coal-handling-guidelines.pdf)
- Except for the higher values of PM_{10} at Coal storage site, Oil Jetty, Tuna Port and Marine Bhavan locations, the monitoring results for the present month suggest that the overall Environment Quality of Deendayal Port is satisfactory.

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ENVIRONMENTAL MONITORING REPORT
FOR
DEENDAYAL PORT TRUST

REPORT NO.	:	DCPL/DPT/20-21/18
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Prepared by	:	DETOX CORPORATION PVT. LTD., SURAT

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Introduction

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

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

1. Ambient Air Quality Monitoring

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

1.1 Air Quality Monitoring Methodology

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

The AAQ samples are collected twice a week from all the eight locations as per the EMP.

1.2 Results

The ambient air quality monitoring data for six stations, viz. Marine Bhavan, Oil Jetty, Port Colony,Gopalpuri Hospital,Tuna Port and Nr. Coal Storage Area for the month of October 2021 are given in Tables 1A to 6B. The ambient air quality monitoring data for two stations at Vadinar (Nr. Admin Building &Nr. Signal Building) are given in Tables 7A to 8B.

Location 1: Marine Bhavan (AL1)

Table 1 : Results of Air Pollutant Concentration at Marine Bhavan

Parameter	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period	-	24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit	-	NS	100 µg/m3	60 µg/m3		80 µg/m3		80 µg/m3		400 µg/m3
AL1 – 1	06.10.2021	349	165	80	2.20	2.64	26.04	25.19	12.76	13.44
					3.96		24.14		12.25	
					1.76		25.41		15.32	
AL1 – 2	08.10.2021	474	229	103	4.40	3.22	15.24	19.27	12.51	13.02
					3.08		16.51		13.02	
					2.20		26.04		13.53	
AL1 – 3	13.10.2021	280	162	58	7.47	7.33	28.58	26.04	10.72	10.81
					8.79		31.12		12.51	
					5.71		18.42		9.19	
AL1 – 4	15.10.2021	404	227	95	3.08	2.49	16.51	15.24	13.79	14.89
					2.64		13.97		15.83	
					1.76		15.24		15.06	
AL1 – 5	20.10.2021	336	156	73	3.52	3.96	18.42	20.54	5.87	9.28
					4.84		20.96		10.72	
					3.52		22.23		11.23	
AL1 - 6	22.10.2021	453	267	85	2.64	3.52	15.88	15.67	10.72	6.47
					5.28		19.69		5.62	
					2.64		11.43		3.06	
AL1 - 7	27.10.2021	338	163	76	3.52	3.37	12.07	16.73	10.47	10.55
					3.96		20.96		11.49	
					2.64		17.15		9.70	
AL1 – 8	29.10.2021	275	152	88	2.64	3.08	24.14	25.19	12.51	9.02
					2.20		29.22		6.64	
					4.40		22.23		7.91	
Monthly Average		364	190	82		3.70		20.48		10.93
Standard Deviation		74	44	14		1.54		4.50		2.75

NS: Not Specified

Table 1B : Results of Air Pollutant Concentration at Marine Bhavan					
Parameter	**Date**	**C_6H_6 [µg/m³]**	**HC* ppm**	**CO [mg/m³]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m³**	**NS**	**4.0 mg/m³**	**NS**
AL1 – 1	06.10.2021	1.12	BQL	1.89	492
AL1 – 2	08.10.2021	1.11	BQL	1.75	489
AL1 – 3	13.10.2021	1.32	BQL	1.82	499
AL1 – 4	15.10.2021	1.15	BQL	1.76	492
AL1 – 5	20.10.2021	1.13	BQL	1.84	493
AL1 - 6	22.10.2021	1.15	BQL	1.86	501
AL1 – 7	27.10.2021	1.21	BQL	1.88	488
AL1 – 8	29.10.2021	1.13	BQL	1.95	511
Monthly Average		**1.17**	**-**	**1.84**	**496**
Standard Deviation		**0.07**	**-**	**0.07**	**8**

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

At Marine Bhavan, the overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_X and NH_3 is attributed mainly by motor vehicle emission produced from various types of automobiles (both diesel and petrol driven). Moreover, the loading and unloading of Food Grains and Timber at Jetty no. 1 and 2 also contributes to the high levels of TSPM and PM_{10}. The mean TSPM value at Marine Bhavan was 364 µg/m³, The mean PM_{10} values were 190.0 µg/m³, which is above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean = 82 µg/m³). The average values of SO_2, NO_x and NH_3 were within the permissible limit. The average values of SO_2, NO_x and NH3 were 3.70 µg/ m³, 20.48 µg/ m³ & 10.93 µg/ m³ respectively. These were within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Marine Bhavan. The mean Benzene concentration was 1.17 µg/m³, well below the permissible limit of 5.0 µg/m³. HC's were below the detectable limit and Carbon Monoxide concentration was 1.84 mg/m³, well below the permissible limit of 4.0 mg/m³.

Location 2: Oil Jetty (AL2)

Table 2 : Results of Air Pollutant Concentration at Oil Jetty										
Parameters	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period	-	24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit	-	NS	100 µg/m3	60 µg/m3	-	80 µg/m3	-	80 µg/m3	-	400 µg/m3
AL2 – 1	06.10.2021	380	162	82	4.40	5.28	33.66	33.66	8.93	9.96
					5.28		36.84		10.21	
					6.15		30.49		10.72	
AL2 – 2	08.10.2021	486	284	103	1.76	3.96	8.89	11.01	6.38	9.62
					4.84		9.53		10.98	
					5.28		14.61		11.49	
AL2 – 3	13.10.2021	451	300	89	7.47	9.52	32.39	24.35	3.57	6.30
					9.23		18.42		6.13	
					11.87		22.23		9.19	
AL2 – 4	15.10.2021	480	335	100	2.20	2.05	16.51	14.82	7.40	8.93
					2.64		14.61		10.47	
					1.32		13.34		8.93	
AL2 – 5	20.10.2021	464	190	76	2.64	2.49	20.33	19.48	9.19	7.32
					1.76		24.77		4.85	
					3.08		13.34		7.91	
AL2 – 6	22.10.2021	509	280	100	4.84	5.28	20.96	14.82	5.62	8.00
					7.03		10.16		7.91	
					3.96		13.34		10.47	
AL2 – 7	27.10.2021	448	215	71	1.76	1.76	22.87	19.48	9.19	10.04
					1.32		14.61		12.51	
					2.20		20.96		8.42	
AL2 – 8	29.10.2021	504	204	92	1.32	2.49	14.61	17.36	6.38	9.10
					2.20		22.87		9.96	
					3.96		14.61		10.98	
Monthly Average		465	246	89		4.10		19.37		8.66
Standard Deviation		41	61	12		2.59		7.01		1.34

NS: Not Specified

Table 2B : Results of Air Pollutant Concentration at Oil Jetty					
Parameter	**Date**	**C_6H_6 [µg/m^3]**	**HC* ppm**	**CO [mg/m^3]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m^3**	**NS**	**4.0 mg/m^3**	**NS**
AL2 -1	06.10.2021	1.11	BQL	1.88	499
AL2 -2	08.10.2021	1.21	BQL	1.78	495
AL2 -3	13.10.2021	1.26	BQL	1.86	468
AL2 -4	15.10.2021	1.11	BQL	1.83	466
AL2 – 5	20.10.2021	1.22	BQL	1.89	458
AL2 – 6	22.10.2021	1.18	BQL	1.87	488
AL2 -7	27.10.2021	1.01	BQL	1.77	498
AL2 – 8	29.10.2021	1.14	BQL	1.82	501
Monthly Average		**1.16**	**-**	**1.84**	**484**
Standard Deviation		**0.08**	**-**	**0.05**	**17**

* NMHC- Non- Methane Hydrocarbons

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

NS- Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Oil Jetty area was mainly by motor vehicle emission produced from various types of vehicles Oil Jetty Area. The mean TSPM values at Oil Jetty were 465 µg/m^3 .The mean PM_{10} values were 246 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean = 89 µg/m^3).The average values of SO_2, NO_x and NH_3 were within the permissible limit, The mean concentration of SO_2, NO_x and NH3 were 4.10 µg/m^3, 19.37 µg/m^3 and 8.66 µg/m^3 respectively.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Oil Jetty. The mean Benzene concentration was 1.16 µg/m^3 .Well below the permissible limit of 5.0 µg/m^3. , HC's were below the detectable limit and Carbon Monoxide concentration was 1.84 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

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

Table 3 : Results of Air Pollutant Concentration at Estate Office										
Parameters	**Date**	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period	-	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit	-	**NS**	**100 µg/m3**	**60 µg/m3**	-	**80 µg/m3**	-	**80 µg/m3**	-	**400 µg/m3**
AL3 – 1	06.10.2021	355	161	79	4.84	3.37	12.70	23.08	14.30	12.00
					3.52		24.14		12.25	
					1.76		32.39		9.45	
AL3 – 2	08.10.2021	280	121	76	3.96	2.64	13.34	12.49	10.47	9.10
					1.32		9.53		11.49	
					2.64		14.61		5.36	
AL3 – 3	13.10.2021	420	282	98	3.08	3.52	13.97	19.48	7.91	5.87
					4.84		19.69		6.38	
					2.64		24.77		3.32	
AL3 – 4	15.10.2021	530	287	101	4.40	2.93	8.89	8.05	12.25	9.10
					2.64		8.26		9.19	
					1.76		6.99		5.87	
AL3 – 5	20.10.2021	401	239	98	5.28	3.66	18.42	23.50	8.93	9.19
					3.08		32.39		9.70	
					2.64		19.69		8.93	
AL3 – 6	22.10.2021	381	244	93	5.28	4.40	18.42	19.27	10.47	8.25
					1.76		14.61		8.93	
					6.15		24.77		5.36	
AL3 – 7	27.10.2021	466	194	90	4.84	2.93	19.69	17.36	11.23	10.81
					2.64		16.51		10.72	
					1.32		15.88		10.47	
AL3 – 8	29.10.2021	380	222	87	1.76	2.93	15.88	16.94	12.00	9.10
					4.40		15.24		9.70	
					2.64		19.69		5.62	
Monthly Average		402	219	90		3.30		17.52		9.18
Standard Deviation		74	58	9		0.56		5.20		1.79

NS: Not Specified

Table 3B : Results of Air Pollutant Concentration at Kandla Port Colony					
Parameter	**Date**	**C_6H_6 [µg/m^3]**	**HC***	**CO [mg/m^3]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m^3**	**NS**	**4.0 mg/m^3**	**NS**
AL3 -1	06.10.2021	1.01	BQL	1.85	489
AL3 -2	08.10.2021	1.12	BQL	1.98	496
AL3 -3	13.10.2021	1.02	BQL	1.79	488
AL3 -4	15.10.2021	1.11	BQL	1.81	499
AL3 – 5	20.10.2021	1.06	BQL	1.88	480
AL3 – 6	22.10.2021	1.18	BQL	1.79	485
AL3 – 7	27.10.2021	1.26	BQL	1.96	472
AL3 – 8	29.10.2021	1.14	BQL	1.88	498
Monthly Average		**1.11**	**-**	**1.87**	**488**
Standard Deviation		**0.08**	**-**	**0.07**	**9**

* NMHC- Non- Methane Hydrocarbons

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

NS- Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Kandla Port Colony was attributed by vehicle emission produced from trucks and heavy duty vehicles that pass through the road outside Kandla Port Colony. The mean TSPM values at Oil Jetty were 402 µg/m^3, The mean PM_{10} values were 219 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean = 90 µg/m^3). The average values of SO_2, NO_x and NH3 were 3.30 µg/m^3, 17.52 µg/m^3 and 9.18 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Kandla Port Colony. The mean Benzene concentration was 1.11 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.87 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 4: Gopalpuri Hospital (AL-4)

Table 4 : Results of Air Pollutant Concentration at Gopalpuri Hospital										
Parameter	**Date**	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period	-	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit	-	**NS**	**100 µg/m3**	**60 µg/m3**	-	**80 µg/m3**	-	**80 µg/m3**	-	**400 µg/m3**
AL4 -1	06.10.2021	158	96	40	6.15	4.40	18.42	25.83	3.83	5.87
					3.96		25.41		7.40	
					3.08		33.66		6.38	
AL4 -2	08.10.2021	246	115	77	3.96	5.28	12.70	10.37	4.85	5.70
					5.28		9.53		5.11	
					6.59		8.89		7.15	
AL4 -3	13.10.2021	302	129	66	2.20	2.64	10.16	11.22	3.83	4.25
					3.08		12.70		4.85	
					2.64		10.80		4.08	
AL4 -4	15.10.2021	414	267	89	2.20	2.20	10.16	8.68	6.38	5.45
					2.64		9.53		4.60	
					1.76		6.35		5.36	
AL4 – 5	20.10.2021	268	128	90	2.64	2.64	14.61	14.61	4.85	6.64
					3.08		9.53		8.42	
					2.20		19.69		6.64	
AL4 – 6	22.10.2021	219	114	93	2.64	2.49	13.34	12.49	4.85	8.51
					3.08		9.53		9.19	
					1.76		14.61		11.49	
AL4 – 7	27.10.2021	274	132	84	2.64	3.08	17.78	15.88	6.38	6.55
					3.08		13.34		7.91	
					3.52		16.51		5.36	
AL4 – 8	29.10.2021	311	142	96	2.20	3.22	13.34	12.70	7.40	8.25
					3.52		13.97		8.42	
					3.96		10.80		8.93	
Monthly Average		274	140	79		3.24		13.97		6.40
Standard Deviation		75	53	18		1.06		5.30		1.43

NS: Not Specified

Table 4B : Results of Air Pollutant Concentration at Gopalpuri Hospital					
Parameter	Date	C_6H_6 [µg/m^3]	HC*	CO [mg/m^3]	CO_2 [ppm]
Sampling Period		8 hr	Grab Sampling	Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m^3	NS	4.0 mg/m^3	NS
AL4 -1	06.10.2021	1.02	BQL	1.88	496
AL4 -2	08.10.2021	1.11	BQL	1.68	482
AL4 -3	13.10.2021	1.32	BQL	1.65	501
AL4 -4	15.10.2021	1.25	BQL	1.79	499
AL4 – 5	20.10.2021	1.52	BQL	1.65	501
AL4 – 6	22.10.2021	1.32	BQL	1.82	508
AL4 – 7	27.10.2021	1.23	BQL	1.7	487
AL4 – 8	29.10.2021	1.58	BQL	1.76	496
Monthly Average		**1.29**	**-**	**1.74**	**496**
Standard Deviation		**0.19**	**-**	**0.08**	**8**

* NMHC- Non- Methane Hydrocarbons

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

NS-Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Gopalpuri Hospital was attributed by vehicle emission produced from light motor vehicles of the colony residents. The mean TSPM values at Oil Jetty were 274 µg/m^3, The mean PM_{10} values were 140 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean= 79 µg/m^3). The average values of SO_2, NO_x and NH_3 were 3.24 µg/m^3, 13.97 µg/m^3 and 6.40 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Gopalpuri Hospital. The mean Benzene concentration was 1.29 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.74 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 5: Coal Storage Area (AL-5)

Table 5 : Results of Air Pollutant Concentration at Coal Storage Area

Parameters	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period	-	24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit	-	NS	100 µg/m3	60 µg/m3	-	80 µg/m3	-	80 µg/m3	-	400 µg/m3
AL5 – 1	06.10.2021	266	122	92	4.40	5.71	44.46	49.33	15.32	14.04
					6.15		49.54		13.53	
					6.59		53.99		13.27	
AL5 – 2	08.10.2021	360	208	79	3.96	3.96	20.33	18.84	15.57	16.25
					2.64		22.23		17.61	
					5.28		13.97		15.57	
AL5 – 3	13.10.2021	647	226	110	10.11	8.65	22.23	22.87	7.91	7.32
					6.15		26.04		6.13	
					9.67		20.33		7.91	
AL5 – 4	15.10.2021	760	217	118	1.32	2.93	16.51	18.84	12.51	9.62
					3.52		19.69		8.42	
					3.96		20.33		7.91	
AL5 – 5	20.10.2021	597	244	110	4.84	4.25	19.69	20.75	10.72	11.32
					4.40		17.78		10.98	
					3.52		24.77		12.25	
AL5 – 6	22.10.2021	647	206	106	3.52	4.54	14.61	17.15	14.30	14.47
					3.96		15.88		15.06	
					6.15		20.96		14.04	
AL5 – 7	27.10.2021	614	249	107	4.40	4.25	13.34	16.51	9.96	9.36
					4.84		17.78		9.19	
					3.52		18.42		8.93	
AL5 – 8	29.10.2021	324	151	117	4.84	4.10	22.87	25.41	12.51	14.04
					3.96		27.95		14.30	
					3.52		25.41		15.32	
Monthly Average		527	203	105		4.80		23.71		12.05
Standard Deviation		182	44	13		1.73		10.76		3.11

NS: Not Specified

Table 5B : Results of Air Pollutant Concentration at Coal Storage Area					
Parameter	**Date**	**C_6H_6 [µg/m³]**	**HC***	**CO [mg/m³]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m³**	**NS**	**4.0 mg/m³**	**NS**
AL5 – 1	06.10.2021	1.22	BQL	1.85	498
AL5 – 2	08.10.2021	1.32	BQL	1.86	488
AL5 – 3	13.10.2021	1.22	BQL	1.89	485
AL5 – 4	15.10.2021	1.16	BQL	1.84	501
AL5 – 5	20.10.2021	1.33	BQL	1.86	496
AL5 – 6	22.10.2021	1.24	BQL	1.9	500
AL5 – 7	27.10.2021	1.15	BQL	1.84	490
AL5 – 8	29.10.2021	1.18	BQL	1.98	498
Monthly Average		**1.23**	**-**	**1.88**	**495**
Standard Deviation		**0.07**	**-**	**0.05**	**6**

* NMHC- Non- Methane Hydrocarbons

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

NS-Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Coal Storage Area was comparatively highest among all the locations of Air Quality monitoring in Kandla Port. High values of TSPM, $PM_{10,}$ $PM_{2.5}$, SO_2, NO_X at this location was due to lifting of coal with grab and other coal handling processes near Berth no. 6 & 7. Moreover, the traffic was also heavy around this place for transport of coal thus emissions produced from heavy vehicles. The mean TSPM values at Coal storage were 527µg/m³. The mean PM_{10} values were 203 µg/m³, which is well above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean = 105 µg/m³). The average values of SO_2, NO_x and NH_3 were 4.80 µg/m³, 23.71 µg/m³ and 12.05 µg/m³ respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Coal Storage Area. The mean Benzene concentration was 1.23 µg/m³, well below the permissible limit of 5.0 µg/m³. HC's were below the detectable limit and Carbon Monoxide concentration was 1.88 mg/m³, well below the permissible limit of 4.0 mg/m³.

Location 6: Tuna Port (AL-6)

Table 6 : Results of Air Pollutant Concentration at Tuna Port											
Parameters	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]		
Sampling Period	-	24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	
NAAQMS limit	-	NS	100 µg/m3	60 µg/m3	-	80 µg/m3	-	80 µg/m3	-	400 µg/m3	
AL6 -1	06.10.2021	280	134	98	4.40	4.10	15.88	29.85	5.62	7.40	
					6.15		33.66		7.66		
					1.76		40.02		8.93		
AL6 – 2	08.10.2021	293	130	92	1.76	3.22	13.34	12.49	13.53	11.49	
					3.08		13.97		12.25		
					4.84		10.16		8.68		
AL6 – 3	13.10.2021	438	251	103	6.15	4.69	16.51	16.94	6.38	5.96	
					5.71		20.96		4.08		
					2.20		13.34		7.40		
AL6 – 4	15.10.2021	466	153	100	2.20	1.76	5.08	6.78	5.62	6.47	
					1.76		8.26		7.15		
					1.32		6.99		6.64		
AL6 – 5	20.10.2021	480	180	94	1.32	2.64	20.33	16.94	12.25	11.57	
					2.64		13.97		11.49		
					3.96		16.51		10.98		
AL6 – 6	22.10.2021	310	123	88	4.84	3.22	32.39	27.31	9.96	12.76	
					2.20		20.96		15.57		
					2.64		28.58		12.76		
AL6 – 7	27.10.2021	275	140	93	2.20	2.49	15.24	15.88	9.19	9.36	
					1.76		16.51		8.42		
					3.52		15.88		10.47		
AL6 – 8	29.10.2021	352	191	98	2.20	2.93	15.88	15.03	10.72	10.30	
					2.64		10.80		8.93		
					3.96		18.42		11.23		
Monthly Average		362	163	96		3.13		17.65		9.41	
Standard Deviation		86	43	5		0.92		7.54		2.55	

NS: Not Specified

Table 6B : Results of Air Pollutant Concentration at Tuna Port					
Parameter	**Date**	**C_6H_6 [µg/m^3]**	**HC***	**CO [mg/m^3]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m^3**	**NS**	**4.0 mg/m^3**	**NS**
AL6 -1	06.10.2021	1.03	BQL	1.79	510
AL6 – 2	08.10.2021	1.11	BQL	1.84	502
AL6 – 3	13.10.2021	1.14	BQL	1.72	511
AL6 – 4	15.10.2021	1.11	BQL	1.69	496
AL6 – 5	20.10.2021	1.18	BQL	1.88	499
AL6 – 6	22.10.2021	1.06	BQL	1.87	502
AL6 – 7	27.10.2021	1.10	BQL	1.74	506
AL6 – 8	29.10.2021	1.01	BQL	1.7	512
Monthly Average		**1.09**	**-**	**1.78**	**505**
Standard Deviation		**0.06**	**-**	**0.08**	**6**

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

The mean TSPM values at Tuna Port were 362 µg/m^3, The mean PM_{10} values were 163 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean = 96 µg/m^3). The average values of SO_2, NO_x and NH_3 were 3.13 µg/m^3, 17.65 µg/m^3 and 9.41 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Tuna Port. The mean Benzene concentration was 1.09 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.78 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

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

Table 7 : Results of Air Pollutant Concentration at Signal Building										
Parameters	**Date**	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period	-	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit	-	**NS**	**100 µg/m3**	**60 µg/m3**	-	**80 µg/m3**	-	**80 µg/m3**	-	**400 µg/m3**
AL7 -1	06.10.2021	115	73	30	4.40	3.52	19.69	18.63	6.89	6.21
					3.52		22.23		6.38	
					2.64		13.97		5.36	
AL7 -2	08.10.2021	111	62	34	3.96	2.78	16.51	16.94	8.42	8.42
					1.76		20.33		6.13	
					2.64		13.97		10.72	
AL7 -3	13.10.2021	198	107	52	3.08	3.08	16.51	16.51	4.60	5.45
					3.96		23.50		5.11	
					2.20		9.53		6.64	
AL7 -4	15.10.2021	146	72	50	3.96	4.40	15.24	12.91	7.91	7.06
					5.28		11.43		9.96	
					3.96		12.07		3.32	
AL7 -5	20.10.2021	171	85	44	3.08	2.64	8.89	9.32	6.89	7.23
					2.20		8.26		8.93	
					2.64		10.80		5.87	
AL7 -6	22.10.2021	178	88	71	3.08	4.54	14.61	12.49	8.42	8.17
					4.84		9.53		8.68	
					5.71		13.34		7.40	
AL7 -7	27.10.2021	160	80	52	3.08	3.81	6.35	11.22	10.98	8.25
					2.64		15.24		5.36	
					5.71		12.07		8.42	
AL7 -8	29.10.2021	177	89	56	2.20	3.52	9.53	10.16	8.42	5.96
					3.96		12.07		3.32	
					4.40		8.89		6.13	
Monthly Average		157	82	49		3.5		13.5		7.1
Standard Deviation		31	14	13		0.7		3.4		1.1

NS: Not Specified

Table 7B : Results of Air Pollutant Concentration at Signal Building					
Parameter	Date	C_6H_6 [µg/m³]	HC*	CO [mg/m³]	CO_2 [ppm]
Sampling Period		8 hr	Grab Sampling	Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m³	NS	4.0 mg/m³	NS
AL7 -1	06.10.2021	1.10	BQL	1.71	466
AL7 – 2	08.10.2021	1.13	BQL	1.62	488
AL7 – 3	13.10.2021	1.06	BQL	1.66	479
AL7 – 4	15.10.2021	1.11	BQL	1.72	480
AL7 – 5	20.10.2021	1.16	BQL	1.59	486
AL7 – 6	22.10.2021	1.17	BQL	1.66	477
AL7 – 7	27.10.2021	1.04	BQL	1.79	468
AL7 – 8	29.10.2021	1.10	BQL	1.64	470
Monthly Average		**1.11**	**-**	**1.67**	**477**
Standard Deviation		**0.04**	**-**	**0.06**	**8**

*

*NMHC- Non- Methane Hydrocarbons

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

NS_ Not Specified

The mean TSPM values at Vadinar Port were 157 µg/m³. The mean PM_{10} values were 82 µg/m³, which is below the permissible limit. $PM_{2.5}$ values were also within the permissible limit (mean = 49 µg/m³). The average values of SO_2, NO_x and NH_3 were 3.5 µg/m³, 13.5 µg/m³ and 7.1 µg/m³ respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Vadinar Port. The mean Benzene concentration was 1.11 µg/m³, well below the permissible limit of 5.0 µg/m³. HC's were below the detectable limit and Carbon Monoxide concentration was 1.67 mg/m³, well below the permissible limit of 4.0 mg/m³.

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

Table 8 : Results of Air Pollutant Concentration at Admin Building										
Parameters	**Date**	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period	-	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit	-	**NS**	**100 µg/m3**	**60 µg/m3**	-	**80 µg/m3**	-	**80 µg/m3**	-	**400 µg/m3**
AL8 -1	06.10.2021	221	113	82	2.64	3.22	8.89	12.28	7.40	5.79
					3.08		14.61		5.87	
					3.96		13.34		4.08	
AL8 -2	08.10.2021	218	126	73	4.40	5.42	27.95	18.21	4.08	6.81
					5.28		15.88		10.72	
					6.59		10.80		5.62	
AL8 -3	13.10.2021	197	104	72	3.08	3.22	10.16	17.57	5.87	9.02
					3.96		26.68		11.74	
					2.64		15.88		9.45	
AL8 -4	15.10.2021	227	111	75	2.20	3.37	20.96	15.24	8.42	6.30
					4.40		14.61		4.08	
					3.52		10.16		6.38	
AL8 -5	20.10.2021	185	88	54	4.40	3.52	15.24	16.73	8.42	6.98
					2.64		20.96		6.64	
					3.52		13.97		5.87	
AL8 -6	22.10.2021	248	121	94	3.96	3.81	8.89	10.37	5.36	5.19
					2.20		8.26		4.08	
					5.28		13.97		6.13	
AL8 -5	27.10.2021	210	138	62	3.08	3.66	13.97	13.76	15.06	10.64
					1.32		6.35		11.49	
					6.59		20.96		5.36	
AL8-6	29.10.2021	186	128	50	3.08	3.23	15.88	11.01	4.08	5.53
					2.20		8.89		5.87	
					4.40		8.26		6.64	
Monthly Average		211	116	70		3.7		14.4		7.0
Standard Deviation		22	16	15		0.7		3.0		1.9

NS: Not Specified

Table 8B : Results of Air Pollutant Concentration at Admin Building					
Parameter	Date	C_6H_6 [µg/m³]	HC*	CO [mg/m³]	CO_2 [ppm]
Sampling Period		8 hr	Grab Sampling	Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m³	NS	4.0 mg/m³	NS
AL8 -1	06.10.2021	1.30	BQL	1.86	451
AL8-2	08.10.2021	1.09	BQL	1.79	450
AL8 -3	13.10.2021	1.20	BQL	1.71	462
AL8-4	15.10.2021	1.11	BQL	1.82	455
AL8 -5	20.10.2021	1.16	BQL	1.69	469
AL8-6	22.10.2021	1.06	BQL	1.77	470
AL8-7	27.10.2021	1.30	BQL	1.82	459
AL8-8	29.10.2021	1.10	BQL	1.74	466
Monthly Average		**1.17**	**-**	**1.78**	**460**
Standard Deviation		**0.09**	**-**	**0.06**	**8**

* NMHC- Non- Methane Hydrocarbons

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

NS-Not Specified

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Admin Building Vadinar was comparatively low among all the locations of Air Quality monitoring in Kandla Port and Vadinar Port. The mean TSPM values at Vadinar Port were 211 µg/m³. The mean PM_{10} values were 116 µg/m³, which is above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean = 70.0 µg/m³). The average values of SO_2, NO_x and NH_3 were 3.7 µg/m³, 14.4 µg/m³ and 7.0 µg/m³ respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Admin Building, Vadinar Port. The mean Benzene concentration was 1.17 µg/m³, well below the permissible limit of 5.0 µg/m³. HC's were below the detectable limit and Carbon Monoxide concentration was 1.78 mg/m³, well below the permissible limit of 4.0 mg/m³.

1.4 Observations and Conclusion

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

2. Drinking Water Quality Monitoring

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

2.1 Drinking Water Monitoring Methodology

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

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

2.2 Results

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

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

Sr. No.	Parameter	Unit	Nirman Building 1	P & C building	Main Gate North	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.3	7.4	7.3	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	970	1310	1250	500	2000
3	Turbidity	NTU	0	1	0	1.0	5.0
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	1860	2560	2430	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2	<2	<2	NS*	NS*
8	Chloride as Cl	mg/l	476.06	440.98	506.13	250.0	1000.0
9	Ca as Ca	mg/l	64.13	68.14	72.14	75.0	200.0
10	Mg as Mg	mg/l	63.18	70.47	65.61	30.0	100.0
11	Total Hardness	mg/l	420	460	450	200.0	600.0
12	Iron as Fe	mg/l	<0.01	<0.01	<0.01	0.3	No Relaxation
13	Fluorides as F	mg/l	0.32	0.35	0.17	1.0	1.5
14	Sulphate as SO4	mg/l	286.8	289.2	194.4	200.0	400
15	Nitrite as NO2	mg/l	<0.01	<0.01	<0.01	NS*	NS*
16	Nitrate as NO3	mg/l	6.41	7.88	13.02	45.0	No Relaxation
17	Salinity	%	0.86	0.80	0.91	NS*	NS*
18	Sodium as Na	mg/l	199	193	258	NS*	NS*
19	Potassium as K	mg/l	3.24	3.68	3.51	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Sr. No.	Parameter	Unit	Canteen	West Gate – I	Wharf Area	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.7	7.4	7.2	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1340	980	1040	500	2000
3	Turbidity	NTU	0	0	1	1.0	5.0
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	2600	1940	2040	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2	<2	<2	NS*	NS*
8	Chloride as Cl	mg/l	526.17	496.10	481.07	250.0	1000.0
9	Ca as Ca	mg/l	60.12	64.13	56.11	75.0	200.0
10	Mg as Mg	mg/l	70.47	65.61	70.47	30.0	100.0
11	Total Hardness	mg/l	440	430	430	200.0	600.0
12	Iron as Fe	mg/l	<0.01	<0.01	<0.01	0.3	No Relaxation
13	Fluorides as F	mg/l	0.46	0.50	0.52	1.0	1.5
14	Sulphate as SO4	mg/l	186	194.4	288	200.0	400
15	Nitrite as NO2	mg/l	<0.01	<0.01	<0.01	NS*	NS*
16	Nitrate as NO3	mg/l	8.59	10.21	9.22	45.0	No Relaxation
17	Salinity	%	0.95	0.90	0.87	NS*	NS*
18	Sodium as Na	mg/l	215	209	231	NS*	NS*
19	Potassium as K	mg/l	4.23	3.88	4.21	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Sr. No.	Parameter	Unit	SewaSadan – 3	Workshop	Custom Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.4	7.8	7.5	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1190	1420	1160	500	2000
3	Turbidity	NTU	1	1	0	1.0	5.0
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	1920	2870	2180	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2	<2	<2	NS*	NS*
8	Chloride	mg/l	616.37	591.31	491.09	250.0	1000.0
9	Ca as Ca	mg/l	64.13	68.14	60.12	75.0	200.0
10	Mg as Mg	mg/l	68.04	58.32	65.61	30.0	100.0
11	Total Hardness	mg/l	440	410	420	200.0	600.0
12	Iron as Fe	mg/l	<0.01	<0.01	<0.01	0.3	No Relaxation
13	Fluorides	mg/l	0.90	0.57	0.63	1.0	1.5
14	Sulphate	mg/l	217.2	205.2	289.2	200.0	400
15	Nitrite	mg/l	<0.01	<0.01	<0.01	NS*	NS*
16	Nitrate	mg/l	13.52	9.93	12.74	45.0	No Relaxation
17	Salinity	%	1.11	1.07	0.89	NS*	NS*
18	Sodium as Na	mg/l	265	218	323	NS*	NS*
19	Potassium as K	mg/l	3.87	3.73	3.56	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Sr. No.	Parameter	Unit	Port Colony Kandla	Hospital Kandla	A.O. Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.3	7.6	7.2	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1090	1460	940	500	2000
3	Turbidity	NTU	0	0	1	1.0	5.0
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	2090	2850	1860	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2	<2	<2	NS*	NS*
8	Chloride	mg/l	445.99	466.04	496.10	250.0	1000.0
9	Ca as Ca	mg/l	56.11	68.14	60.12	75.0	200.0
10	Mg as Mg	mg/l	75.33	72.90	80.19	30.0	100.0
11	Total Hardness	mg/l	450	470	480	200.0	600.0
12	Iron as Fe	mg/l	<0.01	<0.01	<0.01	0.3	No Relaxation
13	Fluorides	mg/l	0.87	0.68	0.92	1.0	1.5
14	Sulphate	mg/l	294	318	210	200.0	400
15	Nitrite	mg/l	<0.01	<0.01	<0.01	NS*	NS*
16	Nitrate	mg/l	9.29	10.14	11.69	45.0	No Relaxation
17	Salinity	%	0.81	0.84	0.90	NS*	NS*
18	Sodium as Na	mg/l	101	221	402	NS*	NS*
19	Potassium as K	mg/l	4.08	4.01	3.99	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Sr. No.	Parameter	Unit	School Gopalpuri	Guest House	E - Type Quarter	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.4	7.4	7.3	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1020	1340	1100	500	2000
3	Turbidity	NTU	1	0	1	1.0	5.0
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	2010	2660	2140	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2	<2	<2	NS*	NS*
8	Chloride	mg/l	466.04	506.13	466.04	250.0	1000.0
9	Ca as Ca	mg/l	52.10	72.14	68.14	75.0	200.0
10	Mg as Mg	mg/l	77.76	55.89	63.18	30.0	100.0
11	Total Hardness	mg/l	450	410	430	200.0	600.0
12	Iron as Fe	mg/l	<0.01	<0.01	<0.01	0.3	No Relaxation
13	Fluorides	mg/l	0.60	0.81	1.08	1.0	1.5
14	Sulphate	mg/l	291.6	294	283.2	200.0	400
15	Nitrite	mg/l	<0.01	<0.01	<0.01	NS*	NS*
16	Nitrate	mg/l	9.29	10.63	9.36	45.0	No Relaxation
17	Salinity	%	0.84	0.91	0.84	NS*	NS*
18	Sodium as Na	mg/l	275	300	130	NS*	NS*
19	Potassium as K	mg/l	3.49	3.50	3.56	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Sr. No.	Parameter	Unit	F - Type Quarter	Hospital Gopalpuri	Tuna Port	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.7	7.4	7.38	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1120	1090	1080	500	2000
3	Turbidity	NTU	0	1	0	1.0	5.0
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Unit	Colorless	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	2210	2190	2160	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2	<2	<2	NS*	NS*
8	Chloride	mg/l	576.28	521.16	520	250.0	1000.0
9	Ca as Ca	mg/l	72.14	76.15	78.56	75.0	200.0
10	Mg as Mg	mg/l	55.89	65.61	54.92	30.0	100.0
11	Total Hardness	mg/l	410	460	422	200.0	600.0
12	Iron as Fe+3	mg/l	<0.01	<0.01	<0.01	0.3	No Relaxation
13	Fluorides	mg/l	1.05	0.93	0.46	1.0	1.5
14	Sulphate	mg/l	265.2	238.8	180	200.0	400
15	Nitrite	mg/l	<0.01	<0.01	<0.01	NS*	NS*
16	Nitrate	mg/l	9.86	7.88	8.2	45.0	No Relaxation
17	Salinity	%	1.04	0.94	0.98	NS*	NS*
18	Sodium as Na	mg/l	235	235	260	NS*	NS*
19	Potassium as K	mg/l	2.18	4.01	2.6	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

Sr. No.	Parameter	Unit	Vadinar Jetty	Port Colony Vadinar	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.5	7.6	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1030	1010	500	2000
3	Turbidity	NTU	ND	ND	1.0	5.0
4	Odor	-	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	2020	1960	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<2	<2	NS*	NS*
8	Chloride	mg/l	425.95	415.92	250.0	1000.0
9	Ca as Ca	mg/l	60.12	52.10	75.0	200.0
10	Mg as Mg	mg/l	75.33	94.26	30.0	100.0
11	Total Hardness	mg/l	460	440	200.0	600.0
12	Iron as Fe+3	mg/l	<0.01	<0.01	0.3	No Relaxation
13	Fluorides	mg/l	0.92	0.67	1.0	1.5
14	Sulphate	mg/l	22.44	22.20	200.0	400
15	Nitrite	mg/l	<0.01	<0.01	NS*	NS*
16	Nitrate	mg/l	7.39	9.99	45.0	No Relaxation
17	Salinity	%	0.90	0.92	NS*	NS*
18	Sodium as Na	mg/l	51.1	44.1	NS*	NS*
19	Potassium as K	mg/l	2.2	<2.0	NS*	NS*
20	Manganese	mg/l	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/l	<0.03	<0.03	NS*	NS*
22	Copper	mg/l	<0.05	<0.05	0.05	1.5
23	Cadmium	mg/l	<0.002	<0.002	0.003	0.003
24	Arsenic	mg/l	<0.01	<0.01	0.01	0.05
25	Mercury	mg/l	<0.001	<0.001	0.001	0.001
26	Lead	mg/l	<0.01	<0.01	0.01	0.01
27	Zinc	mg/l	<0.1	<0.1	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent

*NS: Not Specified

2.3 Results & Discussion

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

pH

The limit of pH value for drinking water is specified as 6.5 to 8.5. pH value in the studied area varied from 7.0 to 8.0 pH unit. All the sampling points showed pH values within the prescribed limit by Indian Standards.

Total Dissolved Solids (TDS)

TDS values in the studied area varied between 900 -1500 mg/l. None of the sampling points showed higher TDS values than the prescribed limit by Indian standards.

Conductivity

Electrical Conductivity is the ability of a solution to transfer (conduct) electric current. Conductivity is used to measure the concentration of dissolved solids which have been ionized in a polar solution such as water. The conductivity in the samples collected during the month of October ranged from 1800-3000 µs/cm. Electrical conductivity standards do not appear in BIS standards for drinking water.

BOD

BOD value in the studied area was less than 2.0 mg/L. Indian standards does not show any standard values for BOD in drinking water.

Chlorides

Excessive chloride concentration increase rates of corrosion of metals in the distribution system. This can lead to increased concentration of metals in the supply. Chloride value in the studied area varied between 400-650 mg/l and is found to be within the Permissible limit of the Drinking Water Standard.

Calcium

Calcium value in the studied area varied between 50 - 80 mg/l and is found to be within the Permissible limit of the Drinking Water Standard. If calcium is present beyond the maximum acceptable limit, it causes incrustation of pipes.

Magnesium

Magnesium value in the studied area varied between 50 – 99 mg/l. All the locations had Magnesium within the prescribed limits of 30-100 mg/L.

Total Hardness

Hardness value in the studied area varied between 400-480 mg/l and is found to be within the Permissible limit of the Drinking Water Standard. The prescribed limit by Indian Standards is 200-600 mg/L.

Iron

Iron value in the studied area was below 0.01mg/L and hence well below the permissible limit as per Indian Standards is 0.3 mg/L. The excess amount of iron causes slight toxicity; gives stringent taste to water.

Fluoride

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

Sulphates

Sulphate value in the studied area varied between 20 – 350 mg/l. All the sampling points showed sulphate values within the prescribed limits by Indian Standards (200-400 mg/L). Sulphate content in drinking water exceeding the 400 mg/L imparts bitter taste.

Nitrites (NO_2) and Nitrates (NO_3)

Nitrite values in all the water samples were <0.1. There are no specified standard values for Nitrites in Drinking water. The mean Nitrate values in drinking water of KPT was 6.41 mg/l which is well within the permissible limit of the Drinking water Standard.

Salinity

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

Sodium and Potassium Salts

Sodium values in the samples collected ranged from 50 - 400 mg/l and Potassium salts ranged from 2.0 to 4.5 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 permissible limits prescribed by the Indian Standards.

Bacteriological Study

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

2.4 Conclusions

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

3. Noise Level Monitoring

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

3.1 Method of Monitoring

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

3.2 Results

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

Sr. No.	Location	Day Time Average Noise Level (SPL) in dB(A)	Night Time Average Noise Level (SPL) in dB(A)
	Sampling Time	**6:00 am to 10:00 PM**	**10:00PM to 6:00 AM**
1	Marine Bhavan	73.9	53.4
2	Nirman Building 1	62.3	51.0
3	Tuna Port	57.2	50.9
4	Main Gate North	67.0	61.8
5	West Gate I	70.5	65.1
6	Canteen Area	64.5	51.0
7	Main Road	68.4	51.5
8	ATM Building	80.4	57.3
9	Wharf Area /Jetty Area	72.9	68.1
10	Port & Custom Office	67.8	41.8
	Vadinar Port		
11	Entrance Gate of Vadinar Port	66.4	53.2
12	Nr. Port Colony, Vadinar	60.7	54.1
13	Nr. Vadinar Jetty	72.4	66.5

3.3 Conclusions- Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. The Day Time Average Noise Level (SPL)in all 13 locations at Deendayal Port ranged from 57.0 dB(A) to 73.9 dB(A) and it was within the permissible limits of 75 dB(A) for the industrial area for the daytime. The Night Time Average Noise Level (SPL) in all 13 locations of Deendayal Port ranged from 41.8 dB to 68.4 dB(A) and it was within the permissible limits of 70 dB(A) for the industrial area for the night time.

4. Soil Monitoring

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

4.1 Methodology

The soil samples were collected in the month of October 2021. The samples collected from the all locations are homogeneous representative of each location. At random locations were identified at each location and soil was dug from 30 cm below the surface. It was uniformly mixed before homogenizing the soil samples. The samples were filled in polythene bags, labeled in the field with number and site name and sent to laboratory for analysis.

4.2 Results

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

Sr. No.	Parameter	Unit	Station Name					
			SL1	SL2	SL3	SL4	SL5	SL6
			Tuna Port	IFFCO Plant	Khori Creek	Nakti Creek	KPT Admin Site	KPT Colony
			Near main gate of Port	10 m away from main gate	Sand from creek at low tide		Vadinar	
1	Texture		Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	pH	-	8.62	8.10	8.75	8.33	8.10	8.22
3	Electrical Conductivity	µs/cm	16,200.0	26,820.0	16,252.0	17,520.0	560.0	480.0
4	Moisture	%	17.00	18.20	19.10	20.22	7.26	8.22
5	Total Organic Carbon	%	0.52	1.02	0.62	3.10	0.12	0.20
6	Alkalinity	mg/kg	60.06	80.44	140.20	80.44	60.06	80.44
7	Total Nitrogen	%	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
8	Chloride	mg/kg	1,620.0	5,380.0	1,820.0	2,078.0	62.0	77.0
9	Sulphate	mg/kg	230.0	198.0	120.0	118.0	16.0	20.0
10	Phosphorus	mg/kg	0.90	0.82	0.96	1.02	0.80	0.72
11	Potassium	mg/kg	396.0	810.0	366.0	460.0	120.0	160.0
12	Sodium	mg/kg	1,620.0	3,400.0	2,122.0	2,012.0	910.0	888.0
13	Calcium	mg/kg	230.32	722.20	252.00	470.42	110.00	82.00
14	Copper as Cu	mg/kg	17.40	38.80	21.20	35.10	16.6	17.0
15	Lead as Pb	mg/kg	6.40	7.90	29.10	7.60	4.8	2.0
16	Nickel as Ni	mg/kg	33.50	13.90	34.50	13.20	13.2	12.2
17	Zinc as Zn	mg/kg	55.90	91.90	77.9	81.90	28.00	36.22
18	Cadmium as Cd	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL

4.3 Discussion

- The data shows that value of pH ranges from 8.10 at IFFCO Plant to 8.75 at Khori Creek indicating that all soil samples are neutral to slight basic. Iffco Plant samples showed maximum conductivity of 26,820 µmhos/cm, while Tuna Port location showed minimum conductivity of 16,200 µmhos/cm. Conductivity at Vadinar Port was 560 and 480 µmhos/cm at Admin site and Vadinar Port colony respectively.
- Total organic Carbon ranged from 0.5 % to 3.1 at Deendayal Port. At Vadinar Port, organic carbon content ranged from 0.1 % to 0.2 %.
- The concentration of Phosphorus and Potassium in the soil samples varies from 0.7 to 1.0 mg/kg and 300.0 to 800 mg/kg respectively at Deendayal Port. The mean concentration of Phosphorous at Vadinar site was 0.76 mg/kg and mean concentration of Potassium at Vadinar site was 140 mg/kg.

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

Heavy Metals in the Soil

Traces of Copper, Lead, Nickel and Zinc were observed in the soil samples collected from all the four locations of Deendayal Port and two locations of Vadinar Port. Cadmium metal was not detected in the Soil.

4.4 Conclusion

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

5. Sewage Treatment Plant Monitoring

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

5.1 Methodology for STP Monitoring

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

5.2 Results

- **Kandla STP**

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

Date of Sampling	08.10.2021

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	7.62	7.4
2	Total Suspended Solids	mg/l	99.2	64.7
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	424.2	98.0
5	BOD @ 27 °C	mg/l	141.0	23.0
6.	Fecal Coliform	MPN Index / 100 ml	-	79.0
Aeration Tank				
7.	MLSS	mg/l	6.0	
8.	MLVSS	%	93.0	

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

Date of Sampling	12.10.2021

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	7.6	7.2
2	Total Suspended Solids	mg/l	152.2	72.4
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	384	103.0
5	BOD @ 27 °C	mg/l	120.0	24.0
6.	Fecal Coliform	MPN Index / 100 ml	-	8.0
Aeration Tank				
7.	MLSS	mg/l	12.0	
8.	MLVSS	%	84.0	

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

Date of Sampling	21.10.2021

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	7.65	7.41
2	Total Suspended Solids	mg/l	223.4	99.8
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	181.8	101
5	BOD @ 27 °C	mg/l	68.0	24.0
6.	Fecal Coliform	MPN Index / 100 ml	-	11.0
Aeration Tank				
7.	MLSS	mg/l	9.0	
8.	MLVSS	%	87.0	

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

Date of Sampling	25.10.2021

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	7.72	7.5
2	Total Suspended Solids	mg/l	284.6	113.6
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	212	101.0
5	BOD @ 27 °C	mg/l	98.0	26.0
6.	Fecal Coliform	MPN Index / 100 ml	-	3.6
Aeration Tank				
7.	MLSS	mg/l	14.0	
8	MLVSS	%	84.0	

- **Gopalpuri Colony STP**

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

Date of Sampling	08.10.2021

Sr. No.	Parameters	Unit	Results	
			Gopalpuri STP I/L	Gopalpuri STP O/L
1	pH	pH unit	7.6	7.4
2	Total Suspended Solids	mg/l	195.6	84.0
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	304.0	104.0
5	BOD @ 27 °C	mg/l	120.0	26.0
6.	Fecal Coliform	MPN Index / 100 ml	-	49.0
Aeration Tank				
7.	MLSS	mg/l	10.0	
8	MLVSS	%	87.0	

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

Date of Sampling	12.10.2021

Sr. No.	Parameters	Unit	Results	
			Gopalpuri STP I/L	Gopalpuri STP O/L
1	pH	pH unit	7.7	7.5
2	Total Suspended Solids	mg/l	388	131.8
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	414.1	106.00
5	BOD @ 27 °C	mg/l	139.0	28.0
6.	Fecal Coliform	MPN Index / 100 ml	-	6.0
Aeration Tank				
7.	MLSS	mg/l	14.0	
8	MLVSS	%	90.0	

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

Date of Sampling	21.10.2021

Sr. No.	Parameters	Unit	Results	
			Gopalpuri STP I/L	Gopalpuri STP O/L
1	pH	pH unit	7.52	7.21
2	Total Suspended Solids	mg/l	354.2	103.3
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	161.6	90.9
5	BOD @ 27 °C	mg/l	80.0	26.0
6.	Fecal Coliform	MPN Index / 100 ml	-	46.0
Aeration Tank				
7.	MLSS	mg/l	14.0	
8	MLVSS	%	84.0	

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

Date of Sampling	25.10.2021

Sr. No.	Parameters	Unit	Results	
			Gopalpuri STP I/L	Gopalpuri STP O/L
1	pH	pH unit	7.45	7.19
2	Total Suspended Solids	mg/l	345.8	105
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	232	106
5	BOD @ 27 °C	mg/l	82.0	28.0
6.	Fecal Coliform	MPN Index / 100 ml	-	32.0
Aeration Tank				
7.	MLSS	mg/l	10.0	
8.	MLVSS	%	89.0	

- **Vadinar STP**

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

Date of Sampling	08.10.2021

Sr. No.	Parameters	Unit	Results	
			Vadinar STP I/L	Vadinar O/L
1	pH	pH unit	7.62	7.4
2	Total Suspended Solids	mg/l	99.2	64.7
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	88.0	60.0
5	BOD @ 27 °C	mg/l	32.0	16.0

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

Date of Sampling	12.10.2021

Sr. No.	Parameters	Unit	Results	
			Vadinar STP I/L	Vadinar O/L
1	pH	pH unit	7.7	7.5
2	Total Suspended Solids	mg/l	133.5	59.9
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	188.0	60.0
5	BOD @ 27 °C	mg/l	60.0	16.0

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

Date of Sampling	21.10.2021

Sr. No.	Parameters	Unit	Results	
			Vadinar STP I/L	Vadinar O/L
1	pH	pH unit	7.7	7.5
2	Total Suspended Solids	mg/l	105	38
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	161.6	70.7
5	BOD @ 27 °C	mg/l	62.0	20.0

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

Date of Sampling	25.10.2021

Sr. No.	Parameters	Unit	Results	
			Vadinar STP I/L	Vadinar O/L
1	pH	pH unit	7.7	7.2
2	Total Suspended Solids	mg/l	105	58.8
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	202	80.8
5	BOD @ 27 °C	mg/l	60.0	20.0

5.3 Conclusions:

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

6. Marine Water Monitoring

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

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

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

Marine Environment

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

Sampling Stations

The monitoring of marine environment for the study of biological and ecological parameters was carried out on 6th& 7th October-2021 in harbor regions of KPT and on 7th October-2021 at Vadinar during spring tide period of New moon phase of Lunar Cycle. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 13th& 14th October 2021 in harbor regions of KPT. 14th October -2021 in Vadinar during Neap tide period first quarter of Lunar Cycle..

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

Sampling Locations

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

6.1 Marine Water Quality

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

The results of marine water quality and Marine sediments are as below;

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

Sr. No.	Parameters	Unit	Kandla Creek Near KPT colony (1)			
			23°0'58"N 70°13'22."E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.14	7.16	7.42	7.36
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	32.5	32.0	32.6	32.0
5	Turbidity	NTU	38	29	36	31
6	Total Dissolved Solids	mg/l	42450	39030	42122.0	41187.0
7	Total Suspended Solids	mg/l	685	950	764.9	558.1
8	Total Solids	mg/l	43135	39980	42886.9	41745.1
9	DO	mg/l	4.1	4	4.3	4.2
10	COD	mg/l	78.0	80.0	80.0	78.0
11	BOD	mg/l	<2.0	<2.0	<2.0	<2.0
12	Silica	mg/l	0.75	0.64	0.65	0.53
13	Phosphate	mg/l	0.36	0.26	0.16	0.18
14	Sulphate	mg/l	3060	2892	2256	2532
15	Nitrate	mg/l	2.89	2.46	2.50	3.48
16	Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05
17	Calcium	mg/l	601.20	521.04	561.12	521.04
18	Magnesium	mg/l	1628.1	1603.8	0	0
19	Sodium	mg/l	9473.0	8438.0	9368	8523
20	Potassium	mg/l	362.1	314.0	360.8	302.8
21	Iron	mg/l	1.63	1.34	1.35	1.24
22	Chromium	mg/l	0.11	0.13	0.12	0.13
23	Copper	mg/l	0.06	0.05	0.06	0.06
24	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01
25	Cadmium	mg/l	0.04	0.05	0.04	0.04
26	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001
27	Lead	mg/l	0.09	0.11	0.11	0.09
28	Zinc	mg/l	0.07	0.06	0.06	0.05

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

Sr. No.	Parameters	Unit	Near passenger Jetty One (2)			
			23° 0'18 "N 70°13'31"E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.25	7.21	7.51	7.1
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31.8	31.9	31.8	31.9
5	Turbidity	NTU	36	25	39	45
6	Total Dissolved Solids	mg/l	33930	47550	40323.0	40031.0
7	Total Suspended Solids	mg/l	658	769	569.8	528.6
8	Total Solids	mg/l	34588	48319	40892.8	40559.6
9	DO	mg/l	4.4	3.8	4.4	4.1
10	COD	mg/l	82.0	86.0	88.0	80.0
11	BOD	mg/l	<2.0	<2.0	<2.0	<2.0
12	Silica	mg/l	0.51	0.60	0.80	0.75
13	Phosphate	mg/l	0.23	0.26	0.18	0.19
14	Sulphate	mg/l	2784	3252	2388	2652
15	Nitrate	mg/l	3.03	3.59	2.89	4.04
16	Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05
17	Calcium	mg/l	561.12	641.28	480.96	561.12
18	Magnesium	mg/l	1555.2	1628.1	0	0
19	Sodium	mg/l	9670.0	9156.0	9686	9192
20	Potassium	mg/l	380.0	326.1	354.2	278.2
21	Iron	mg/l	1.90	1.73	1.68	1.33
22	Chromium	mg/l	0.13	0.11	0.11	0.15
23	Copper	mg/l	0.07	0.05	0.07	0.07
24	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01
25	Cadmium	mg/l	0.05	0.04	0.04	0.05
26	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001
27	Lead	mg/l	0.12	0.12	0.09	0.11
28	Zinc	mg/l	0.05	0.06	0.08	0.09

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

Sr. No.	Parameters	Unit	Near Coal Berth			
			22°59'12"N 70°13'40"E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.40	7.52	7.2	7.41
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	32.2	32.0	32.0	31.7
5	Turbidity	NTU	36	28	33	41
6	Total Dissolved Solids	mg/l	45010	41120	40162.0	42404.0
7	Total Suspended Solids	mg/l	586	838	492.9	627.8
8	Total Solids	mg/l	45596	41958	40654.9	43031.8
9	DO	mg/l	4.1	5	4.5	5.2
10	COD	mg/l	88.0	90.0	79.0	74.0
11	BOD	mg/l	<2.0	<2.0	<2.0	<2.0
12	Silica	mg/l	0.69	0.76	0.53	0.71
13	Phosphate	mg/l	0.27	0.37	0.16	0.19
14	Sulphate	mg/l	3300	1872	2688	2256
15	Nitrate	mg/l	3.87	4.36	2.96	2.59
16	Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05
17	Calcium	mg/l	601.20	681.36	521.04	480.96
18	Magnesium	mg/l	1676.7	1652.4	0	0
19	Sodium	mg/l	9421.0	8958.0	9328	8688
20	Potassium	mg/l	354.2	343.7	283.8	332.6
21	Iron	mg/l	1.56	1.88	1.93	1.57
22	Chromium	mg/l	0.14	0.14	0.14	0.11
23	Copper	mg/l	0.06	0.07	0.06	0.06
24	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01
25	Cadmium	mg/l	0.05	0.04	0.06	0.05
26	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001
27	Lead	mg/l	0.13	0.10	0.08	0.10
28	Zinc	mg/l	0.07	0.08	0.06	0.07

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

Sr. No.	Parameters	Unit	KPT 4			
			Near 15/16 Berth			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.28	7.40	7.3	7.4
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31.5	32.6	32.4	32.0
5	Turbidity	NTU	46	36	50	30
6	Total Dissolved Solids	mg/l	42910	48900	40963.0	41643.0
7	Total Suspended Solids	mg/l	660	562	711.1	509.7
8	Total Solids	mg/l	43570	49462	41674.1	42152.7
9	DO	mg/l	4.7	4.6	5.8	5.6
10	COD	mg/l	72.0	76.0	82.0	78.0
11	BOD	mg/l	<2.0	<2.0	<2.0	<2.0
12	Silica	mg/l	0.73	0.62	0.65	0.49
13	Phosphate	mg/l	0.28	0.24	0.22	0.19
14	Sulphate	mg/l	1500	3336	2412	2124
15	Nitrate	mg/l	1.76	2.89	2.78	2.02
16	Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05
17	Calcium	mg/l	521.04	601.20	440.88	601.2
18	Magnesium	mg/l	1676.7	1555.2	0	0
19	Sodium	mg/l	9979.0	9708.0	9808	9629
20	Potassium	mg/l	373.2	343.9	327.8	305.6
21	Iron	mg/l	1.73	1.67	1.02	1.68
22	Chromium	mg/l	0.15	0.17	0.09	0.09
23	Copper	mg/l	0.05	0.08	0.07	0.07
24	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01
25	Cadmium	mg/l	0.03	0.06	0.07	0.04
26	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001
27	Lead	mg/l	0.09	0.01	0.09	0.08
28	Zinc	mg/l	0.06	0.08	0.07	0.05

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

Sr. No.	Parameters	Unit	Nakti Creek Near Tuna Port			
			22°57'49."N 70° 7'0.67"E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.20	7.40	7.2	7.4
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	32.1	31.9	31.6	31.2
5	Turbidity	NTU	34	46	33	29
6	Total Dissolved Solids	mg/l	48700	49900	40306.0	38117.0
7	Total Suspended Solids	mg/l	867	848	441.1	513
8	Total Solids	mg/l	49567	50748	40747.1	38630.0
9	DO	mg/l	4.2	4.8	4.8	4.7
10	COD	mg/l	96.0	98.0	90.0	92.0
11	BOD	mg/l	<2.0	<2.0	<2.0	<2.0
12	Silica	mg/l	0.53	0.84	0.73	0.60
13	Phosphate	mg/l	0.25	0.24	0.20	0.17
14	Sulphate	mg/l	3504	3780	2772	2364
15	Nitrate	mg/l	3.24	3.59	2.74	4.60
16	Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05
17	Calcium	mg/l	521.04	601.20	480.96	521.04
18	Magnesium	mg/l	1652.4	1676.7	0	0
19	Sodium	mg/l	10156.0	10254.0	10268	10438
20	Potassium	mg/l	336.9	336.4	278.6	297.8
21	Iron	mg/l	1.54	1.83	1.55	1.50
22	Chromium	mg/l	0.12	0.11	0.14	0.16
23	Copper	mg/l	0.08	0.07	0.05	0.05
24	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01
25	Cadmium	mg/l	0.04	0.06	0.06	0.04
26	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001
27	Lead	mg/l	0.12	0.13	0.11	0.13
28	Zinc	mg/l	0.08	0.09	0.05	0.09

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

Sr. No.	Parameters	Unit	Nakti Creek Near NH-8A			
			23° 02'01"N 70° 09'31"E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.50	Sampling not possible during Low Tide	7.5	Sampling not possible during Low Tide
2	Color	-	Colorless		Colorless	
3	Odor	-	Odorless		Odorless	
4	Salinity	ppt	31.8		31.0	
5	Turbidity	NTU	34		34	
6	Total Dissolved Solids	mg/l	43730		40522.0	
7	Total Suspended Solids	mg/l	635		432.9	
8	Total Solids	mg/l	44365		40954.9	
9	DO	mg/l	4.6		5.2	
10	COD	mg/l	98.0		90.0	
11	BOD	mg/l	<2.0		<2.0	
12	Silica	mg/l	1.00		0.51	
13	Phosphate	mg/l	0.24		0.17	
14	Sulphate	mg/l	3576		2352	
15	Nitrate	mg/l	3.03		3.37	
16	Nitrite	mg/l	<0.05		<0.05	
17	Calcium	mg/l	561.12		601.2	
18	Magnesium	mg/l	1725.3		0	
19	Sodium	mg/l	10760.0		10536	
20	Potassium	mg/l	335.1		335.1	
21	Iron	mg/l	1.80		1.33	
22	Chromium	mg/l	0.16		0.10	
23	Copper	mg/l	0.07		0.06	
24	Arsenic	mg/l	<0.01		<0.01	
25	Cadmium	mg/l	0.03		0.05	
26	Mercury	mg/l	<0.001		<0.001	
27	Lead	mg/l	0.12		0.11	
28	Zinc	mg/l	0.09		0.07	

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

Sr. No.	Parameters	Unit	Nr.Vadinar Jetty 22°26'25.26"N 69°40'20.41"E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.50	7.80	7.54	7.45
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	32.0	32.0	32.1	31.9
5	Turbidity	NTU	46	36	46	42
6	Total Dissolved Solids	mg/l	47700	46610	37421.0	38258.0
7	Total Suspended Solids	mg/l	483	476	553.6	490
8	Total Solids	mg/l	48183	47086	37974.6	38748.0
9	DO	mg/l	4.3	4.5	4.6	4.8
10	COD	mg/l	86.0	88.0	88.0	86.0
11	BOD	mg/l	<2.0	<2.0	<2.0	<2.0
12	Silica	mg/l	0.85	0.93	0.71	0.89
13	Phosphate	mg/l	0.23	0.25	0.18	0.17
14	Sulphate	mg/l	2784	2556	2532	2448
15	Nitrate	mg/l	2.46	2.89	3.60	3.37
16	Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05
17	Calcium	mg/l	641.28	561.12	561.12	521.04
18	Magnesium	mg/l	1506.6	1579.5	0	0
19	Sodium	mg/l	10233.0	10490.0	10860.0	10880.0
20	Potassium	mg/l	331.3	363.9	336.0	333.0
21	Iron	mg/l	1.38	1.69	1.34	1.2
22	Chromium	mg/l	0.15	0.19	0.11	0.12
23	Copper	mg/l	0.06	0.08	0.06	0.06
24	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01
25	Cadmium	mg/l	0.04	0.04	0.06	0.05
26	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001
27	Lead	mg/l	0.11	0.11	0.09	0.09
28	Zinc	mg/l	0.06	0.08	0.06	0.05

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

Sr. No.	Parameters	Unit	Nr.Vadinar SPM			
			22°30'56.15"N 69°42'12.07"E			
			Spring Tide		Neap Tide	
	Tide →		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.70	7.50	7.42	7.36
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31.5	32.6	32.0	31.8
5	Turbidity	NTU	34	32	38	44
6	Total Dissolved Solids	mg/l	40230	39870	40119.0	40011.0
7	Total Suspended Solids	mg/l	470	447	496.1	457.4
8	Total Solids	mg/l	40700	40317	40615.1	40468.4
9	DO	mg/l	4.2	4.1	4.4	4.5
10	COD	mg/l	88.0	90	88.0	86
11	BOD	mg/l	<2.0	<2.0	<2.0	<2.0
12	Silica	mg/l	0.82	0.93	0.62	0.76
13	Phosphate	mg/l	0.24	0.25	0.17	0.17
14	Sulphate	mg/l	2688	2340	2352	2472
15	Nitrate	mg/l	2.68	2.82	3.27	3.60
16	Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05
17	Calcium	mg/l	601.20	641.28	0	0
18	Magnesium	mg/l	1579.5	1652.4	0	0
19	Sodium	mg/l	10575	10639	10936.0	10886.0
20	Potassium	mg/l	370.1	367.9	331	402
21	Iron	mg/l	1.57	1.81	1.07	1.63
22	Chromium	mg/l	0.17	0.18	0.09	0.11
23	Copper	mg/l	0.06	0.08	0.06	0.04
24	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01
25	Cadmium	mg/l	0.04	0.05	0.04	0.06
26	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001
27	Lead	mg/l	0.13	0.12	0.08	0.08
28	Zinc	mg/l	0.06	0.07	0.07	0.08

6.1.1 Marine Sediments

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

6.2 Results

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

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

Sr. No.	Parameters	Unit	KPT - 1	KPT - 2	KPT - 3	KPT - 4	KPT - 5	Jetty	SPM
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	1.10	1.08	1.01	1.02	0.98	2.03	0.81
3	Organic Carbon	mg/kg	0.65	0.52	0.60	0.56	0.56	1.08	0.47
4	Inorganic Phosphate	mg/kg	110.0	131.0	132.0	145.0	145.0	132.0	149.0
5	Moisture	%	18.96	19.65	21.0	22.10	23.5	17.7	27.00
6	Aluminium	mg/kg	ND	ND	ND	ND	ND	ND	ND
7	Silica	mg/kg	16.5	15.6	12.0	16.3	15.5	18.7	18.00
8	Phosphate	mg/kg	8.02	10.99	7.22	11.00	7.65	9.52	11.20
9	Sulphate	mg/kg	205.0	265.0	266.0	198.0	221.0	197.6	265.0
10	Nitrite	mg/kg	0.1	0.15	0.11	0.13	0.13	0.09	0.11
11	Nitrate	mg/kg	9.35	7.32	7.06	8.65	8.99	7.65	8.88
12	Calcium	mg/kg	325.0	306.0	396.0	388.0	324.0	324.0	378.0
13	Magnesium	mg/kg	195.0	185.0	243.0	244.0	188.0	175.0	210.0
14	Sodium	mg/kg	3745.0	3945.0	4660.0	2566.0	2899.0	2253.0	2854.0
15	Potassium	mg/kg	238.0	194.0	186.0	178.0	138.0	152.0	110.0
16	Chromium	mg/kg	8.1	48.3	30.7	40.3	23.3	36.4	6.6
17	Nickel	mg/kg	16.4	31.8	22.9	25.8	14	46.6	3.7
18	Copper	mg/kg	27.7	36.9	8.7	14.3	4.2	19.2	1.9
19	Zinc	mg/kg	32.40	40.50	35.10	36.20	21.20	21.30	5.00
20	Cadmium	mg/kg	ND	ND	ND	ND	ND	ND	ND
21	Lead	mg/kg	3.8	5.8	3.3	4.4	4.9	ND	1.2
22	Mercury	mg/kg	ND	ND	ND	ND	ND	ND	ND
23	Arsenic	mg/kg	ND	ND	ND	ND	ND	ND	ND

*ND - Not Detected

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

Sr. No.	Parameters	Unit	KPT – 1	KPT - 2	KPT - 4	SPM
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	1.99	0.85	1.11	1.08
3	Organic Carbon	mg/kg	1.12	0.41	0.65	0.65
4	Inorganic Phosphate	mg/kg	120.0	130.0	148.0	152.0
5	Moisture	%	19.20	18.50	17.7	17.56
6	Aluminium	mg/kg	ND	ND	ND	ND
7	Silica	mg/kg	21.88	18.00	17.5	14.72
8	Phosphate	mg/kg	5.62	8	7.65	8.65
9	Sulphate	mg/kg	225.0	240.0	211.5	195.0
10	Nitrite	mg/kg	0.1	0.11	0.09	0.1
11	Nitrate	mg/kg	7.66	8.11	6.65	6.85
12	Calcium	mg/kg	321.0	310.0	345.0	265.0
13	Magnesium	mg/kg	205.0	197.0	202.0	169.0
14	Sodium	mg/kg	4120.0	3842.0	4465.0	3589.0
15	Potassium	mg/kg	201.0	147.0	154.0	154.00
16	Chromium	mg/kg	13.3	10.5	13	16.8
17	Nickel	mg/kg	8.8	6	8.2	10.5
18	Copper	mg/kg	4.3	2	2.2	5.5
19	Zinc	mg/kg	18.20	9.90	10.30	12.10
20	Cadmium	mg/kg	ND	ND	ND	ND
21	Lead	mg/kg	2.1	2.5	2.8	1.8
22	Mercury	mg/kg	ND	ND	ND	ND
23	Arsenic	mg/kg	ND	ND	ND	ND

*Grab samples could not be collected due high current at KPT – 3,KPT – 5 Location.
*ND - Not Detected

REPORT

ON

ECOLOGICAL MONITORING

OF MARINE ENVIRONMENT

IN

DPT HARBOUR AREA, NEAR BY CREEKS

AND

VADINAR JETTY AND SPM

FOR

DEENDAYAL PORT TRUST

OCTOBER, 2021

INTRODUCTION:

Sampling Stations:

The monitoring of marine environment for the study of biological and ecological Parameters was carried out on6thOctober, 2021 in harbour region of DPT at Kandla Creek, and on 7thOctober,2021 in creeks near by the port during spring tide. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 13thOctober ,2021 in harbour region of DPT at Kandla Creek and on 14thOctober 2021 in creeks near by the port during neap tidal condition.

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

Plankton samples from sub surface layer were collected during high tide period and low tide period from monitoring station near Vadinar jetty at Path Finder Creek during spring tide period and during neap tide. Sampling was conducted at only during Neap tide period nearSPM both during High tide period and low tide period. Collected water samples were processed for estimation of Chlorophyll-a, Pheophytin- a, qualitative &quantitative evaluation of phytoplankton, qualitative &quantitative evaluation zooplanktons (density and their population).

TABLE #1 SAMPLING LOCATIONS

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

Sampling methodology adopted:

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

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

Samples Processing for chlorophyll estimation:

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

PLANKTON:

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

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

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

Phytoplankton in the marine environment:

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

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

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

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

Zooplankton in the marine environment:

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

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

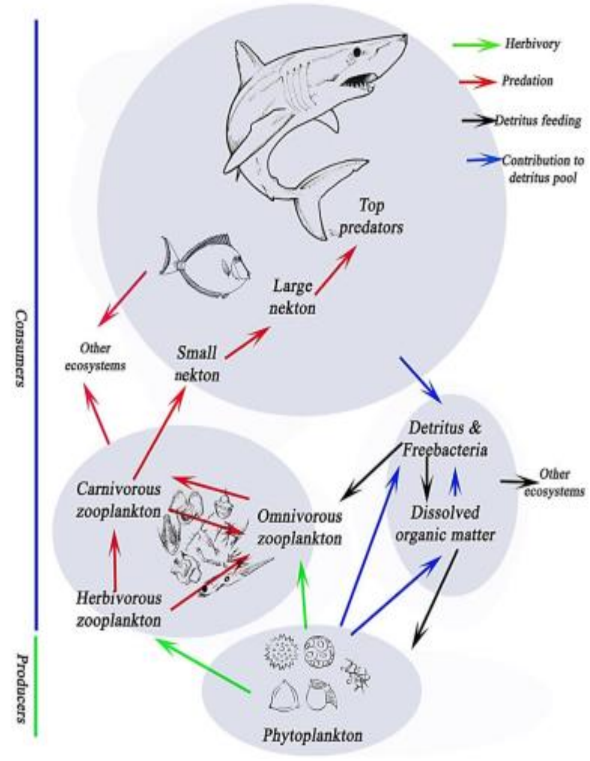
Based on the duration of planktonic life, zooplankton are categorised into Holoplankton (organisms which complete their entire lifecycle as plankton) and Meroplankton (organisms which are planktonic during the early part of their lives such as the larval stages of benthic and nektonic organisms). Tychoplankton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

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

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

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

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



Simplified marine food web

Spatial distribution of Plankton:

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

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

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

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

Methodology adopted for Plankton sampling:

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

Preservation and storage:

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

Sample concentration:

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

Taxonomic evaluation:

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

Cell counts by drop count method:

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

plankton, total number of plankton in the original volume of sample filtered was calculated as units/L.

BENTHIC ORGANISMS:

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

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

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

SAMPLING METHODOLOGY ADOPTED FOR SUB TIDAL REGION:

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

Sample sieving:

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

Sample staining:

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

DIVERSITY INDICES:

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

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

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

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

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

Simpson's diversity index

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

The formula for calculating D is presented as:

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

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

N = the total number of organisms of all species

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

Low species diversity suggests:

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

High species diversity suggests:

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

Species richness indices

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

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

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

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

Shannon-Wiener's index:

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

Shannon and Weiner index represents entropy. It is a diversity index taking into account the number of individuals as well as the number of taxa. It varies from 0 for communities with only single taxa to high values for community with many taxa each with few individuals. This index can also determine the pollution status of a water body. Normal values range from 0 to 4. This index is a combination of species present and the evenness of the species. Examining the diversity in the range of polluted and unpolluted ecosystems, Wilham and Dorris (1968) concluded that the values of the index greater than 3 indicate clean water, values in the range of 1 to 3 are characterized by moderate pollution and values less than 1 are characterized as heavily polluted

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

RESULTS:

CHLOROPHYLL-a:

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

In the sub surface water chlorophyll-a was varying from 0.615 -1.459mg/m^3.in harbour region of DPT in Kandla Creek during sampling done in spring tide period of October, 2021. In the nearby creeks chlorophyll-a was varying from 0.153 -1.497mg/m^3.Pheophytin –a level was below detectable limit-the all the sampling stations during springtide except at KPT-I in the harbour region of DPT.

In the sub surface water chlorophyll-a was varying from 0.204 -0.749mg/m^3.in harbour region of DPT in Kandla Creek during sampling done in neap tide period of October , 2021 . In the nearby creeks chlorophyll-a was varying from 0.184-0.610 mg/m^3.·Pheophytin –a level was below detectable limit-the all the sampling stations during neap tide in the harbour region of DPT.

In the sub surface water chlorophyll-a was varying from 0.527 -0.733 mg/m^3.in harbour region of DPT OOT in path finder Creek during sampling done in spring tide period of October, 2021. In the sub surface water chlorophyll-a was varying from 0.750 -1.175 mg/m^3.in harbour region of DPT OOT in path finder Creek during sampling done in Neap Tide period of October, 2021

TABLE #2 VARIATIONS IN CHLOROPHYLL –a PHEOPHYTIN- a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPT HARBOUR AREA IN KANDLA CREEK ,NEAR BY CREEKS AND DPT OOT JETTY IN PATH FINDER CREEK AND SPM NEAR VADINAR DURING SPRING TIDE IN OCTOBER,2021

Sr.No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPTHARBOUR AREAKANDLA CREEK					
1	KPT1	High tide	1.459	0.821	97.75
		Low tide	1.187	0.661	79.53
2	KPT 2	High tide	0.765	BQL	51.25
		Low tide	0.852	BQL	57.08
3	KPT 3	High tide	0.968	BQL	64.85
		Low tide	0.615	BQL	41.20
CREEKS					
4	KPT-4 Khori-I	High tide	1.056	BQL	70.75
		Low tide	1.497	BQL	100.2
5	KPT-5 Nakti-I	High tide	0.764	BQL	51.19
		Low tide	0.612	BQL	41.00
6	KPT-5 Nakti-II	High tide	0.153	BQL	10.24
PATHFINDER CREEK VADINAR					
7	VADINAR-I jetty	Low tide	0.527	BQL	35.31
8		High tide	0.733	BQL	49.11
9	SPM	High tide	No sample	--	--
10	SPM	Low tide	No sample	-	--

BDL: Below Quantification Limit.

TABLE #3 VARIATIONS IN CHLOROPHYLL –a PHEOPHYTIN- a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPT HARBOUR AREA ,NEAR BY CREEKS AND DPT OOT JETTY IN PATH FINDER CREEK AND SPM NEAR VADINAR DURING NEAP TIDE IN OCTOBER,2021

Sr.No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin- a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPTHARBOUR AREA KANDLA CREEK					
1	KPT1	High tide	0.307	BQL	20.57
		Low tide	0.529	BQL	35.44
2	KPT 2	High tide	0.749	BQL	50.18
		Low tide	0.614	BQL	41.14
3	KPT 3	High tide	0.204	BQL	13.67
		Low tide	0.542	BQL	36.31
CREEKS					
4	KPT-4 Khori-I	High tide	0.441	BQL	29.54
		Low tide	0.426	BQL	28.54
5	KPT-5 Nakti-I	High tide	0.610	BQL	40.87
		Low tide	0.441	BQL	29.55
6	KPT-5 Nakti-II	High tide	0.184	BQL	12.33
PATHFINDER CREEK VADINAR					
7	VADINAR-I jetty	Low tide	0.750	0.435	50.25
8		High tide	0.820	0.484	54.94
9	SPM	High tide	1.071	0.610	71.76
10	SPM	Low tide	1.175	0.680	78.73

BDL: Below Quantification Limit.

PHYTOPLANKTON POPULATION:

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

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by,Diatoms blue green algae and dinoflagellatesduring spring tide period.Diatoms were represented by 19genera. Blue green were represented by 3 genera and dinoflagellates were represented by two generaduring the sampling conducted in spring tide in OCTOBER,2021. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 46-209units/ L during high tide period and183-229 units/ L during low tide of Spring Tide.

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by Diatoms.Blue green algae and Dinoflagellates duringNeap tide period.Diatoms were represented by 20genera Blue green algae were represented 3 genera and dinoflagellates with two genera during the sampling conducted in Neap tide in October,2021. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from88-170units/ L during high tide period and 120-157 units/ L during low tide of Neap Tide.

For the evaluation of the Phytoplankton population in DPT OOT jetty area in Path Finder creek sampling was conducted from one sampling locations ; jetty area during high tide period and low tide of spring tide. For the evaluation of the Phytoplankton population in DPT OOT jetty area in Path Finder creek in Vadinar sampling was conducted from 2 sampling locations ; jetty area and one near SPM during high tide period and low tide of Neap tide.

The phytoplankton community of the sub surface water in the path finder creeks was represented by only Diatoms spring tide period.Diatoms were represented by 9 genera during the sampling conducted in spring tide in October, 2021. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 131 units/ L during high tide period and 147 units/ L during low tide of Spring Tide.

The phytoplankton community of the sub surface water in the path finder creeks was represented by Diatoms, Blue green algae and Dinoflagellatesduring Neap tide period.Diatoms were represented by 10 genera Blue green algae were represented single genera and dinoflagellates by four genera during the sampling conducted in Neap tide in October, 2021. Phytoplankton of the sampling stations at sub surface path finder creek was varying from 203-427 units/ L during high tide period and 544-744 units/ L during low tide of Neap Tide.

Species Richness Indices and Diversity Indices:

Margalef's diversity index (Species Richness)S

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

Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek and nearby creeks sampling stations was varying from 2.059-3.212 with an average of 2.632during the sampling conducted in High tide period of spring tide.While Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek region and nearby creeks was varying from2.687-3.144 with an average of 2.923 during the consecutive low tide period.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations in Kandla creek and nearby creeks was varying from 1.582-3.384 with an average of 2.477 during the sampling conducted in High tide period of Neaptide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek region and nearby creeks was varying from1.582-3.040 with an average of 2.141 during consecutive low tide.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations was 1.641 during the sampling conducted in High tide period of spring tide at Path Finder Creek, Vadinar . While Margalef's diversity index (Species Richness) S of phytoplankton communities in the path finder creek was1.603 during the consecutive low tide period at Path Finder Creek, Vadinar .

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations was varying from 1.981-2.064 during the sampling conducted in consecutive High tide period and low tide period of Neap Tide at jetty area of Path finder Creek. While Margalef's diversity index (Species Richness) S of phytoplankton communities near the SPM was varying from 2.259- 1.512 during the consecutive high tide and low tide period of Neap tide.

Shannon-Wiener's index:

Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.802- 0.935 (H'(log10)) between selected sampling stations with an average value of 0.860 during high tide period of spring tide at Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.858-0.979 (H'(log10)) between selected sampling stations with an average value of 0.909 during consecutive lowtide at Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.774 -0.934 (H'(log10)) between selected sampling stations with an average value of 0.868 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 0.773 -0.927 (H'(log10)) between selected sampling stations with an average value of 0.842during consecutive low tideat Kandla creek and nearby creeks.

Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations in the stations was 0.684 during the sampling conducted in High tide period of spring tide at Path Finder Creek, Vadinar. Shannon-Wiener's Index (H)of phytoplankton communities in the path finder creek was 0.695 during the consecutive low tide period at Path Finder Creek, Vadinar .

Shannon-Wiener's Index (H) of phytoplankton communities in the stations was varying from 0.356-0.255 during the sampling conducted in consecutive High tide period and low tide period of Neap Tide at jetty area of Path finder Creek. While Shannon-Wiener's Index (H) of phytoplankton communities near the SPM was varying from 0.508-0.234 during the consecutive high tide and low tide period of Neap tide.

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

Simpson's diversity index:

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

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks, which was varying from 0.809- 0.852 between selected sampling stations with an average of 0.827 during high tide period of spring tide. Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stationsin the Kandla Harbour region and nearby creeks, which was varying from 0.819- 0.865 between selected sampling stations with an average of 0.840during consecutive low tide .

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in Kandla Harbour region and nearby creeks, during high tide period and low tide period during neap tide also, which was varying from 0.809-0.853 with an average value of 0.835 between selected sampling stations during high tide period and varying from 0.809-0.852 with an average value of 0.831 between selected sampling stations during consecutive low tide period Low species diversity suggests a relatively few successful species in this habitat.

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

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in path finder Creek, which was 0-720 during high tide period and 0.751 during low tide period of spring tide at Jetty region . Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the in path finder Creek, which was varying from 0.720-0.751 at jetty region of path finder creek during consecutive high tide and low tide period of Spring Tide and recorded below 9 at SPM during consecutive high tide and low tide period of Neap tide also , 0.329 - 0.499 during high tide and 0.218-0.201 during low tide

Table # 4PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND ,NEAR BY CREEKS DURING SPRING TIDE IN OCTOBER,2021

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	199	18/24	75	3.212	0.9355	0.8519
	2	209	12/24	50	2.059	0.8018	0.8091
	3	204	14/24	58.3	2.444	0.8451	0.8244
	4	204	17/24	70.83	3.009	0.9095	0.837
	5	199	14/24	58.3	2.456	0.8497	0.8167
	6	46	11/24	45.83	2.612	0.8208	0.8232
LOW TIDE	1	223	18/24	75	3.144	0.9797	0.8653
	2	214	17/24	70.83	2.982	0.9126	0.8446
	3	193	17/24	70.83	3.04	0.919	0.8416
	4	229	16/24	66.66	2.761	0.8806	0.8312
	5	183	15/24	62.5	2.687	0.858	0.8193

Table # 5 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND ,NEAR BY CREEKS DURING NEAP TIDE IN OCTOBER,2021

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	170	18/25	72	3.31	0.9214	0.8451
	2	133	14/25	56	2.658	0.8621	0.8308
	3	142	11/25	44	2.018	0.8693	0.847
	4	152	18/25	72	3.384	0.9173	0.8463
	5	128	12/25	48	2.267	0.8398	0.828
	6	88	14/25	56	2.904	0.9345	0.8406
LOW TIDE	1	143	11/25	44	2.015	0.8355	0.832
	2	149	13/25	52	2.398	0.8822	0.842
	3	139	16/25	64	3.04	0.9274	0.8526
	4	157	9/25	36	1.582	0.7937	0.8176
	5	120	9/25	36	1.671	0.7738	0.8094

Table # 6 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND , NEAR BY CREEKS DURING SPRING TIDE IN OCTOBER, 2021

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	DIATOMS	39-204	19/24	79.2
			BLUE GREEN	3-8	3/24	12.5
			DINOFLAGELLATES	2-9	2/24	8.3
			TOTAL PHYTO PLANKTON	**46-209**	**24**	-
LOW TIDE	Sub surface	5	DIATOMS	176-222	19/24	79.2
			BLUE GREEN	3-8	3/24	12.5
			DINOFLAGELLATES	2-6	2/24	8.3
			TOTAL PHYTO PLANKTON	183-229	**24**	-

Table # 7 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND , NEAR BY CREEKS DURING NEAP TIDE IN OCTOBER,2021

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	DIATOMS	81-164	20/25	80
			BLUE GREEN	1-6	3/25	12
			DINOFLAGELLATES	0-4	2/25	8
			TOTAL PHYTO PLANKTON	**88-170**		
LOW TIDE	Sub surface	5	DIATOMS	117-157	20/25	80
			BLUE GREEN	0-7	3/25	12
			DINOFLAGELLATES	0-4	2/25	8
			TOTAL PHYTO PLANKTON	**120-157**		

Table # 8 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT OOTAT PATH FINDER CREEK , VADINAR &NEAR BY SPM, DURING SPRING TIDE IN OCTOBER, 2021

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	131	9/9	100	1.641	0.6874	0.7201
LOW TIDE	jetty	147	9/9	100	1.603	0.6956	0.7508

Table # 9 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT OOTAT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING NEAP TIDE IN OCTOBER, 2021

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	427	13/15	86.67	1.981	0.3559	0.3291
	SPM	203	13/15	86.67	2.259	0.5079	0.499
LOW TIDE	jetty	544	14/15	93.33	2.064	0.2555	0.2188
	SPM	744	11/15	73.33	1.512	0.2343	0.2011

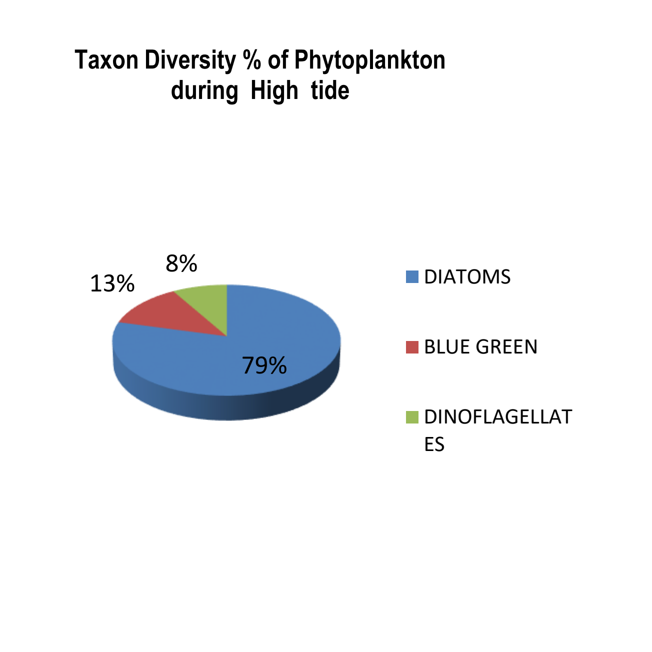
Table # 10 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT DPTOOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING SPRING TIDE IN OCTOBER, 2021

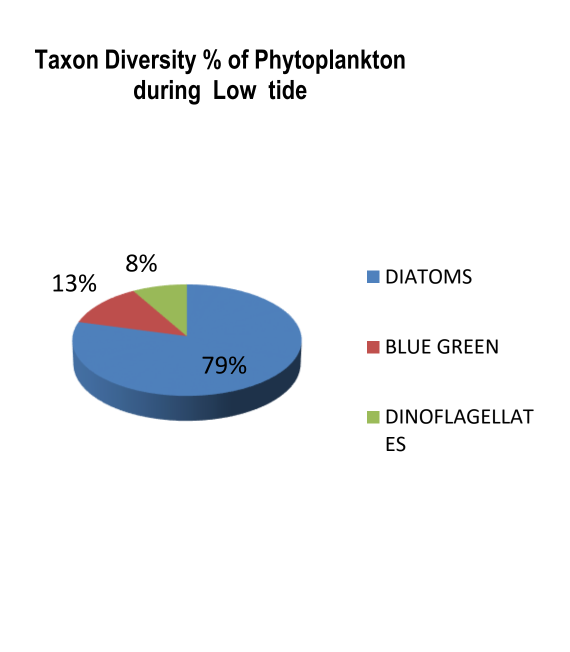
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	1	DIATOMS	131	9/9	100
			TOTAL PHYTO PLANKTON	**131**	**9**	
LOW TIDE	Sub surface	1	DIATOMS	147	9/9	100
			TOTAL PHYTO PLANKTON	147	**9**	

Table # 11 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT DPTOOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING NEAP TIDE IN OCTOBER, 2021

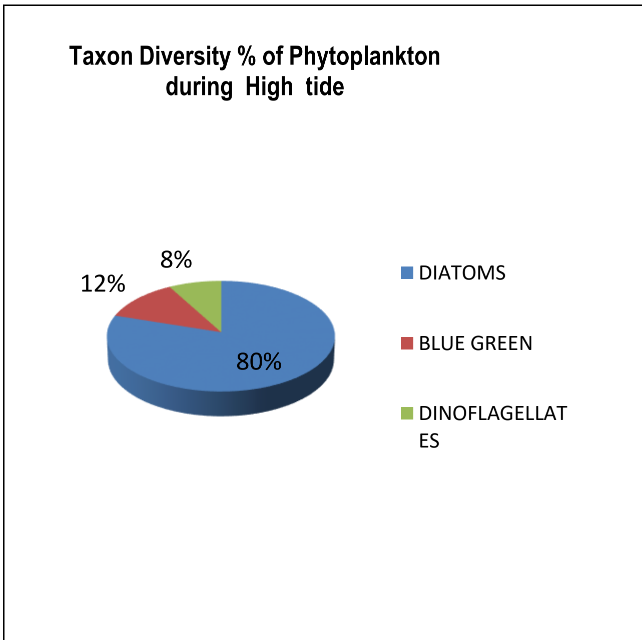
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	DIATOMS	189-424	10/15	66.5
			BLUE GREEN	1-4	1/15	7.5
			DINOFLAGELLATES	4-10	4/15	26.0
			TOTAL PHYTO PLANKTON	**203-427**		
LOW TIDE	Sub surface	2	DIATOMS	480-664		
			BLUE GREEN	2	10/15	66.5
			DINOFLAGELLATES	5-10	1/15	7.5
			TOTAL PHYTO PLANKTON	544-744	4/15	26.0

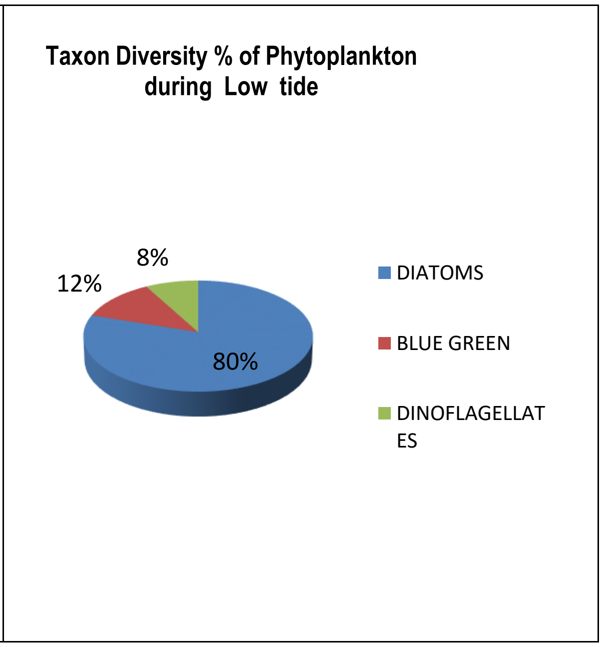
Taxon Diversity % of Phytoplankton during High tide and Low tide period during spring tide in Kandala creek and nearby creeks



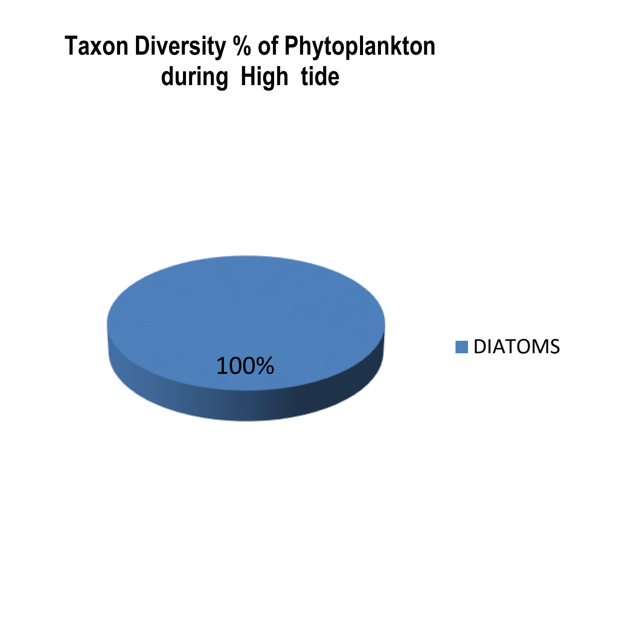


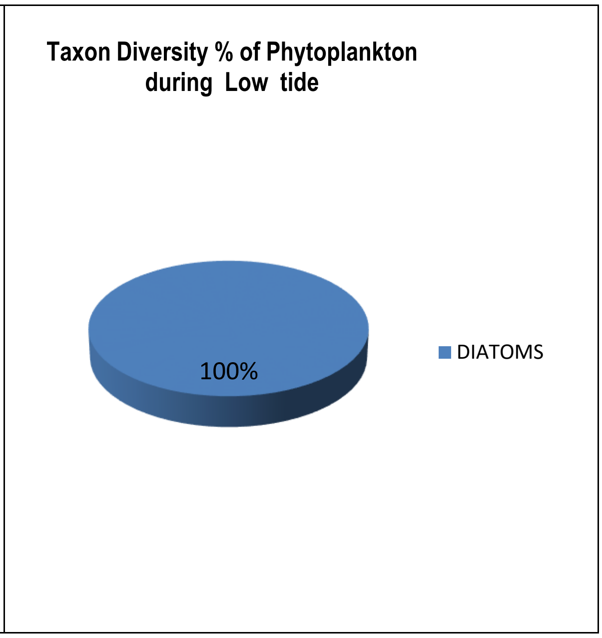
Taxon Diversity % of Phytoplankton during High tide and Low tide period during Neap tide inKandala creek and nearby creeks



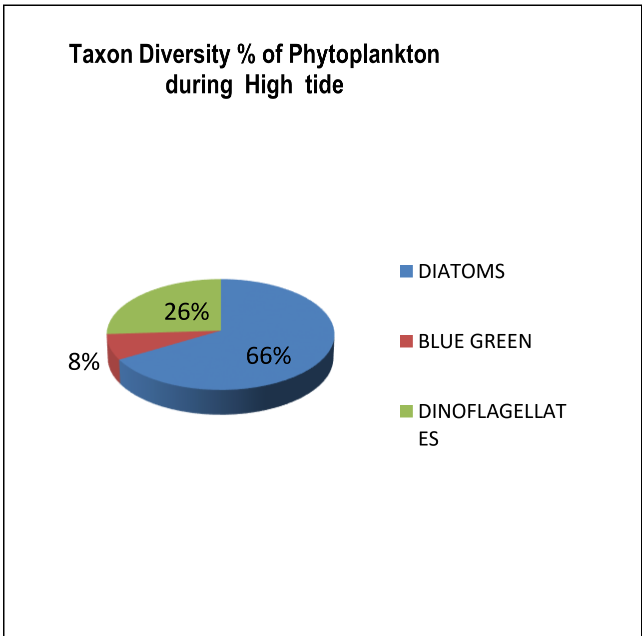


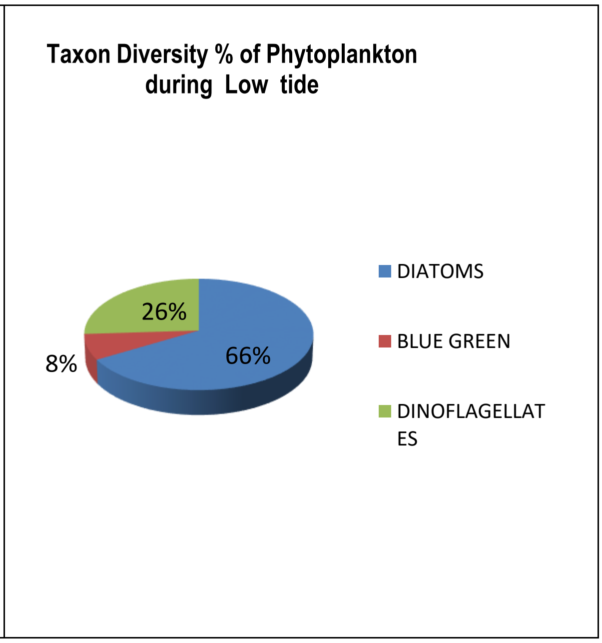
Taxon Diversity % of Phytoplankton during High tide and Low tide period during spring tide in Path Finder Creek, Vadinar





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





ZOOPLANKTON POPULATION:

For the evaluation of the Zooplankton population in DPT harbour area and within the immediate surroundings of the port sampling was conducted from 6 sampling locations (3 in harbour area and two in Nakti creek and one in Khoricreek) during high tide period and low tide period of spring tide and Neap tide in October,2021. The Zooplankton community of the sub surface water in the harbour and nearby creeks during spring tide was represented by mainly 9 groups, and 7 larval forms; Tintinids, Copepods,Rotifers, Arrow worms, Mysids, Urochordates ,Ciliates ,Unidentified medusa and Foraminiferans.Larval forms represented from the group of Crustacea, Molluscansand Polychaetes. The Zooplankton community of the sub surface water in the harbour and nearby creeks during neap tide was represented by mainly 9groups, and Eight larval forms . The major zooplankton group was Tintinids, Copepods, Rotifers, Arrow worms ,Mysids, Urochordata, Ciliates , Medusa and Foraminiferans . Larval forms were represented from the group of Crustaceans ,Echinodermata, Bryozoans , Molluscansand Polychaetes,

Zooplankton of the sampling stations at sub surface layer in the DPT harbour area and nearby creek was varying from 33-132 x10^3 N/ m^3 during high tide and 81-107x10^3 N/ m^3during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPT harbour area and nearby creek was varying from 47-167x10^3 N/ m^3 during high tide and9-112x10^3 N/ m^3during low tide of Neap Tide period.

For the evaluation of the Zoo plankton population in DPT OOT jetty area in Path Finder creek and SPM in Vadinar selected 2 sampling locations (1 in jetty area and one near SPM) Duringspring tide sampling plankton sample were collected only at Jetty area during consecutive high tide period and low tide period. During Neap tide sampling Plankton samples were collected from jetty area and SPM during consecutive high tide period and low tide period.

The Zooplankton community of the sub surface water in the path finder creek creeks during spring tide was represented by mainly two groups, Tintinids, Copepods, and larval forms of Crustacea and Molluscans. The Zooplankton community of the sub surface water in the path Finder creeks at Jetty region and SPM during neap tide was represented by mainly Five groups, Tintinids, Copepods, Arrow worms , Urochordata and ,Mysids .Larval forms were represented from the major group of Crustaceans , Molluscans , Echinodremataand Polychaetes,.

Zooplankton of the sampling stations at sub surface layer in the DPT OOTjetty area of path finder creek was 76 x10^3 N/ m^3 during high tide and 74 x10^3 N/ m^3 during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPT OOTjetty area in path finder creekwas recorded 54x10^3 N/ m^3during high tide and 73 x10^3 N/ m^3 during consecutive low tide period of Neap . Zooplankton of the sampling stations at sub surface layer in the DPT SPM area in path finder creek was recorded 78 x10^3 N/ m^3during high tide and 82 x10^3 N/ m^3 during consecutive low tide period of Neap Tide .

Species Richness Indices and Diversity Indices:

Margalef's diversity index (Species Richness)S

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

Margalef's diversity index (Species Richness) S of Zooplankton communities in the stations Kandla creek region and nearby creeks was varying from 3.146-4.804 with an average of 3.874during the sampling conducted in High tide period.Margalef's diversity index (Species Richness) S of Zooplankton communities varying from.2.842-4.280 with an average of 3.393 during the sampling conducted in low tide period during Spring tide.

Margalef's diversity index (Species Richness) S of Zooplankton communities in the Kandla creek region and nearby creeks sampling stations was varying from3.117- 6.839 with an average of 5.036 during the sampling conducted in high tide and varying from. 3.034 -4.570 with an average of 3.769 during the sampling conducted in low tide during Neap tide period

Margalef's diversity index (Species Richness) S of Zooplankton communities in the sampling stationnear jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 1.847 and 1. 859 respectively..

Margalef's diversity index (Species Richness) S of Zooplankton communities in the two stations at Path finder creek was varying from 3.259-3.443 during the sampling conducted in High tide period of Neap tide. While Margalef's diversity index (Species Richness) S of Zooplankton communities in the two stations at Path finder creekwas varying from 2.797-4.085 during the consecutive 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 0.912 -1.060 (H'(log10)) between selected sampling stations with an average value of 0.992 (H'(log10)) during high tide period of spring tide. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.844-0.965(H'(log10)) between selected sampling stations with an average value of 0.894 (H'(log10)) during consecutive low tide period .

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.834 -1.336 (H'(log10)) between selected sampling stations with an average value of 1.146 (H'(log10)) during high tide period of Neap tide. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.949-1.139 (H'(log10)) between selected sampling stations with an average value of 1.043 (H'(log10)) during consecutive low tide period.

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.775 and 0.822 respectively..

Shannon-Wiener's Index (H)of Zooplankton communities in the two stations at Path finder creek was varying from 0.991-0.927 during the sampling conducted in High tide period of Neap tide. While Shannon-Wiener's Index (H)of Zooplankton communities in the two stations at Path finder creek was varying from 0.815-1.004 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 Zooplankton of Kandla Harbour region and nearby creeks stations is slightly high with very minimum diverse population but very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson's diversity index:

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

Simpson diversity index (1-D) of Zooplankton communities was below 0.9 most of sampling stations in the Kandla Harbour region and nearby creeksduring high tide and low tide of spring tide period, which was varying from 0.848-0.881between selected sampling stations with an average of 0.865 during high tide period and was varying from 0.812- 0.845 with an average value of 0.827 between selected sampling stations during low tide

Simpson diversity index (1-D) of Zooplankton communities was blow 0.9 at all sampling stationsin the Kandla Harbour region and nearby creeks except few during high tide and low tide period, which was varying from 0.793- 0.937 between selected sampling stations with an average of 0.894 during high tide period and was varying from 0.861- 0.910 with an average value of 0.884 between selected sampling stations during consecutive low tide

This high species diversity suggests a relatively more number of successful species in this habitat during October ,2021 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 0.800 and 0.827 respectively..

Simpson diversity index (1-D) of Zooplankton communities in the two stations at Path finder creek was varying from 0.884 -0.838 during the sampling conducted in High tide period of Neap tide. While Shannon-Wiener's Index (H)of Zooplankton communities in the two stations at Path finder creek was varying from 0.816 -0.863 during the consecutive low tide period.

Table # 12 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND NEAR BY CREEKS DURING SPRING TIDE IN OCTOBER,2021

Tide	Sampling Station	Abundance In N / m³	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	120 x10³	24/32	75	4.804	1.06	0.8695
	2	105 x10³	21/32	65.62	4.297	1.045	0.8753
	3	132 x10³	18/32	56.25	3.482	0.9555	0.8523
	4	117 x10³	18/32	56.25	3.57	1.032	0.8811
	5	123 x10³	20/32	62.50	3.948	0.9513	0.8481
	6	33 x10³	12/32	37.5	3.146	0.9125	0.8636
LOW TIDE	1	97 x10³	14/32	43.75	2.842	0.8439	0.8174
	2	107 x10³	21/32	65.63	4.28	0.9654	0.8455
	3	81 x10³	15/32	46.87	3.186	0.9009	0.8315
	4	93 x10³	16/32	50	3.309	0.8669	0.8125
	5	88 x10³	16/32	50	3.35	0.8971	0.8325

Table # 13 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREAAT KANDLA CREEK AND NEAR BY CREEKS DURING NEAP TIDE IN OCTOBER,2021

Tide	Sampling Station	Abundance In No / m³	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	167 x10³	36/37	97.30	6.839	1.336	0.9367
	2	124 x10³	28/37	75.68	5.601	1.282	0.9373
	3	133 x10³	24/37	64.86	4.703	1.163	0.9108
	4	144 x10³	29/37	78.38	5.634	1.19	0.8993
	5	102 x10³	21/37	56.75	4.324	1.075	0.8893
	6	47 x10³	13/37	35.13	3.117	0.834	0.7928
LOW TIDE	1	112 x10³	18/37	48.65	3.603	0.9973	0.8637
	2	90 x10³	19/37	51.35	4	1.065	0.8974
	3	99 x10³	22/37	59.46	4.57	1.139	0.9105
	4	107 x10³	18/37	48.65	3.638	1.068	0.8889
	5	101 x10³	15/37	40.54	3.034	0.9498	0.861

Table # 14 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREAATKANDLA CREEK AND ,NEAR BY CREEKS DURING SPRING TIDE IN OCTOBER,2021

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton x10^3 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinids	3-21	6/32	18.75
			Copepods	13-68	10/32	31.25
			Rotifers	0-4	1/32	3.13
			Arrow worms	0-2	1/32	3.13
			Mysids	0-2	2/32	6.25
			Urochordata	0-1	1/32	3.12
			Ciliates	1-7	1/32	3.12
			Medusa	0-1	1/32	3.12
			Larval forms	11-43	7/32	21.88
			Foraminiferans	0-1	2/32	6.25
			TOTAL ZOOPLANKTON N/ M^3	**33-132**	**32**	
LOW TIDE	Sub surface	5	Tintinids	4-15	6/32	18.75
			Copepods	45-59	10/32	31.25
			Rotifers	0-1	1/32	3.13
			Arrow worms	0-1	1/32	3.13
			Mysids	0-1	2/32	6.25
			Urochordata	0-1	1/32	3.12
			Ciliates	1-6	1/32	3.12
			Medusa	0	1/32	3.12
			Larval forms	22-33	7/32	21.88
			Foraminiferans	0-2	2/32	6.25
			TOTAL ZOOPLANKTON N/M^3	**81-107**	**32**	

Table # 15 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA IN KANDLA CREEK AND , NEAR BY CREEKS DURING NEAP TIDE IN OCTOBER, 2021

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^3$ Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinids	2-26	6/37	16.22
			Copepods	18-76	11/37	29.73
			Rotifers	0-2	1/37	2.70
			Mysids	0-6	4/37	10.81
			Arrow worms	0-4	1/37	2.70
			Urochordata	0-4	1/37	2.70
			Ciliates	0-8	1/37	2.70
			Medusa	0-4	1/37	2.70
			Larval forms	20-46	9/37	24.32
			Foraminiferans	0-6	2/37	5.42
			TOTAL ZOOPLANKTON N/M^3	**47-165**		
LOW TIDE	Sub surface	5	Tintinids	13-22	6/37	16.22
			Copepods	42-47	11/37	29.73
			Rotifers	0	1/37	2.70
			Mysids	0-4	4/37	10.81
			Arrow worms	0-1	1/37	2.70
			Urochordata	0-2	1/37	2.70
			Ciliates	1-5	1/37	2.70
			Medusa	0	1/37	2.70
			Larval forms	21-40	9/37	24.32
			Foraminiferans	**0-5**	2/37	5.42
			TOTAL ZOOPLANKTON N/M^3	**89-112**		

Table # 16 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING SPRING TIDE IN OCTOBER,2021

Tide	Sampling Station	Abundance In 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	76 x10^3	9/9	100	1.847	0.7749	0.8004
LOW TIDE	Jetty	74 x10^3	9/9	100	1.859	0.8222	0.8278

Table # 17 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING NEAP TIDE IN OCTOBER,2021

Tide	Sampling Station	Abundance In 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	54 $x10^3$	14/23	60.87	3.259	0.9911	0.884
	SPM	78 $x10^3$	16/23	69.56	3.443	0.9276	0.8385
LOW TIDE	Jetty	73 $x10^3$	13/23	56.52	2.797	0.8156	0.8166
	SPM	82 $x10^3$	19/23	82.61	4.085	1.004	0.863

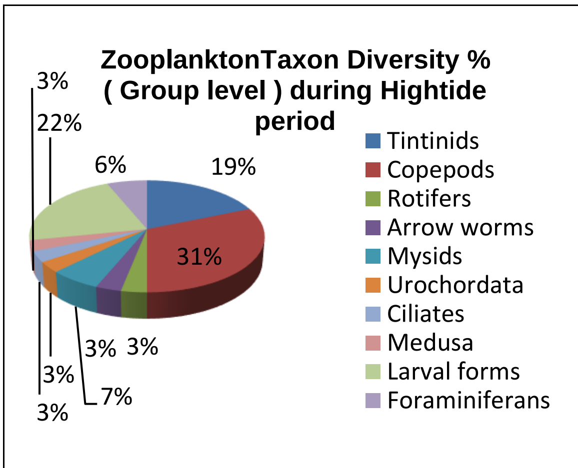
Table # 18 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT OOT AREAAT PATH FINDER CREEK AND NEAR BY SPM DURING SPRING TIDE IN OCTOBER,2021

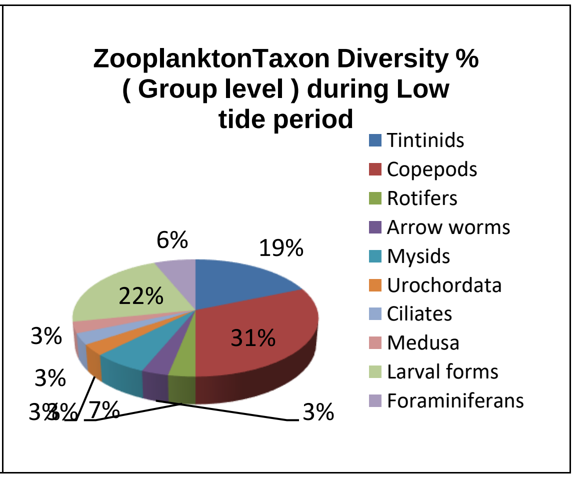
Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $x10^3$ Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	1	Tintinids	40	5/9	55.56
			Copepods	18	2/9	22.22
			Larval forms	18	2/9	22.22
			TOTAL ZOOPLANKTON NO/L	**76**	**9**	
LOW TIDE	Sub surface	1	Tintinids	38	5/9	55.56
			Copepods	16	2/9	22.22
			Larval forms	20	2/9	22.22
			TOTAL ZOOPLANKTON NO/M3	**74**	**9**	

Table # 19 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT OOT AREAAT PATH FINDER CREEK AND NEAR BY SPM DURING NEAP TIDE IN OCTOBER, 2021

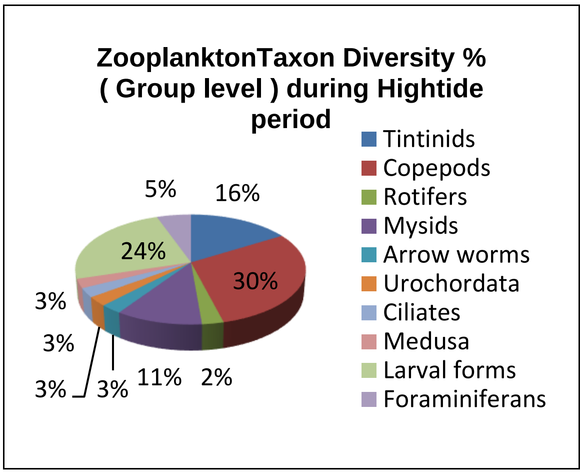
Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton x10^3 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	Tintinids	1-2	2/23	8.70
			Copepods	30-45	8/23	34.78
			Arrow worms	0-1	1/23	4.35
			Mysids	4-9	4/23	17.39
			Urochordata	2-4	1/23	4.35
			Larval forms	12-22	7/23	30.43
			TOTAL ZOOPLANKTON	**41-60**		
LOW TIDE	Sub surface	2	Tintinids	1-2	2/23	8.70
			Copepods	49-53	8/23	34.78
			Arrow worms	1	1/23	4.35
			Mysids	2-5	4/23	17.39
			Urochordata	1	1/23	4.35
			Larval forms	19-20	7/23	30.43
			TOTAL ZOOPLANKTON NO/M3	**73-82**		

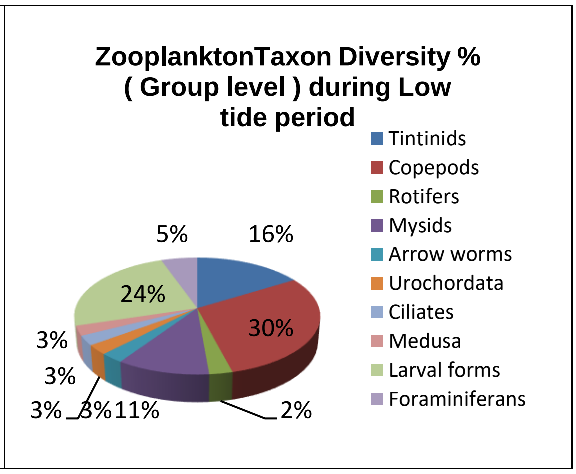
Taxon Diversity % of Zooplankton during High tide and Low tide period of Spring tide In Kandla Creek and nearby Creeks



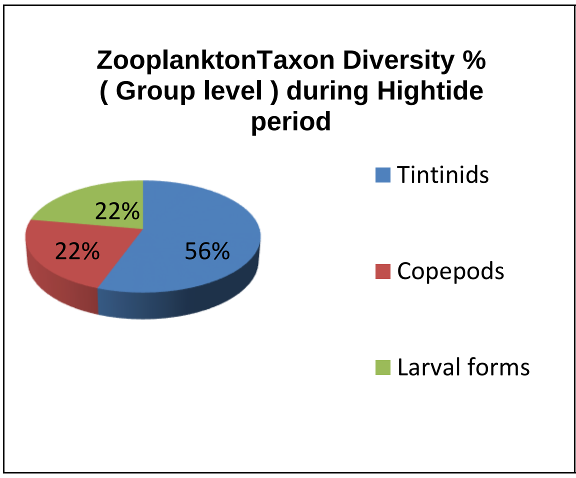


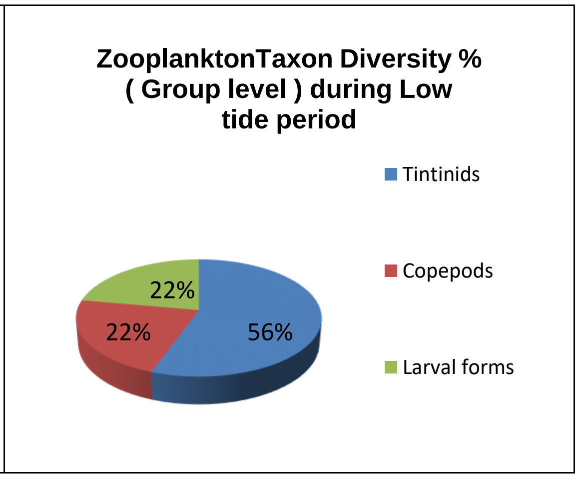
Taxon Diversity % of Zooplankton during High tide and Low tide period of Neap tide In Kandla Creek and nearby Creeks



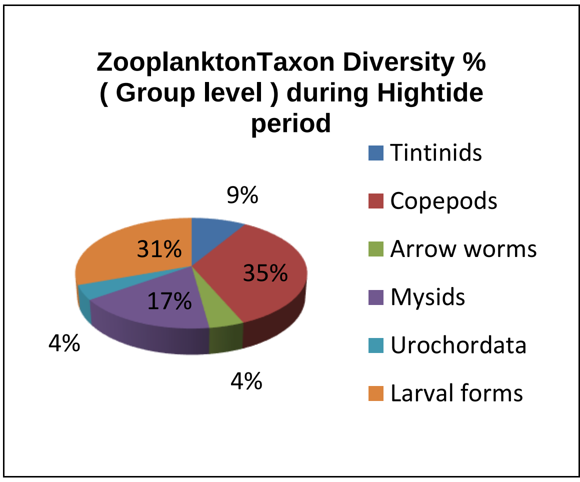


Taxon Diversity % of Zooplankton during High tide and Low tide period of Spring tide In Path Finder Creek and near Jetty





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



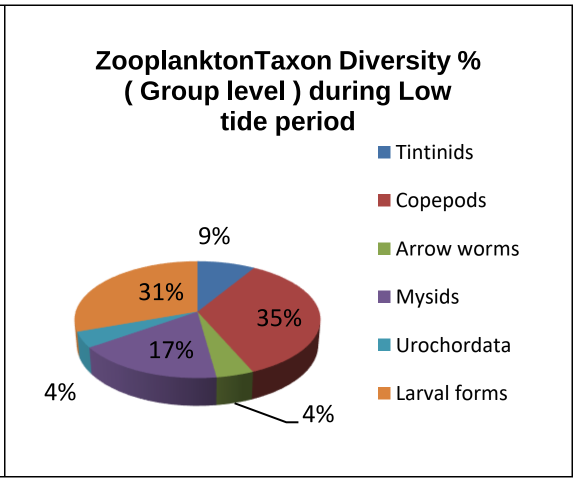


TABLE # 20SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS OF DPT HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURINGSPRING TIDE OF OCTOBER 2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAE	Cyanophyta	Cyanophyceae	Nostocales	Oscillatoriaceae	*Oscillatoria* sp.	B1	Occasional
					Arthrospira sp.	B2	Rare
			Stigonematales	Stigonemataceae	*Stigonema sp.*	B3	Occasional
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Thalassiosirales	Thalassiosiraceae	*Planktoniella*sp	D1	Occasional
			Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D2	Dominant
			Triceratiales	Triceratiaceae	*Odontella*sp	D3	Occasional
					*Triceratium*sp.	D4	Rare
			Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D5	Abundant
			Hemiaulales	Bellerocheaceae	*Bellerochea*sp	D6	Rare
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D7	Rare
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros*sp	D8	Frequent
			Leptocylindrales	Leptocylindraceae	*Leptocylindrus*sp	D9	Occasional
			Lithodesmiales	Lithodesmiaceae	*Ditylum*sp	D10	Dominant
			Melosirales	Melosiraceae	*Melosira*sp	D11	Rare
		Bacillariophyceae	Naviculales	Pleurosigmataceae	*Pleurosigma*sp	D12	Rare
			Surirellales	Surirellaceae	*Surirella*sp	D13	Rare
		Fragilariophyceae	Thalassionematales	Thalassionemataceae	*Thalassiothrix sp.*	D14	Abundant
					Thalassionema sp.	D15	Rare
			Fragilariales	Fragilariaceae	*Asterionellopsis sp.*	D16	Occasional
					*Fragilaria*sp	D17	Frequent
					*Synedra*sp	D18	Rare
			Tabellariales	Tabellariaceae	*Tabellaria*sp	D19	Rare
DINO FLAGELLATES	Dinoflagellata / Dinozoa	Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Rare
			Gonyaulacales	Ceratiaceae	*Ceratiumfurca*	DF2	Occasional

TABLE # 21 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPT HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING AND NEAP TIDE OF OCTOBER,2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAE	Cyanophyta	Cyanophyceae	Nostocales	Oscillatoriaceae	*Oscillatoria* sp.	B1	Rare
					Arthrospira sp.	B2	Rare
			Stigonematales	Stigonemataceae	*Stigonema sp.*	B3	Rare
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Thalassiosirales	Thalassiosiraceae	*Planktoniellasp*	D1	Occasional
					Thalassiosirasp	D2	Rare
			Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D3	Dominant
			Triceratiales	Triceratiaceae	*Odontellasp*	D4	Occasional
					*Triceratium*sp.	D5	Rare
			Biddulphiales	Biddulphiaceae	*Biddulphiasp*	D6	Abundant
			Hemiaulales	Bellerocheaceae	*Bellerochea*sp	D7	Rare
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D8	Rare
			Chaetocerotales	Chaetocerotaceae	*Chaetocerossp*	D9	Frequent
			Leptocylindrales	Leptocylindraceae	*Leptocylindrussp*	D10	Occasional
			Lithodesmiales	Lithodesmiaceae	*Ditylumsp*	D11	Dominant
		Bacillariophyceae	Naviculales	Naviculaceae	*Naviculasp*	D12	Rare
				Pleurosigmataceae	*Gyrosigmasp*	D13	Rare
					Pleurosigmasp	D14	Rare
			Surirellales	Surirellaceae	*Surirellasp*	D15	Rare
		Fragilariophyceae	Thalassionematales	Thalassionemataceae	*Thalassiothrix sp.*	D16	Abundant
					Thalassionema sp.	D17	Rare
			Fragilariales	Fragilariaceae	*Fragilariasp*	D18	Frequent
					Synedrasp	D19	Rare
			Tabellariales	Tabellariaceae	*Tabellaria*sp	D20	Rare
DINO FLAGELLATES	Dinoflagellata / Dinozoa	Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Rare
			Gonyaulacales	Ceratiaceae	*Ceratiumfurca*	DF2	Occasional

TABLE # 22 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPT OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING SPRING TIDE OF OCTOBER 2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D1	Occasional
			Triceratiales	Triceratiaceae	*Triceratium*sp.	D2	Rare
			Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D3	Rare
			Hemiaulales	Bellerocheaceae	*Bellerochea*sp	D4	Rare
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D5	Rare
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros*sp	D6	Dominant
			Lithodesmiales	Lithodesmiaceae	*Ditylum*sp	D7	Occasional
			Bacillariales	Bacillariaceae	*Pseudo-Nitzschia*sp	D8	Abundant
		Fragilariophyceae	Thalassionematales	Thalassionemataceae	*Thalassiothrix sp.*	D9	Frequent

TABLE # 23 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPT OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING AND NEAP TIDE OF OCTOBER, 2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAE	Cyanophyta	Cyanophyceae	Nostocales	Oscillatoriaceae	*Oscillatoria* sp.	B1	Rare
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Thalassiosirales	Thalassiosiraceae	*Planktoniella*sp	D1	Occasional
				Lauderiaceae	*Lauderia*sp	D2	Rare
			Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D3	Abundant
			Hemiaulales	Bellerocheaceae	*Bellerochea*sp	D4	Occasional
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D5	Rare
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros*sp	D6	Dominant
			Lithodesmiales	Lithodesmiaceae	*Ditylum*sp	D7	Occasional
		Bacillariophyceae	Naviculales	Pleurosigmataceae	*Pleurosigma*sp	D8	Rare
			Bacillariales	Bacillariaceae	*Pseudo-Nitzschia*sp	D9	Frequent
			Fragilariales	Fragilariaceae	*Synedra*sp	D10	Rare

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
DINO FLAGELLATES	Dinoflagellata / Dinozoa	Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Rare
			Gonyaulacales	Ceratiaceae	*Ceratiumfurca*	DF2	Occasional
					Ceratiumfusus	DF3	Rare
					Ceratiumtripos	DF4	Rare

TABLE #24 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPT HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKSDURING SPRING TIDE OF OCTOBER,2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnussp.*	T1	Occasional
				Codonellidae	*Tintinnopsisdadayi*	T2	Rare
					Tintinnopsisgracilis	T3	Occasional
					Tintinnopsis radix	T4	Rare
					Tintinnopsisfailakkaensis	T5	Occasional
				Xystonellidae	*Favella* sp.	T6	Rare
COPEPODS	ATHROPODA	Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Abundant
					Bestiolina sp.	C2	Rare
				Eucalanidae	*Subeucalanus sp.*	C3	Rare
				Clausocalanidae	*Clausocalanus sp.*	C4	Occasional
				Centropagidae	*Centropages sp.*	C5	Rare
				Acartiidae	*Acartia sp.*	C6	Rare
			Cyclopoida	Oithonidae	*Oithona sp.*	C7	Dominant
			Harpacticoida	Ectinosomatidae	*Microsetella*sp.	C8	Rare
				Euterpinidae	*Euterpina sp.*	C9	Frequent
			Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C10	Rare
ROTIFERS	ROTIFERA	Rotifera Subclass: Eurotatoria	Superorder: Monogononta Order:Ploimida	Brachionidae	*Brachionusplicatilis*	R1	Rare
ARROW WORMS	CHAETOGNATHA	Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Rare
MYSIDS	ATHROPODA CRUSTACEA	Malacostraca	Mysida, Decapoda	Penaeidae	*Metapenaeussp.*	M1	Rare
					Penaeussp.	M2	Rare

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
UROCHORDATA	CHORDATA SUB PHYLUM UROCHORDATA	Appendicularia		Oikopleuridae	*Oikopleura sp.*	U1	Rare
CILIATES	CILIOPHORA	Oligohymenophorea	Sessilida	Zoothamniidae	*Zoothamniumsp.*	CI1	Occasional
MEDUSA	PHYLUM CNIDARIA	Hydrozoa			Unidentified medusa	ME1	Rare
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of Copepods	L1	Dominant
BRACHYURA LARVAE	ARTHROPODA (CRUSTACEA)	Malacostraca Decapoda			Brachyuran Zoea larvae	L2	Rare
BARNACLE LARVAE	ATHROPODA CRUSTACEA	Maxillopoda Thecostraca			Cirripede larvae	L3	Rare
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L4	Rare
CHORDATA	VERTEBRATA	Pisces			Fish larvae	L5	Rare
POLYCHAETE LARVAE	ANNELIDA	Polychaeta			Trochophore larvae	L6	Occasional
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of Bivalves	L7	Rare
FORAMINIFERA	FORAMINIFERA	Globothalamea	Rotaliida	Globigerinidae	*Globigerina* sp.	F1	Rare
				Rotalliidae	*Rotalia* sp.	F2	Rare

TABLE # 25 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING OF DPT HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKSDURING NEAP TIDE OF OCTOBER,2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnussp.*	T1	Frequent
				Codonellidae	*Tintinnopsisdadayi*	T2	Rare
					Tintinnopsisgracilis	T3	Rare
					Tintinnopsis radix	T4	Occasional
					Tintinnopsisfailakkaensis	T5	Rare
				Codonellopsidae	*Codonellopsis* sp.	T6	Rare
COPEPODS	ATHROPODA	Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Abundant
				Eucalanidae	*Pareucalanus sp.*	C2	Rare
					Subeucalanus sp.	C3	Rare
				Clausocalanidae	*Clausocalanus sp.*	C4	Occasional
				Centropagidae	*Centropages sp.*	C5	Rare
				Temoridae	*Temora sp.*	C6	Rare
				Acartiidae	*Acartia sp.*	C7	Occasional
			Cyclopoida	Oithonidae	*Oithona sp.*	C8	Abundant
			Harpacticoida	Ectinosomatidae	*Microsetella*sp.	C9	Occasional
				Euterpinidae	*Euterpina sp.*	C10	Frequent
			Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C11	Rare
ROTIFERS	ROTIFERA	Rotifera Subclass: Eurotatoria	Superorder: Monogononta Order:Ploimida	Brachionidae	*Brachionusplicatilis*	R1	Rare
ARROW WORMS	CHAETOGNATHA	Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Rare
MYSIDS	ATHROPODA CRUSTACEA	Malacostraca	Mysida, Decapoda	Solenoceridae	*Solenocerasp.*	M1	Rare
				Penaeidae	*Metapenaeussp.*	M2	Rare
					Penaeussp.	M3	Rare
				Luciferidae	*Lucifer sp.*	M4	Rare
UROCHORDATA	CHORDATA SUB PHYLUM UROCHORDATA	Appendicularia		Oikopleuridae	*Oikopleura sp.*	U1	Rare
CILIATES	CILIOPHORA	Oligohymenophorea	Sessilida	Zoothamniidae	*Zoothamniumsp.*	CI1	Occasional

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
MEDUSA	PHYLUM CNIDARIA	Hydrozoa			Unidentified medusa	ME1	Rare
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of Copepods	L1	Dominant
BRACHYURA LARVAE	ARTHROPODA (CRUSTACEA)	Malacostraca Decapoda			Brachyuran Zoea larvae	L2	Occasional
BARNACLE LARVAE	ATHROPODA CRUSTACEA	Maxillopoda Thecostraca			Cirripede larvae	L3	Rare
CYPHONAUTES LARVAE	BRYOZOA				Cyphonautes larvae	L4	Occasional
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L5	Rare
ECHINODERMATA LARVAE	ECHINODERMATA				Ophipluutes larvae/ Echinoplutes larvae	L6	Rare
CHORDATA	VERTEBRATA	Pisces			Fish larvae	L7	Rare
POLYCHAETE LARVAE	ANNELIDA	Polychaeta			Trochophore larvae	L8	Occasional
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of Bivalves	L9	Rare
FORAMINIFERA	FORAMINIFERA	Globothalamea	Rotaliida	Globigerinidae	*Globigerina* sp.	F1	Occasional
				Rotalliidae	*Rotalia* sp.	F2	Rare

TABLE # 26 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPT OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING SPRING TIDE OF OCTOBER,2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnussp.*	T1	Dominant
				Codonellidae	*Tintinnopsisgracilis*	T2	Occasional
					Tintinnopsis radix	T3	Occasional
					Tintinnopsistocantinensis	T4	Occasional
				Xystonellidae	*Favella* sp.	T5	Rare
COPEPODS	ATHROPODA	Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Occasional
			Cyclopoida	Oithonidae	*Oithona sp.*	C2	Frequent
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of Copepods	L1	Abundant
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of Bivalves	L2	Rare

TABLE # 27 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPT OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING NEAP TIDE OF OCTOBER,2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnussp.*	T1	Rare
				Xystonellidae	*Favella* sp.	T2	Rare
COPEPODS	ATHROPODA	Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Dominant
				Eucalanidae	*Pareucalanus sp.*	C2	Rare
					Subeucalanus sp.	C3	Rare
				Clausocalanidae	*Clausocalanus sp.*	C4	Occasional
				Tortanidae	*Tortanus sp.*	C5	Rare
			Cyclopoida	Oithonidae	*Oithona sp.*	C6	Abundant
			Harpacticoida	Euterpinidae	*Euterpina sp.*	C7	Frequent
			Poicilostomatatoida	Corycaeidae	*Corycaeus sp.*	C8	Rare

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
ARROW WORMS	CHAETOGNATHA	Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Rare
MYSIDS	ATHROPODA CRUSTACEA	Malacostraca	Mysida, Decapoda	Solenoceridae	*Solenocerasp.*	M1	Rare
				Penaeidae	*Metapenaeussp.*	M2	Rare
					Penaeussp.	M3	Rare
				Luciferidae	*Lucifer sp.*	M4	Rare
UROCHORDATA	CHORDATA SUB PHYLUM UROCHORDATA	Appendicularia		Oikopleuridae	*Oikopleura sp.*	U1	Rare
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of Copepods	L1	Frequent
BRACHYURA LARVAE	ARTHROPODA (CRUSTACEA)	Malacostraca Decapoda			Brachyuran Zoea larvae	L2	Rare
BARNACLE LARVAE	ATHROPODA CRUSTACEA	Maxillopoda Thecostraca			Cirripede larvae	L3	Rare
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L4	Rare
ECHINODERMATA LARVAE	ECHINODERMATA				Ophipluutes larvae/ Echinoplutes larvae	L5	Rare
POLYCHAETE LARVAE	ANNELIDA	Polychaeta			Trochophore larvae	L6	Occasional
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of Bivalves	L7	Rare

BENTHIC ORGANISMS:

Few Benthic organismswere observed in the collected sediments by using the Van-veen grabs during the sampling conducted during spring tide period and while no Benthic organisms were observed during sampling conducted in Neap tide period from DPT harbour region and nearby creek except few dead shells.The meiobenthic organisms during spring tide were represented by Polychaetes,and Nematodes. The polychaetes were represented by *Scyphoproctus sp.* ,during spring tide sampling.The meiobenthic organisms in the collected samples were varying from 40-60N/M ^{2}during spring tide

Table # 28BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPT HARBOUR AREA CREEKS DURING NEAP TIDE IN OCTOBER ,2021

Benthic fauna	ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS REPRESENTATION BY GROUP						
	DPT HARBOUR			CREEKS			
POLYCHAETES	KPT-1	KPT-2	KPT-3	KPT-4	KPT-5	KPT-6	
Family : Capitellidae **Scyphoproctus** *sp.*	20	40	20	20	20	NS	
Total Polychates N/M^2	20	40	20	20	20	NS	
Un identified Nematode worms	40	20	20	40	20	NS	
TOTAL Benthic Fauna NUMBER/ M^2	60	60	40	60	40	-	

NS : No sample

7. Meteorological Data

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

Temperature

The mean day time temperature for Deendayal Port was 30.3 °C. The day-time maximum temperature was 38.6 °C. The mean night time temperature was 26.5 °C. The minimum mean night time temperature recorded was 30.6 °C.

Air Pressure

The mean absolute air pressure for the month of October was 1009.9 hpa, whereas the mean relative pressure was 1009.3 hpa. The maximum absolute air pressure recorded for the month of October was 1016.5 hpa.

Heat Index

The mean day-time heat index for the month of October was 33.8 ^{o}C. The maximum heat index recorded was 55^{o}C.

Solar Radiation

The mean Solar Radiation in October was 252.2 w/m^2. The maximum solar radiation recorded in the month of October was 746.6 w/m^2.

Humidity

The mean day-time humidity was 60.0 % for the month of October and mean night time humidity was 72.4%. Maximum humidity recorded during day-time was 94.0 % and maximum humidity recorded during night-time was 93.0%.

Wind Velocity and Wind Direction

The mean wind velocity for the entire month of October was 4.6 km/hour. Maximum wind velocity recorded was 29.2 Km/hr . The wind direction was mostly S to N.

Conclusive Summary and Remedial measures Suggested

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

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

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

- The sewage treated water of Deendayal Port Colony (Gopalpuri) was in line with the standards set by the Gujarat Pollution Control Board. The STP at Deendayal Port is not fully operational and STP at Vadinar Port was found non-operational.

Reasons for higher Values of PM_{10}

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

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

Remedial Measures

The values of PM_{10} during the month of October, 2021 were observed beyond the permissible limit at four locations mentioned above. Given below are the remedial measures suggest to minimize the Air pollution at Deendayal Port.

- Guidelines for Coal Handling by GPCB should be strictly followed. (http://gpcb.gov.in/pdf/coal-handling-guidelines.pdf)
- Except for the higher values of PM_{10} at Coal storage site, Oil Jetty, Tuna Port and Marine Bhavan locations, the monitoring results for the present month suggest that the overall Environment Quality of Deendayal Port is satisfactory.

SOURCE OF LITERATURE AND ADDITIONAL REFERENCE FOR ECOLOGICAL STUDY

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ENVIRONMENTAL MONITORING REPORTFOR

DEENDAYAL PORT TRUST

REPORT	:	DCPL/DPT/20-21/19
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Introduction

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

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

1. Ambient Air Quality Monitoring

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

1.1 Air Quality Monitoring Methodology

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

1.2 Results

The ambient air quality monitoring data for six stations, viz. Marine Bhavan, Oil Jetty, Port Colony,Gopalpuri Hospital,Tuna Port and Nr. Coal Storage Area for the month of November 2021 are given in Tables 1A to 6B. The ambient air quality monitoring data for two stations at Vadinar (Nr. Admin Building &Nr. Signal Building) are given in Tables 7A to 8B.

Location 1: Marine Bhavan (AL1)

Table 1 : Results of Air Pollutant Concentration at Marine Bhavan										
Parameter	**Date**	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period	**-**	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit	**-**	**NS**	**100 µg/m3**	**60 µg/m3**		**80 µg/m3**		**80 µg/m3**		**400 µg/m3**
AL1 – 1	01.11.21	326	193	86	3.52	3.96	22.23	21.60	9.70	10.21
					4.84		19.69		9.96	
					3.52		22.87		10.98	
AL1 – 2	09.11.21	303	156	90	5.71	6.15	15.88	20.54	13.02	13.36
					6.15		17.15		12.76	
					6.59		28.58		14.30	
AL1 – 3	12.11.21	402	191	96	7.47	6.74	28.58	27.31	11.49	11.49
					7.03		32.39		13.27	
					5.71		20.96		9.70	
AL1 – 4	17.11.21	438	180	90	3.08	2.64	19.69	16.73	15.57	16.00
					2.20		14.61		18.12	
					2.64		15.88		14.30	
AL1 – 5	19.11.21	530	156	88	4.40	4.40	20.96	20.54	5.62	9.19
					5.28		18.42		11.49	
					3.52		22.23		10.47	
AL1 - 6	24.11.21	468	182	90	2.64	3.52	14.61	16.30	10.98	7.49
					5.28		20.96		6.64	
					2.64		13.34		4.85	
AL1 - 7	26.11.21	597	274	92	3.52	2.93	14.61	17.78	14.30	10.89
					3.08		19.69		9.96	
					2.20		19.05		8.42	
AL1 – 8	29.11.21	613	210	90	2.20	2.78	26.04	24.98	10.47	8.00
					2.64		29.22		6.38	
					3.52		19.69		7.15	
Monthly Average		460	193	90		4.14		20.72		10.83
Standard Deviation		116	38	3		1.55		3.90		2.82

NS: Not Specified

Table 1B : Results of Air Pollutant Concentration at Marine Bhavan					
Parameter	**Date**	**C_6H_6 [µg/m^3]**	**HC* ppm**	**CO [mg/m^3]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m^3**	**NS**	**4.0 mg/m^3**	**NS**
AL1 – 1	1.11.21	1.27	BQL	2.15	581
AL1 – 2	9.11.21	1.12	BQL	1.9	497
AL1 – 3	12.11.21	1.11	BQL	1.94	361
AL1 – 4	17.11.21	1.05	BQL	2.04	357
AL1 – 5	19.11.21	1.12	BQL	1.85	541
AL1 - 6	24.11.21	1.38	BQL	1.91	561
AL1 – 7	26.11.21	1.07	BQL	1.98	567
AL1 – 8	29.11.21	1.14	BQL	2.21	541
Monthly Average		**1.16**	**-**	**2.00**	**501**
Standard Deviation		**0.11**	**-**	**0.13**	**91**

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

At Marine Bhavan, the overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_X and NH_3 is attributed mainly by motor vehicle emission produced from various types of automobiles (both diesel and petrol driven). Moreover, the loading and unloading of Food Grains and Timber at Jetty no. 1 and 2 also contributes to the high levels of TSPM and PM_{10}. The mean TSPM value at Marine Bhavan was 460 µg/m^3, The mean PM_{10} values were 193.0 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean 90.0 µg/m^3). The average values of SO_2, NO_x and NH_3 were within the permissible limit. The average values of SO_2, NO_x and NH3 were 4.14 µg/ m^3, 20.72 µg/ m^3 & 10.83 µg/ m^3 respectively. These were within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Marine Bhavan. The mean Benzene concentration was 1.16 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC’s were below the detectable limit and Carbon Monoxide concentration was 2.0 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 2: Oil Jetty (AL2)

Table 2 : Results of Air Pollutant Concentration at Oil Jetty										
Parameters	**Date**	**TSPM** [µg/m3]	**PM10** [µg/m3]	**PM2.5** [µg/m3]	**SO2** [µg/m3]		**NOx** [µg/m3]		**NH3** [µg/m3]	
Sampling Period	**-**	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit	**-**	**NS**	**100 µg/m3**	**60 µg/m3**	**-**	**80 µg/m3**	**-**	**80 µg/m3**	**-**	**400 µg/m3**
AL2 – 1	01.11.21	421	151	92	3.96	3.66	17.15	15.67	13.79	14.81
					4.40		13.34		15.06	
					2.64		16.51		15.57	
AL2 – 2	09.11.21	532	176	89	1.76	2.93	13.34	12.49	6.13	9.70
					2.64		11.43		11.23	
					4.40		12.70		11.74	
AL2 – 3	12.11.21	539	180	96	7.03	8.79	32.39	25.19	4.85	7.32
					9.23		20.96		7.91	
					10.11		22.23		9.19	
AL2 – 4	17.11.21	510	200	101	3.96	2.93	15.88	15.24	7.91	9.79
					2.20		16.51		11.49	
					2.64		13.34		9.96	
AL2 – 5	19.11.21	407	234	98	3.52	2.49	17.78	19.48	9.19	8.00
					2.20		24.77		5.87	
					1.76		15.88		8.93	
AL2 – 6	24.11.21	520	152	100	7.03	6.45	20.96	15.88	5.87	8.42
					8.35		11.43		8.93	
					3.96		15.24		10.47	
AL2 – 7	26.11.21	434	150	98	1.32	1.90	22.87	19.69	9.19	10.04
					1.76		15.24		13.02	
					2.64		20.96		7.91	
AL2 – 8	29.11.21	551	278	100	2.20	2.93	16.51	18.42	6.64	9.02
					2.64		22.87		9.45	
					3.96		15.88		10.98	
Monthly Average		489	190	97		4.01		17.76		9.64
Standard Deviation		59	46	4		2.37		3.86		2.29

NS: Not Specified

Table 2B : Results of Air Pollutant Concentration at Oil Jetty					
Parameter	**Date**	**C_6H_6 [µg/m^3]**	**HC* ppm**	**CO [mg/m^3]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m^3**	**NS**	**4.0 mg/m^3**	**NS**
AL2 -1	1.11.21	1.12	BQL	2	618
AL2 -2	9.11.21	1.09	BQL	1.91	583
AL2 -3	12.11.21	1.07	BQL	2.08	509
AL2 -4	17.11.21	1.19	BQL	2.04	487
AL2 – 5	19.11.21	1.27	BQL	2.07	590
AL2 – 6	24.11.21	1.16	BQL	2.05	549
AL2 -7	26.11.21	1.17	BQL	1.99	578
AL2 – 8	29.11.21	1.09	BQL	1.98	624
Monthly Average		**1.15**	**-**	**2.02**	**567**
Standard Deviation		**0.07**	**-**	**0.06**	**49**

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

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Oil Jetty area was mainly by motor vehicle emission produced from various types of vehicles Oil Jetty Area. The mean TSPM values at Oil Jetty were 489 µg/m^3 .The mean PM_{10} values were 190 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean = 97 µg/m^3).The average values of SO_2, NO_x and NH_3 were within the permissible limit, The mean concentration of SO_2, NO_x and NH3 were 4.01 µg/m^3, 17.76 µg/m^3 and 9.79 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 .Well below the permissible limit of 5.0 µg/m^3. , HC's were below the detectable limit and Carbon Monoxide concentration was 2.02 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

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

Table 3 : Results of Air Pollutant Concentration at Estate Office										
Parameters	**Date**	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period		**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit		**NS**	**100 µg/m3**	**60 µg/m3**	**-**	**80 µg/m3**	**-**	**80 µg/m3**	**-**	**400 µg/m3**
AL3 – 1	01.11.21	205	114	80	2.20	2.64	22.87	22.23	13.79	16.34
					2.64		30.49		16.85	
					3.08		13.34		18.38	
AL3 – 2	09.11.21	302	134	90	3.08	3.08	13.97	13.97	9.70	7.49
					2.64		11.43		7.40	
					3.52		16.51		5.36	
AL3 – 3	12.11.21	422	215	92	3.52	3.81	13.34	19.27	8.93	6.98
					4.84		19.69		7.40	
					3.08		24.77		4.60	
AL3 – 4	17.11.21	610	270	108	5.28	3.08	10.80	9.32	13.02	10.21
					2.64		10.16		10.47	
					1.32		6.99		7.15	
AL3 – 5	19.11.21	459	269	100	5.28	3.96	26.04	25.41	8.93	9.19
					3.96		33.66		9.96	
					2.64		16.51		8.68	
AL3 – 6	24.11.21	736	363	102	5.71	4.84	19.69	19.48	10.47	8.93
					2.64		14.61		9.70	
					6.15		24.14		6.64	
AL3 – 7	26.11.21	483	180	98	5.28	3.81	20.96	17.57	11.49	10.98
					3.96		15.24		10.98	
					2.20		16.51		10.47	
AL3 – 8	29.11.21	677	189	105	2.20	3.22	15.88	16.73	12.25	9.02
					4.84		14.61		8.93	
					2.64		19.69		5.87	
Monthly Average		487	217	97		3.55		18.00		9.89
Standard Deviation		182	81	9		0.69		4.93		2.91

NS: Not Specified

Table 3B : Results of Air Pollutant Concentration at Kandla Port Colony					
Parameter	**Date**	**C_6H_6 [µg/m^3]**	**HC***	**CO [mg/m^3]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m^3**	**NS**	**4.0 mg/m^3**	**NS**
AL3 -1	1.11.21	1.07	BQL	2.07	577
AL3 -2	9.11.21	1.1	BQL	1.91	583
AL3 -3	12.11.21	1.19	BQL	1.8	510
AL3 -4	17.11.21	1.11	BQL	1.91	480
AL3 – 5	19.11.21	1	BQL	2.1	652
AL3 – 6	24.11.21	1.1	BQL	1.84	672
AL3 – 7	26.11.21	1.26	BQL	2.12	364
AL3 – 8	29.11.21	1.26	BQL	2.01	426
Monthly Average		**1.14**	**-**	**1.97**	**533**
Standard Deviation		**0.09**	**-**	**0.12**	**108**

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

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Kandla Port Colony was attributed by vehicle emission produced from trucks and heavy duty vehicles that pass through the road outside Kandla Port Colony. The mean TSPM values at Oil Jetty were 487 µg/m^3, The mean PM_{10} values were 217 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean = 97 µg/m^3). The average values of SO_2, NO_x and NH3 were 3.55 µg/m^3, 18.0 µg/m^3 and 9.89 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Kandla Port Colony. The mean Benzene concentration was 1.14 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.97 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 4: Gopalpuri Hospital (AL-4)

Table 4 : Results of Air Pollutant Concentration at Gopalpuri Hospital

Parameter	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit		NS	100 µg/m3	60 µg/m3	-	80 µg/m3	-	80 µg/m3	-	400 µg/m 3
AL4 -1	01.11.21	145	81	36	3.52	2.78	8.26	12.91	9.19	8.93
					2.20		15.88		10.47	
					2.64		14.61		7.15	
AL4 -2	09.11.21	254	132	89	2.64	2.05	9.53	12.28	5.87	5.36
					1.32		13.34		5.36	
					2.20		13.97		4.85	
AL4 -3	12.11.21	309	136	92	2.20	2.78	10.16	9.95	3.83	5.02
					3.52		8.26		5.87	
					2.64		11.43		5.36	
AL4 -4	17.11.21	474	249	101	3.52	2.78	9.53	10.16	6.64	5.70
					2.64		11.43		4.60	
					2.20		9.53		5.87	
AL4 – 5	19.11.21	298	127	90	2.64	2.64	16.51	15.46	5.87	6.81
					3.52		10.16		8.42	
					1.76		19.69		6.13	
AL4 – 6	24.11.21	351	170	98	3.08	2.49	15.88	13.13	5.87	8.85
					2.64		10.16		9.19	
					1.76		13.34		11.49	
AL4 – 7	26.11.21	285	132	87	2.64	3.22	17.78	16.73	6.38	6.55
					3.96		16.51		7.91	
					3.08		15.88		5.36	
AL4 – 8	29.11.21	738	469	104	3.52	3.37	13.34	13.34	8.17	8.34
					3.96		14.61		8.93	
					2.64		12.07		7.91	
Monthly Average		357	187	87		2.77		12.99		6.95
Standard Deviation		180	124	21		0.41		2.33		1.58

NS: Not Specified

Table 4B : Results of Air Pollutant Concentration at Gopalpuri Hospital

Parameter	Date	C_6H_6 [µg/m^3]	HC*	CO [mg/m^3]	CO_2 [ppm]
Sampling Period		8 hr	Grab Sampling	Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m^3	NS	4.0 mg/m^3	NS
AL4 -1	1.11.21	1.02	BQL	2.01	609
AL4 -2	9.11.21	1.15	BQL	2.04	509
AL4 -3	12.11.21	1.26	BQL	1.94	487
AL4 -4	17.11.21	1.09	BQL	1.73	450
AL4 – 5	19.11.21	1.08	BQL	1.88	544
AL4 – 6	24.11.21	1.2	BQL	2.13	580
AL4 – 7	26.11.21	1.18	BQL	1.91	559
AL4 – 8	29.11.21	1.14	BQL	2.2	505
Monthly Average		**1.14**	**-**	**1.98**	**530**
Standard Deviation		**0.08**	**-**	**0.15**	**52**

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

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Gopalpuri Hospital was attributed by vehicle emission produced from light motor vehicles of the colony residents. The mean TSPM values at Oil Jetty were 357 µg/m^3, The mean PM_{10} values were 187 µg/m^3, which is above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean= 87 µg/m^3). The average values of SO_2, NO_x and NH_3 were 2.77 µg/m^3, 12.99 µg/m^3 and 6.95 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Gopalpuri Hospital. The mean Benzene concentration was 1.14 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.98 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 5: Coal Storage Area (AL-5)

Table 5 : Results of Air Pollutant Concentration at Coal Storage Area											
Parameters	**Date**	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**		
Sampling Period	**-**	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	
NAAQMS limit	**-**	**NS**	**100 µg/m3**	**60 µg/m3**	**-**	**80 µg/m3**	**-**	**80 µg/m3**	**-**	**400 µg/m3**	
AL5 – 1	01.11.21	306	154	89	2.20	3.22	20.96	20.33	8.93	9.79	
					3.08		21.60		7.40		
					4.40		18.42		13.02		
AL5 – 2	09.11.21	590	288	106	9.67	6.15	19.69	19.69	15.83	16.34	
					4.84		23.50		17.61		
					3.96		15.88		15.57		
AL5 – 3	12.11.21	680	351	104	10.55	9.08	22.87	26.68	8.68	7.83	
					7.03		26.04		6.64		
					9.67		31.12		8.17		
AL5 – 4	17.11.21	712	355	108	2.20	2.49	19.69	20.96	13.53	10.21	
					1.76		20.96		9.19		
					3.52		22.23		7.91		
AL5 – 5	19.11.21	696	380	110	5.28	5.13	20.96	22.44	10.72	11.23	
					6.15		19.69		9.96		
					3.96		26.68		13.02		
AL5 – 6	24.11.21	622	352	101	3.52	4.40	14.61	17.57	15.83	14.64	
					3.96		18.42		15.06		
					5.71		19.69		13.02		
AL5 – 7	26.11.21	578	218	106	3.52	3.96	16.51	18.63	10.98	9.36	
					4.84		20.96		9.19		
					3.52		18.42		7.91		
AL5 – 8	29.11.21	596	241	108	5.28	3.37	22.23	26.25	10.98	12.76	
					2.64		27.31		13.02		
					2.20		29.22		14.30		
Monthly Average		598	292	104		4.73		21.57		11.52	
Standard Deviation		128	81	7		2.10		3.36		2.87	

NS: Not Specified

Table 5B : Results of Air Pollutant Concentration at Coal Storage Area					
Parameter	**Date**	**C_6H_6 [µg/m^3]**	**HC***	**CO [mg/m^3]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m^3**	**NS**	**4.0 mg/m^3**	**NS**
AL5 – 1	1.11.21	1.1	BQL	1.97	593
AL5 – 2	9.11.21	1.28	BQL	1.56	582
AL5 – 3	12.11.21	1.07	BQL	2.1	453
AL5 – 4	17.11.21	1.02	BQL	1.98	494
AL5 – 5	19.11.21	1.17	BQL	2.07	544
AL5 – 6	24.11.21	1	BQL	1.91	571
AL5 – 7	26.11.21	1.23	BQL	1.78	636
AL5 – 8	29.11.21	1.20	BQL	2.07	511
Monthly Average		**1.13**	**-**	**1.93**	**548**
Standard Deviation		**0.10**	**-**	**0.18**	**59**

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

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Coal Storage Area was comparatively highest among all the locations of Air Quality monitoring in Kandla Port. High values of TSPM, $PM_{10,}$ $PM_{2.5}$, SO_2, NO_X at this location was due to lifting of coal with grab and other coal handling processes near Berth no. 6 & 7. Moreover, the traffic was also heavy around this place for transport of coal thus emissions produced from heavy vehicles. The mean TSPM values at Coal storage were 598µg/m^3. The mean PM_{10} values were 292 µg/m^3, which is well above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean = 104 µg/m^3). The average values of SO_2, NO_x and NH_3 were 4.73 µg/m^3, 21.57 µg/m^3 and 11.52 µg/m^3 respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Coal Storage Area. The mean Benzene concentration was 1.13 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.93 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

Location 6: Tuna Port (AL-6)

Table 6 : Results of Air Pollutant Concentration at Tuna Port

Parameters	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period	-	24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit	-	NS	100 µg/m3	60 µg/m3	-	80 µg/m3	-	80 µg/m3	-	400 µg/m3
AL6 -1	01.11.21	214	97	61	3.52	2.64	20.96	14.82	14.04	12.08
					2.64		12.07		12.51	
					1.76		11.43		9.70	
AL6 – 2	09.11.21	314	149	102	1.76	1.90	10.16	10.59	6.38	7.15
					2.64		11.43		6.64	
					1.32		10.16		8.42	
AL6 – 3	12.11.21	425	208	104	4.84	4.25	16.51	17.57	6.64	6.55
					5.28		20.96		4.85	
					2.64		15.24		8.17	
AL6 – 4	17.11.21	504	280	110	2.20	2.34	5.08	7.20	6.13	7.06
					1.76		7.62		8.42	
					3.08		8.89		6.64	
AL6 – 5	19.11.21	432	242	106	2.64	2.20	22.87	18.21	13.02	11.74
					2.20		13.34		11.74	
					1.76		18.42		10.47	
AL6 – 6	24.11.21	315	149	96	5.28	3.66	30.49	26.89	9.96	12.76
					1.76		22.23		15.57	
					3.96		27.95		12.76	
AL6 – 7	26.11.21	326	140	98	2.20	2.93	13.34	15.03	9.19	9.53
					3.08		15.24		8.93	
					3.52		16.51		10.47	
AL6 – 8	29.11.21	569	298	104	2.20	2.93	15.88	15.88	10.72	10.30
					2.64		13.34		8.93	
					3.96		18.42		11.23	
Monthly Average		387	195	98		2.86		15.77		9.65
Standard Deviation		116	73	15		0.78		5.79		2.48

NS: Not Specified

Table 6B : Results of Air Pollutant Concentration at Tuna Port					
Parameter	**Date**	**C_6H_6 [µg/m³]**	**HC***	**CO [mg/m³]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m³**	**NS**	**4.0 mg/m³**	**NS**
AL6 -1	01.11.21	1.2	BQL	1.91	586
AL6 – 2	09.11.21	1.02	BQL	2.1	600
AL6 – 3	12.11.21	1.08	1.91	1.91	452
AL6 – 4	17.11.21	1.26	BQL	1.94	507
AL6 – 5	19.11.21	1.21	BQL	2.08	593
AL6 – 6	24.11.21	1.01	BQL	1.98	568
AL6 – 7	26.11.21	1.203	BQL	2.08	577
AL6 – 8	29.11.21	1.19	BQL	2.04	517
Monthly Average		**1.15**	**-**	**2.01**	**550**
Standard Deviation		**0.10**	**-**	**0.08**	**52**

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

The mean TSPM values at Tuna Port were 387 µg/m³, The mean PM_{10} values were 195 µg/m³, which is above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean = 98 µg/m³). The average values of SO_2, NO_x and NH_3 were 2.86 µg/m³, 15.77 µg/m³ and 9.65 µg/m³ respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Tuna Port. The mean Benzene concentration was 1.15 µg/m³, well below the permissible limit of 5.0 µg/m³. HC's were below the detectable limit and Carbon Monoxide concentration was 2.01 mg/m³, well below the permissible limit of 4.0 mg/m³.

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

Table 7 : Results of Air Pollutant Concentration at Signal Building

Parameters	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period	-	24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS limit	-	NS	100 µg/m3	60 µg/m3	-	80 µg/m3	-	80 µg/m3	-	400 µg/m3
AL7 -1	01.11.21	251	137	109	2.20	3.22	7.62	11.86	6.89	5.70
					3.96		13.34		6.13	
					3.52		14.61		4.08	
AL7 -2	09.11.21	215	115	84	5.71	6.30	26.04	17.36	4.60	6.98
					6.15		14.61		10.47	
					7.03		11.43		5.87	
AL7 -3	12.11.21	202	104	76	3.52	3.96	10.16	16.51	6.38	8.68
					4.84		26.04		10.72	
					3.52		13.34		8.93	
AL7 -4	17.11.21	200	103	84	2.64	3.96	19.69	14.40	7.91	6.13
					5.28		13.34		4.60	
					3.96		10.16		5.87	
AL7 -5	19.11.21	224	104	94	5.71	3.96	13.97	16.30	9.19	7.66
					3.52		19.69		7.15	
					2.64		15.24		6.64	
AL7 -6	24.11.21	238	118	77	4.40	4.40	10.16	10.59	5.87	5.96
					2.64		6.99		4.60	
					6.15		14.61		7.40	
AL7 -7	26.11.21	213	120	64	2.64	3.52	15.88	14.40	14.04	10.38
					2.20		7.62		10.72	
					5.71		19.69		6.38	
AL7 -8	29.11.21	207	115	84	5.71	3.22	10.16	13.34	8.17	7.66
					2.64		15.24		7.91	
					1.32		14.61		6.89	
Monthly Average		219	115	84		4		14		7
Standard Deviation		18	11	13		1		2		2

NS: Not Specified

Table 7B : Results of Air Pollutant Concentration at Signal Building					
Parameter	**Date**	**C_6H_6 [µg/m^3]**	**HC***	**CO [mg/m^3]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m^3**	**NS**	**4.0 mg/m^3**	**NS**
AL7 -1	01.11.21	1.03	BQL	1.75	569
AL7 – 2	09.11.21	1.16	BQL	1.85	629
AL7 – 3	15.11.2021	1.35	BQL	1.78	501
AL7 – 4	18.11.2021	1.09	BQL	2	449
AL7 – 5	19.11.2021	1	BQL	1.89	458
AL7 – 6	22.11.2021	1.22	BQL	1.87	510
AL7 – 7	25.11.2021	1.08	BQL	1.99	541
AL7 – 8	29.11.2021	1.18	BQL	1.88	565
Monthly Average		**1.14**	**-**	**1.88**	**528**
Standard Deviation		**0.11**	**-**	**0.09**	**60**

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

The mean TSPM values at Vadinar Port were 219 µg/m^3. The mean PM_{10} values were 115 µg/m^3, which is below the permissible limit. $PM_{2.5}$ values were also within the permissible limit (mean = 84 µg/m^3). The average values of SO_2, NO_x and NH_3 were 4.0 µg/m^3, 14.0 µg/m^3 and 7.0µg/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 1.14 µg/m^3, well below the permissible limit of 5.0 µg/m^3. HC's were below the detectable limit and Carbon Monoxide concentration was 1.88 mg/m^3, well below the permissible limit of 4.0 mg/m^3.

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

Table 8 : Results of Air Pollutant Concentration at Admin Building										
Parameters	**Date**	**TSPM [µg/m3]**	**PM10 [µg/m3]**	**PM2.5 [µg/m3]**	**SO2 [µg/m3]**		**NOx [µg/m3]**		**NH3 [µg/m3]**	
Sampling Period	**-**	**24hr**	**24hr**	**24hr**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**	**8 hr**	**24hr (Avg.)**
NAAQMS limit	**-**	**NS**	**100 µg/m3**	**60 µg/m3**	**-**	**80 µg/m3**	**-**	**80 µg/m3**	**-**	**400 µg/m3**
AL8 -1	01.11.21	204	83	73	4.84	3.22	20.96	18.63	6.38	5.96
					2.64		19.69		5.87	
					2.20		15.24		5.62	
AL8 -2	09.11.21	193	86	75	4.40	3.08	13.34	15.67	8.93	8.85
					2.64		20.33		6.64	
					2.20		13.34		10.98	
AL8 -3	12.11.21	241	126	107	2.64	2.49	15.88	16.09	4.85	5.96
					3.08		22.87		5.62	
					1.76		9.53		7.40	
AL8 -4	17.11.21	167	100	53	3.52	3.81	17.78	12.91	8.42	7.57
					4.84		10.16		10.47	
					3.08		10.80		3.83	
AL8 -5	19.11.21	183	151	72	2.20	2.49	10.16	10.59	5.36	6.55
					1.76		9.53		8.17	
					3.52		12.07		6.13	
AL8 -6	24.11.21	197	104	80	3.52	5.28	15.88	13.55	8.93	7.66
					5.71		10.16		7.91	
					6.59		14.61		6.13	
AL8 -5	26.11.21	226	111	88	3.52	3.37	10.16	11.43	11.74	8.85
					1.76		13.34		5.87	
					4.84		10.80		8.93	
AL8-6	29.11.21	226	104	106	2.64	2.78	10.16	13.13	9.19	7.40
					3.52		20.96		5.87	
					2.20		8.26		7.15	
Monthly Average		205	108	82		3		14		7
Standard Deviation		25	22	18		1		3		1

NS: Not Specified

Table 8B : Results of Air Pollutant Concentration at Admin Building					
Parameter	**Date**	**C_6H_6 [µg/m³]**	**HC***	**CO [mg/m³]**	**CO_2 [ppm]**
Sampling Period		**8 hr**	**Grab Sampling**	**Grab Sampling**	**Grab Sampling**
NAAQMS limit		**5.0 µg/m³**	**NS**	**4.0 mg/m³**	**NS**
AL8 -1	01.11.21	1.23	BDL	1.88	571
AL8-2	09.11.21	1.09	BDL	2.04	581
AL8 -3	15.11.2021	1.29	BDL	2.17	465
AL8-4	18.11.2021	1.05	BDL	1.82	452
AL8 -5	19.11.2021	1.01	BDL	1.92	482
AL8-6	22.11.2021	1.28	BDL	1.73	496
AL8-7	25.11.2021	1.15	BDL	1.85	524
AL8-8	29.11.2021	1.13	BDL	2.02	561
Monthly Average		**1.15**	**-**	**1.93**	**517**
Standard Deviation		**0.10**	**-**	**0.14**	**50**

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

The overall values of TSPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and NH_3 at Admin Building Vadinar was comparatively low among all the locations of Air Quality monitoring in Kandla Port and Vadinar Port. The mean TSPM values at Vadinar Port were 205 µg/m³. The mean PM_{10} values were 108 µg/m³, which is above the permissible limit. $PM_{2.5}$ values were above the permissible limit (mean = 82.0 µg/m³). The average values of SO_2, NO_x and NH_3 were 3.0 µg/m³, 14.0 µg/m³ and 7.0 µg/m³ respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Admin Building, Vadinar Port. The mean Benzene concentration was 1.15 µg/m³, well below the permissible limit of 5.0 µg/m³. HC's were below the detectable limit and Carbon Monoxide concentration was 1.93 mg/m³, well below the permissible limit of 4.0 mg/m³.

1.4 Observations and Conclusion

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

2. Drinking Water Quality Monitoring

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

2.1 Drinking Water Monitoring Methodology

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

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

2.2 Results

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

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

Sr. No.	Parameter	Unit	Nirman Building 1	P & C building	Main Gate North	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.3	7.4	7.2	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	990	1280	1310	500	2000
3	Turbidity	NTU	0	1	0	1.0	5.0
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	1860	2430	2540	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	491.09	461.02	516.15	250.0	1000.0
9	Ca as Ca	mg/l	64.13	68.14	60.12	75.0	200.0
10	Mg as Mg	mg/l	63.18	70.47	68.04	30.0	100.0
11	Total Hardness	mg/l	420	460	430	200.0	600.0
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.32	0.35	0.34	1.0	1.5
14	Sulphate as SO4	mg/l	286.8	289.2	283.2	200.0	400
15	Nitrite as NO2	mg/l	<0.1	<0.1	<0.1	NS*	NS*
16	Nitrate as NO3	mg/l	6.41	7.88	6.20	45.0	No Relaxation
17	Salinity	%	0.86	0.80	0.89	NS*	NS*
18	Sodium as Na	mg/l	202	225	277	NS*	NS*
19	Potassium as K	mg/l	5.08	3.26	5.26	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	0.003
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	0.001
26	Lead	mg/l	BQL	BQL	BQL	0.01	0.01
27	Zinc	mg/l	BQL	BQL	BQL	5.0	15.0
28	Bacterial Count	CFU/100 ml	Absent	Absent	Absent	Absent	Absent

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

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

Sr. No.	Parameter	Unit	Canteen	West Gate – I	Wharf Area	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.5	7.3	7.2	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1410	1350	1420	500	2000
3	Turbidity	NTU	0	0	1	1.0	5.0
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	2710	2560	2730	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride as Cl	mg/l	541.20	486.08	491.09	250.0	1000.0
9	Ca as Ca	mg/l	64.13	56.11	64.13	75.0	200.0
10	Mg as Mg	mg/l	68.04	68.04	72.90	30.0	100.0
11	Total Hardness	mg/l	440	420	460	200.0	600.0
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides as F	mg/l	0.41	0.29	0.34	1.0	1.5
14	Sulphate as SO4	mg/l	291.6	204.0	194.4	200.0	400
15	Nitrite as NO2	mg/l	<0.1	<0.1	<0.1	NS*	NS*
16	Nitrate as NO3	mg/l	8.10	12.25	8.87	45.0	No Relaxation
17	Salinity	%	0.83	0.93	0.98	NS*	NS*
18	Sodium as Na	mg/l	201	195	279	NS*	NS*
19	Potassium as K	mg/l	4.28	4.08	4.69	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	0.003
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	0.001
26	Lead	mg/l	BQL	BQL	BQL	0.01	0.01
27	Zinc	mg/l	BQL	BQL	BQL	5.0	15.0
28	Bacterial Count	CFU/100 ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

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

Sr. No.	Parameter	Unit	Sewa Sadan – 3	Workshop	Custom Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.4	7.7	7.5	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1360	1325	1430	500	2000
3	Turbidity	NTU	1	1	0	1.0	5.0
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	2530	2480	2680	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride	mg/l	656.46	611.36	516.15	250.0	1000.0
9	Ca as Ca	mg/l	56.11	60.12	64.13	75.0	200.0
10	Mg as Mg	mg/l	75.33	65.61	72.90	30.0	100.0
11	Total Hardness	mg/l	450	420	460	200.0	600.0
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides	mg/l	0.23	0.45	0.46	1.0	1.5
14	Sulphate	mg/l	198.0	290.4	230.4	200.0	400
15	Nitrite	mg/l	<0.1	<0.1	<0.1	NS*	NS*
16	Nitrate	mg/l	10.42	9.57	13.94	45.0	No Relaxation
17	Salinity	%	0.88	0.89	1.19	NS*	NS*
18	Sodium as Na	mg/l	303	248	327	NS*	NS*
19	Potassium as K	mg/l	4.30	5.61	8.26	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	0.003
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	0.001
26	Lead	mg/l	BQL	BQL	BQL	0.01	0.01
27	Zinc	mg/l	BQL	BQL	BQL	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

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

Sr. No.	Parameter	Unit	Port Colony Kandla	Hospital Kandla	A.O. Building	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.6	7.3	7.2	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1310	1410	1430	500	2000
3	Turbidity	NTU	0	0	1	1.0	5.0
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	Colorless	5.0	15.0
6	Conductivity	μs/cm	2540	2690	2740	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	<0.1	<0.1	<0.1	NS*	NS*
8	Chloride	mg/l	481.07	531.18	516.15	250.0	1000.0
9	Ca as Ca	mg/l	72.14	76.15	64.13	75.0	200.0
10	Mg as Mg	mg/l	55.89	58.32	68.04	30.0	100.0
11	Total Hardness	mg/l	410	430	440	200.0	600.0
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides	mg/l	0.48	0.85	0.52	1.0	1.5
14	Sulphate	mg/l	210.0	291.6	301.2	200.0	400
15	Nitrite	mg/l	<0.1	<0.1	<0.1	NS*	NS*
16	Nitrate	mg/l	10.28	13.24	9.79	45.0	No Relaxation
17	Salinity	%	1.10	0.93	0.87	NS*	NS*
18	Sodium as Na	mg/l	154	384	218	NS*	NS*
19	Potassium as K	mg/l	3.26	4.69	4.03	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	0.003
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	0.001
26	Lead	mg/l	BQL	BQL	BQL	0.01	0.01
27	Zinc	mg/l	BQL	BQL	BQL	5.0	15.0
28	Bacterial Count	CFU/100 ml	Absent	Absent	Absent	Absent	Absent

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

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

Sr. No.	Parameter	Unit	School Gopalpuri	Guest House	E - Type Quarter	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.4	7.6	7.5	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1400	1720	1090	500	2000
3	Turbidity	NTU	1	0	1	1.0	5.0
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	2640	2730	2130	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride	mg/l	496.10	526.17	481.07	250.0	1000.0
9	Ca as Ca	mg/l	60.12	56.11	68.14	75.0	200.0
10	Mg as Mg	mg/l	80.19	77.76	65.61	30.0	100.0
11	Total Hardness	mg/l	480	460	440	200.0	600.0
12	Iron as Fe	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides	mg/l	0.60	0.81	0.63	1.0	1.5
14	Sulphate	mg/l	314.4	214.8	289.2	200.0	400
15	Nitrite	mg/l	<0.1	<0.1	<0.1	NS*	NS*
16	Nitrate	mg/l	10.91	12.39	10.00	45.0	No Relaxation
17	Salinity	%	0.96	0.93	0.90	NS*	NS*
18	Sodium as Na	mg/l	287	106	246	NS*	NS*
19	Potassium as K	mg/l	5.28	6.29	2.25	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	0.003
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	0.001
26	Lead	mg/l	BQL	BQL	BQL	0.01	0.01
27	Zinc	mg/l	BQL	BQL	BQL	5.0	15.0
28	Bacterial Count	CFU/100 ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

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

Sr. No.	Parameter	Unit	F - Type Quarter	Hospital Gopalpuri	Tuna Port	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.6	7.3	7.42	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1020	1250	1150	500	2000
3	Turbidity	NTU	0	1	0	1.0	5.0
4	Odor	-	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Unit	Colorless	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	1950	2380	2000	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	BQL	NS*	NS*
8	Chloride	mg/l	611.36	576.28	520	250.0	1000.0
9	Ca as Ca	mg/l	64.13	60.12	76.15	75.0	200.0
10	Mg as Mg	mg/l	55.89	72.90	55.89	30.0	100.0
11	Total Hardness	mg/l	390	450	420	200.0	600.0
12	Iron as Fe+3	mg/l	BQL	BQL	BQL	0.3	No Relaxation
13	Fluorides	mg/l	0.86	0.57	0.75	1.0	1.5
14	Sulphate	mg/l	301.2	285.6	274.8	200.0	400
15	Nitrite	mg/l	<0.1	<0.1	<0.1	NS*	NS*
16	Nitrate	mg/l	10.91	10.07	9.93	45.0	No Relaxation
17	Salinity	%	0.95	0.87	1.10	NS*	NS*
18	Sodium as Na	mg/l	235	235	248	NS*	NS*
19	Potassium as K	mg/l	3.98	5.54	4.8	NS*	NS*
20	Manganese	mg/l	BQL	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	BQL	0.003	0.003
24	Arsenic	mg/l	BQL	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	BQL	0.001	0.001
26	Lead	mg/l	BQL	BQL	BQL	0.01	0.01
27	Zinc	mg/l	BQL	BQL	BQL	5.0	15.0
28	Bacterial Count	CFU/100 ml	Absent	Absent	Absent	Absent	Absent

*NS: Not Specified

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

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

Sr. No.	Parameter	Unit	Vadinar Jetty	Port Colony Vadinar	Acceptable Limits as per IS 10500 : 2012	Permissible Limits in the absence of Alternate Source as per IS 10500 : 2012
1	pH	pH Unit	7.5	7.3	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/l	1060	1120	500	2000
3	Turbidity	NTU	ND	ND	1.0	5.0
4	Odor	-	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	5.0	15.0
6	Conductivity	µs/cm	1960	2150	NS*	NS*
7	Biochemical Oxygen Demand	mg/l	BQL	BQL	NS*	NS*
8	Chloride	mg/l	486.08	521.16	250.0	1000.0
9	Ca as Ca	mg/l	68.14	60.12	75.0	200.0
10	Mg as Mg	mg/l	68.04	68.04	30.0	100.0
11	Total Hardness	mg/l	450	430	200.0	600.0
12	Iron as Fe+3	mg/l	BQL	BQL	0.3	No Relaxation
13	Fluorides	mg/l	0.86	0.69	1.0	1.5
14	Sulphate	mg/l	23.04	22.56	200.0	400
15	Nitrite	mg/l	<0.1	<0.1	NS*	NS*
16	Nitrate	mg/l	7.88	10.63	45.0	No Relaxation
17	Salinity	%	0.88	0.94	NS*	NS*
18	Sodium as Na	mg/l	52.8	40.2	NS*	NS*
19	Potassium as K	mg/l	3.3	2.1	NS*	NS*
20	Manganese	mg/l	BQL	BQL	0.1	0.3
21	Hexavalent Chromium	mg/l	BQL	BQL	NS*	NS*
22	Copper	mg/l	BQL	BQL	0.05	1.5
23	Cadmium	mg/l	BQL	BQL	0.003	0.003
24	Arsenic	mg/l	BQL	BQL	0.01	0.05
25	Mercury	mg/l	BQL	BQL	0.001	0.001
26	Lead	mg/l	BQL	BQL	0.01	0.01
27	Zinc	mg/l	BQL	BQL	5.0	15.0
28	Bacterial Count	CFU/100ml	Absent	Absent	Absent	Absent

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

2.3 Results & Discussion

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

pH

The limit of pH value for drinking water is specified as 6.5 to 8.5. pH value in the studied area varied from 7.1 to 7.7 pH unit. All the sampling points showed pH values within the prescribed limit by Indian Standards.

Total Dissolved Solids (TDS)

TDS values in the studied area varied between 900 -1800 mg/l. None of the sampling points showed higher TDS values than the prescribed limit by Indian standards.

Conductivity

Electrical Conductivity is the ability of a solution to transfer (conduct) electric current. Conductivity is used to measure the concentration of dissolved solids which have been ionized in a polar solution such as water. The conductivity in the samples collected during the month of November ranged from 1800-3000 µs/cm. Electrical conductivity standards do not appear in BIS standards for drinking water.

BOD

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

Chlorides

Excessive chloride concentration increase rates of corrosion of metals in the distribution system. This can lead to increased concentration of metals in the supply. Chloride value in the studied area varied between 400-700 mg/l and is found to be within the Permissible limit of the Drinking Water Standard.

Calcium

Calcium value in the studied area varied between 50 - 80 mg/l and is found to be within the Permissible limit of the Drinking Water Standard. If calcium is present beyond the maximum acceptable limit, it causes incrustation of pipes.

Magnesium

Magnesium value in the studied area varied between 50-85 mg/l. All the locations had Magnesium within the prescribed limits of 30-100 mg/L.

Total Hardness

Hardness value in the studied area varied between 350-480 mg/l and is found to be within the Permissible limit of the Drinking Water Standard. The prescribed limit by Indian Standards is 200-600 mg/L.

Iron

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

Fluoride

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

Sulphates

Sulphate value in the studied area varied between 20 – 350 mg/l. All the sampling points showed sulphate values within the prescribed limits by Indian Standards (200-400 mg/L). Sulphate content in drinking water exceeding the 400 mg/L imparts bitter taste.

Nitrites (NO_2) and Nitrates (NO_3)

Nitrite values in all the water samples were found Below Quantification Limit (0.1 mg/l). There are no specified standard values for Nitrites in Drinking water. The minimim Nitrate value in drinking water of KPT was 6.20 mg/l which is well within the permissible limit of the Drinking water Standard.

Salinity

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

Sodium and Potassium Salts

Sodium values in the samples collected ranged from 40 - 400 mg/l and Potassium salts ranged from 2.0 to 8.5 mg/l. There are no prescribed limits of Sodium and Potassium in Indian standards for Drinking water.

Heavy Metals in Drinking Water

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

Bacteriological Study

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

2.4 Conclusions

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

3. Noise Level Monitoring

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

3.1 Method of Monitoring

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

3.2 Results

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

Sr. No.	Location	Day Time Average Noise Level (SPL) in dB(A)	Night Time Average Noise Level (SPL) in dB(A)
	Sampling Time	**6:00 am to 10:00 PM**	**10:00PM to 6:00 AM**
1	Marine Bhavan	73.9	53.4
2	Nirman Building 1	62.3	51.0
3	Tuna Port	57.2	50.9
4	Main Gate North	67.0	61.8
5	West Gate I	70.5	65.1

6	Canteen Area	64.5	51.0
7	Main Road	68.4	51.5
8	ATM Building	74.4	57.3
9	Wharf Area /Jetty Area	72.9	68.1
10	Port & Custom Office	67.8	41.8
	Vadinar Port		
11	Entrance Gate of Vadinar Port	66.4	53.2
12	Nr. Port Colony, Vadinar	60.7	54.1
13	Nr. Vadinar Jetty	72.4	66.5

3.3 **Conclusions-** Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading containers and ships. The Day Time Average Noise Level (SPL)in all 13 locations at Deendayal Port ranged from 57.2 dB(A) to 74.4 dB(A) and it was within the permissible limits of 75 dB(A) for the industrial area for the daytime. The Night Time Average Noise Level (SPL) in all 13 locations of Deendayal Port ranged from 41.8 dB to 68.4 dB(A) and it was within the permissible limits of 70 dB(A) for the industrial area for the night time.

4. Soil Monitoring

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

4.1 Methodology

The soil samples were collected in the month of November 2021. The samples collected from the all locations are homogeneous representative of each location. At random locations were identified at each location and soil was dug from 30 cm below the surface. It was uniformly mixed before homogenizing the soil samples. The samples were filled in polythene bags, labeled in the field with number and site name and sent to laboratory for analysis.

4.2 Results

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

Sr. No.	Parameter	Unit	Station Name					
			SL1	SL2	SL3	SL4	SL5	SL6
			Tuna Port	IFFCO Plant	Khori Creek	Nakti Creek	KPT Admin Site	KPT Colony
			Near main gate of Port	10 m away from main gate	Sand from creek at low tide		Vadinar	
1	Texture		Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	pH	-	8.42	7.92	8.44	8.23	7.79	8.43
3	Electrical Conductivity	µs/cm	14,070.0	16,210.0	13,680.0	9,240.0	387.0	314.0
4	Moisture	%	18.17	9.01	21.39	21.08	3.46	3.95
5	Total Organic Carbon	%	0.20	0.49	0.20	0.72	0.85	0.43
6	Alkalinity	mg/kg	80.08	120.12	60.06	100.10	60.06	80.08
7	Total Nitrogen	%	BQL	BQL	BQL	BQL	BQL	BQL
8	Chloride	mg/kg	1,956.8	4,112.2	1,800.9	514.7	21.7	113.4
9	Sulphate	mg/kg	212.0	279.0	93.3	165.1	44.7	27.7
10	Phosphorus	mg/kg	2.20	1.89	1.41	2.15	BQL	1.74
11	Potassium	mg/kg	539.0	327.4	409.2	667.6	70.4	62.0
12	Sodium	mg/kg	5,752.0	4,061.6	3,954.0	1,477.0	72.8	65.9
13	Calcium	mg/kg	200.40	488.98	252.00	470.42	436.87	256.51
14	Copper as Cu	mg/kg	14.90	29.50	9.80	27.60	88.4	48.4
15	Lead as Pb	mg/kg	5.80	6.40	3.50	8.20	BQL	4.2
16	Nickel as Ni	mg/kg	35.30	16.60	23.50	37.70	33.8	27.3
17	Zinc as Zn	mg/kg	40.60	104.80	25.4	55.20	66.00	30.50
18	Cadmium as Cd	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL

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

4.3 Discussion

The data shows that value of pH ranges from 7.92 at IFFCO Plant to 8.44 at Khori Creek indicating that all soil samples are neutral to slight basic. Iffco Plant samples showed maximum conductivity of 16,210.0 µmhos/cm, while Tuna Port location showed minimum conductivity of 14,070.0 µmhos/cm. Conductivity at Vadinar Port was 387 and 314 µmhos/cm at Admin site and Vadinar Port colony respectively.

Total organic Carbon ranged from 0.2 % to 0.72 at Deendayal Port. At Vadinar Port, organic carbon content ranged from 0.85 % to 0.43 %.

The concentration of Phosphorus and Potassium in the soil samples varies from 1.41 to 2.15 mg/kg and 327.0 to 670.0 mg/kg respectively at Deendayal Port. The mean concentration of Phosphorous at Vadinar site was 1.74 mg/kg and mean concentration of Potassium at Vadinar site was 132 mg/kg.

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

Heavy Metals in the Soil

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

4.4 Conclusion

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

5. Sewage Treatment Plant Monitoring

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

5.1 Methodology for STP Monitoring

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

5.2 Results

Kandla STP

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

Date of Sampling	02.11.2021

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	7.82	7.46
2	Total Suspended Solids	mg/l	206	116.1
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	393.0	152.0
5	BOD @ 27 °C	mg/l	110.0	53.0
6.	Fecal Coliform	MPN Index / 100 ml	-	>1600.0
Aeration Tank				
7.	MLSS	mg/l	35.0	
8.	MLVSS	%	6.0	

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

Date of Sampling	11.11.2021

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	7.6	7.2
2	Total Suspended Solids	mg/l	152.2	72.4
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	384	103.0
5	BOD @ 27 °C	mg/l	120.0	24.0
6.	Fecal Coliform	MPN Index / 100 ml	-	9.2
Aeration Tank				
7.	MLSS	mg/l	7.0	
8.	MLVSS	%	90.0	

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

Date of Sampling	17.11.2021

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	7.35	7.14
2	Total Suspended Solids	mg/l	204	144
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	162	71
5	BOD @ 27 °C	mg/l	60.0	20.0
6.	Fecal Coliform	MPN Index / 100 ml	-	24.0
Aeration Tank				
7.	MLSS	mg/l	12.0	
8.	MLVSS	%	93.0	

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

Date of Sampling	22.11.2021

Sr. No.	Parameters	Unit	Results	
			KPT STP I/L	KPT STP O/L
1	pH	pH unit	7.82	7.46
2	Total Suspended Solids	mg/l	306	116
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	242	103.0
5	BOD @ 27 °C	mg/l	86.0	26.0
6.	Fecal Coliform	MPN Index / 100 ml	-	170.0
Aeration Tank				
7.	MLSS	mg/l	9.0	
8	MLVSS	%	98.0	

Gopalpuri Colony STP

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

Date of Sampling	02.11.2021

Sr. No.	Parameters	Unit	Results	
			Gopalpuri STP I/L	Gopalpuri STP O/L
1	pH	pH unit	7.50	7.20
2	Total Suspended Solids	mg/l	210	120
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	414.0	142.0
5	BOD @ 27 °C	mg/l	122.0	53.0
6.	Fecal Coliform	MPN Index / 100 ml	-	>1600.0
Aeration Tank				
7.	MLSS	mg/l	86.0	
8	MLVSS	%	97.0	

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

Date of Sampling	11.11.2021

Sr. No.	**Parameters**	**Unit**	**Results**	
			Gopalpuri STP I/L	**Gopalpuri STP O/L**
1	pH	pH unit	7.46	7.2
2	Total Suspended Solids	mg/l	379.2	118
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	454	163.00
5	BOD @ 27 °C	mg/l	148.0	56.0
6.	Fecal Coliform	MPN Index / 100 ml	-	21.0
Aeration Tank				
7.	MLSS	mg/l	94.0	
8	MLVSS	%	92.0	

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

Date of Sampling	17.11.2021

Sr. No.	**Parameters**	**Unit**	**Results**	
			Gopalpuri STP I/L	**Gopalpuri STP O/L**
1	pH	pH unit	7.35	7.14
2	Total Suspended Solids	mg/l	204	144
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	162	71
5	BOD @ 27 °C	mg/l	60.0	20.0
6.	Fecal Coliform	MPN Index / 100 ml	-	24.0
Aeration Tank				
7.	MLSS	mg/l	12.0	
8	MLVSS	%	93.0	

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

Date of Sampling	22.11.2021

Sr. No.	Parameters	Unit	Results	
			Gopalpuri STP I/L	Gopalpuri STP O/L
1	pH	pH unit	7.82	7.46
2	Total Suspended Solids	mg/l	306	116
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	242	103.0
5	BOD @ 27 °C	mg/l	86.0	26.0
6.	Fecal Coliform	MPN Index / 100 ml	-	170.0
Aeration Tank				
7.	MLSS	mg/l	9.0	
8.	MLVSS	%	98.0	

Vadinar STP

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

Date of Sampling	02.11.2021

Sr. No.	Parameters	Unit	Results	
			Vadinar STP I/L	Vadinar O/L
1	pH	pH unit	7.62	7.41
2	Total Suspended Solids	mg/l	121	69
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	89.0	72.0
5	BOD @ 27 °C	mg/l	34.0	15.0

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

Date of Sampling	11.11.2021

Sr. No.	Parameters	Unit	Results	
			Vadinar STP I/L	Vadinar O/L
1	pH	pH unit	7.5	7.2
2	Total Suspended Solids	mg/l	109	31
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	173.0	62.0
5	BOD @ 27 °C	mg/l	48.0	20.0

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

Date of Sampling	17.11.2021

Sr. No.	Parameters	Unit	Results	
			Vadinar STP I/L	Vadinar O/L
1	pH	pH unit	7.7	7.5
2	Total Suspended Solids	mg/l	105	38
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	150	62
5	BOD @ 27 °C	mg/l	48.0	18.0

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

Date of Sampling	**25.10.2021**

Sr. No.	**Parameters**	**Unit**	**Results**	
			Vadinar STP I/L	**Vadinar O/L**
1	pH	pH unit	7.5	7.3
2	Total Suspended Solids	mg/l	117	69
3	Residual Chlorine	mg/l	-	<0.5
4	COD	mg/l	192	101
5	BOD @ 27 °C	mg/l	60.0	24.0

5.3 Conclusions:

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

Marine Water Monitoring

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

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

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

Marine Environment

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

Sampling Stations

The monitoring of marine environment for the study of biological and ecological parameters was carried out on 19^{th}& 20^{th} November-2021 in harbor regions of KPT and on 19^{th} November-2021 at Vadinar during spring tide period of New moon phase of Lunar Cycle. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 26^{th}& 27^{th} November 2021 in harbor regions of KPT. 26^{th} November -2021 in Vadinar during Neap tide period first quarter of Lunar Cycle..

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

Sampling Locations

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

5.4 Marine Water Quality

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

The results of marine water quality and Marine sediments are as below;

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

Sr. No.	Parameters	Unit	Kandla Creek Near KPT colony (1)			
			23°0'58"N 70°13'22."E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.21	7.26	7.45	7.26
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31.6	31.9	32.0	31.5
5	Turbidity	NTU	36	31	33	32
6	Total Dissolved Solids	mg/l	41592	42007	41300.0	41443.0

Sr. No.	Parameters	Unit	Kandla Creek Near KPT colony (1) 23°0'58"N 70°13'22."E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
7	Total Suspended Solids	mg/l	655	870	754.2	571.1
8	Total Solids	mg/l	42247	42877	42054.2	42014.1
9	DO	mg/l	4	4.2	4.1	4.3
10	COD	mg/l	82.0	90.0	80.0	78.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.65	0.60	0.76	0.65
13	Phosphate	mg/l	0.35	0.24	0.16	0.18
14	Sulphate	mg/l	2772	2700	2184	2580
15	Nitrate	mg/l	2.89	2.46	2.45	3.44
16	Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05
17	Calcium	mg/l	561.12	480.96	480.96	521.04
18	Magnesium	mg/l	1725.3	1530.9	1676.7	1603.8
19	Sodium	mg/l	9038.0	8014.0	8629.0	9638.0
20	Potassium	mg/l	313.0	271.0	336.0	378.0
21	Iron	mg/l	1.42	1.30	1.32	1.10
22	Chromium	mg/l	0.12	0.11	0.13	0.12
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	0.05	0.06	0.06	0.05
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	0.07	0.09	0.06	0.08
28	Zinc	mg/l	BQL	BQL	BQL	BQL

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

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

Sr. No.	Parameters	Unit	Near passenger Jetty One (2) 23° 0'18 "N 70°13'31"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.12	7.31	7.30	7.20
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	32.0	31.6	32.2	31.4
5	Turbidity	NTU	35	28	38	42
6	Total Dissolved Solids	mg/l	39062	40035	40245.0	36627.0
7	Total Suspended Solids	mg/l	784	773	528.3	504
8	Total Solids	mg/l	39845	40808	40773.3	37131.0
9	DO	mg/l	4.3	3.9	4.2	4
10	COD	mg/l	88.0	86.0	92.0	90.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.56	0.53	0.76	0.69
13	Phosphate	mg/l	0.24	0.26	0.19	0.20
14	Sulphate	mg/l	2580	3132	2340	2700
15	Nitrate	mg/l	3.03	3.31	2.80	3.98
16	Nitrite	mg/l	BQL	BQL	BQL	BQL
17	Calcium	mg/l	601.20	681.36	561.12	601.2
18	Magnesium	mg/l	1555.2	1652.4	1676.7	1628.1
19	Sodium	mg/l	9530.0	9278.0	9116.0	9368.0
20	Potassium	mg/l	349.0	336.0	272.0	302.0
21	Iron	mg/l	1.88	1.70	1.48	1.55
22	Chromium	mg/l	0.12	0.11	0.11	0.14
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	0.04	0.05	0.06	0.04
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	0.10	0.09	0.09	0.10
28	Zinc	mg/l	BQL	BQL	BQL	BQL

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

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

Sr. No.	Parameters	Unit	Near Coal Berth			
			22°59'12"N 70°13'40"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.30	7.46	7.30	7.36
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	32.0	31.8	32.7	31.0
5	Turbidity	NTU	34	29	36	40
6	Total Dissolved Solids	mg/l	43205	41674	43606.0	40029.0
7	Total Suspended Solids	mg/l	590	863	500.2	604.3
8	Total Solids	mg/l	43795	42537	44106.2	40633.3
9	DO	mg/l	4	5.1	4.5	4.4
10	COD	mg/l	90.0	86.0	88.0	79.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.69	0.75	0.56	0.64
13	Phosphate	mg/l	0.28	0.34	0.17	0.20
14	Sulphate	mg/l	3240	2016	2676	2148
15	Nitrate	mg/l	3.87	4.58	2.95	2.62
16	Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05
17	Calcium	mg/l	641.28	601.20	480.96	521.04
18	Magnesium	mg/l	1628.1	1749.6	1749.6	1749.6
19	Sodium	mg/l	9425.0	8408.0	9423.0	8709.0
20	Potassium	mg/l	339.0	299.0	306.0	230.0
21	Iron	mg/l	1.41	1.78	1.76	1.56
22	Chromium	mg/l	0.11	0.13	0.13	0.12
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	0.06	0.05	0.05	0.07
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	0.08	0.09	0.09	0.07
28	Zinc	mg/l	BQL	BQL	BQL	BQL

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

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

Sr. No.	Parameters	Unit	KPT 4			
			Near 15/16 Berth			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.35	7.50	7.50	7.20
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	32.1	32.6	31.9	31.6
5	Turbidity	NTU	43	39	45	33
6	Total Dissolved Solids	mg/l	42399	39089	38986.0	39711.0
7	Total Suspended Solids	mg/l	743	577	681.8	530.3
8	Total Solids	mg/l	43142	39666	39667.8	40241.3
9	DO	mg/l	4.6	4.5	5.2	5.6
10	COD	mg/l	92.0	90.0	82.0	89.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.82	0.58	0.58	0.51
13	Phosphate	mg/l	0.28	0.25	0.22	0.20
14	Sulphate	mg/l	1620	3492	2388	2100
15	Nitrate	mg/l	1.97	3.03	2.71	2.06
16	Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05
17	Calcium	mg/l	561.12	641.28	561.12	440.88
18	Magnesium	mg/l	1579.5	1603.8	1603.8	1822.5
19	Sodium	mg/l	9423.0	9014.0	9526.0	9468.0
20	Potassium	mg/l	341.0	301.0	218.0	221.0
21	Iron	mg/l	1.62	1.33	1.74	1.21
22	Chromium	mg/l	0.16	0.12	0.14	0.16
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	0.04	0.05	0.06	0.04
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	0.08	0.06	0.09	0.08
28	Zinc	mg/l	BQL	BQL	BQL	BQL

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

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

Sr. No.	Parameters	Unit	Nakti Creek Near Tuna Port			
			22°57'49."N 70° 7'0.67"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.30	7.20	7.30	7.40
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31.6	31.2	31.2	31.1
5	Turbidity	NTU	36	42	36	31
6	Total Dissolved Solids	mg/l	40770	38329	38644.0	38955.0
7	Total Suspended Solids	mg/l	766	853	494.2	474
8	Total Solids	mg/l	41536	39182	39138.2	39429.0
9	DO	mg/l	4.1	4.7	4.6	4.8
10	COD	mg/l	98.0	96.0	96.0	98.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.53	0.89	0.75	0.64
13	Phosphate	mg/l	0.24	0.24	0.21	0.18
14	Sulphate	mg/l	3456	3732	2820	2424
15	Nitrate	mg/l	2.75	3.38	2.77	4.31
16	Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05
17	Calcium	mg/l	561.12	521.04	480.96	561.12
18	Magnesium	mg/l	1676.7	1725.3	1773.9	1676.7
19	Sodium	mg/l	9839.0	10125.0	10118.0	10168.0
20	Potassium	mg/l	399.0	402.0	387.0	390.0
21	Iron	mg/l	1.20	1.13	1.45	1.10
22	Chromium	mg/l	0.11	0.13	0.14	0.14
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	0.05	0.07	0.07	0.08

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
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	0.07	0.09	0.10	0.09
28	Zinc	mg/l	BQL	BQL	BQL	BQL

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

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

Sr. No.	Parameters	Unit	Nakti Creek Near NH-8A			
			23° 02'01"N 70° 09'31"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.52	Sampling not possible during Low Tide	7.52	Sampling not possible during Low Tide
2	Color	-	Colorless		Colorless	
3	Odor	-	Odorless		Odorless	
4	Salinity	ppt	31.8		32.2	
5	Turbidity	NTU	35		35	
6	Total Dissolved Solids	mg/l	41695		42152.0	
7	Total Suspended Solids	mg/l	684		452	
8	Total Solids	mg/l	42379		42604.0	
9	DO	mg/l	4.8		5.1	
10	COD	mg/l	100.0		94.0	
11	BOD	mg/l	BQL		BQL	
12	Silica	mg/l	0.96		0.53	
13	Phosphate	mg/l	0.23		0.17	
14	Sulphate	mg/l	3780		2376	
15	Nitrate	mg/l	3.24		3.61	
16	Nitrite	mg/l	<0.05		<0.05	
17	Calcium	mg/l	480.96		601.2	

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
18	Magnesium	mg/l	1725.3		1628.1	
19	Sodium	mg/l	10308.0		10319.0	
20	Potassium	mg/l	409.0		364.0	
21	Iron	mg/l	1.20		1.35	
22	Chromium	mg/l	0.11		0.12	
23	Copper	mg/l	BQL		BQL	
24	Arsenic	mg/l	BQL		BQL	
25	Cadmium	mg/l	0.06		0.06	
26	Mercury	mg/l	BQL		BQL	
27	Lead	mg/l	0.08		0.11	
28	Zinc	mg/l	BQL		BQL	

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

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

Sr. No.	Parameters	Unit	Nr.Vadinar Jetty			
			22°26'25.26"N 69°40'20.41"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.60	7.70	7.41	7.52
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	31.2	32.0	31.5	31.4
5	Turbidity	NTU	45	39	42	40
6	Total Dissolved Solids	mg/l	38510	42661	40025.0	40250.0
7	Total Suspended Solids	mg/l	585	523	548.9	505
8	Total Solids	mg/l	39095	43184	40573.9	40755.0
9	DO	mg/l	4.4	4.6	4.7	4.6

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
10	COD	mg/l	76.0	80.0	72.0	70.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.85	1.02	0.75	0.82
13	Phosphate	mg/l	0.22	0.25	0.18	0.17
14	Sulphate	mg/l	2580	2700	2592	2508
15	Nitrate	mg/l	2.75	3.59	3.67	3.39
16	Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05
17	Calcium	mg/l	601.20	521.04	641.28	480.96
18	Magnesium	mg/l	1603.8	1676.7	1652.4	1676.7
19	Sodium	mg/l	10968.0	10848.0	11126.0	10829.0
20	Potassium	mg/l	344.0	382.0	355.0	392.0
21	Iron	mg/l	1.06	1.70	1.12	1.42
22	Chromium	mg/l	0.12	0.13	0.14	0.13
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	0.05	0.04	0.08	0.07
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	0.10	0.08	0.10	0.09
28	Zinc	mg/l	BQL	BQL	BQL	BQL

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

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

Sr. No.	Parameters	Unit	Nr.Vadinar SPM 22°30'56.15"N 69°42'12.07"E			
			Spring Tide		Neap Tide	
	Tide		High Tide	Low Tide	High Tide	Low Tide
1	pH	pH unit	7.40	7.60	7.45	7.26

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
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odorless	Odorless	Odorless	Odorless
4	Salinity	ppt	32.2	32.1	32.0	31.8
5	Turbidity	NTU	33.0	34.0	36.0	33.0
6	Total Dissolved Solids	mg/l	41700.0	41987	40610.0	40925
7	Total Suspended Solids	mg/l	635.0	480	513.0	548
8	Total Solids	mg/l	43340.0	43924	41384.0	42000
9	DO	mg/l	4.3	4.1	4.5	4.3
10	COD	mg/l	90.0	92.0	78.0	70.0
11	BOD	mg/l	BQL	BQL	BQL	BQL
12	Silica	mg/l	0.92	0.96	0.6	0.78
13	Phosphate	mg/l	0.24	0.25	0.2	0.16
14	Sulphate	mg/l	2628.0	2364	2316.0	2556
15	Nitrate	mg/l	3.10	3.38	3.34	3.68
16	Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05
17	Calcium	mg/l	481.0	561.12	521.0	561.12
18	Magnesium	mg/l	1652.4	2065.5	1676.7	1701
19	Sodium	mg/l	10318	10829	10418	10786
20	Potassium	mg/l	354	355	377	354
21	Iron	mg/l	1.60	1.80	1.27	1.90
22	Chromium	mg/l	0.14	0.14	0.13	0.12
23	Copper	mg/l	BQL	BQL	BQL	BQL
24	Arsenic	mg/l	BQL	BQL	BQL	BQL
25	Cadmium	mg/l	0.05	0.04	0.08	0.08
26	Mercury	mg/l	BQL	BQL	BQL	BQL
27	Lead	mg/l	0.09	0.08	0.11	0.09

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
28	Zinc	mg/l	BQL	BQL	BQL	BQL

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

5.4.1 Marine Sediments

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

5.5Results

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

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

Sr. No.	Parameters	Unit	KPT - 1	KPT - 2	KPT - 3	KPT - 4	KPT - 5	Jetty	SPM
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	1.72	1.34	1.36	2.74	1.53	2.31	2.00
3	Organic Carbon	mg/kg	0.99	0.78	0.79	1.59	0.89	1.34	1.16
4	Inorganic Phosphate	mg/kg	112.0	121.0	116.0	124.0	128.0	122.0	133.0
5	Moisture	%	29.43	23.11	31.0	27.25	25.69	27.4	43.00
6	Aluminium	mg/kg	ND	ND	ND	ND	ND	ND	ND
7	Silica	mg/kg	11.2	10.5	12.3	11.4	10.5	13.2	13.00
8	Phosphate	mg/kg	2.57	2.73	9.48	6.12	11.84	5.96	6.68
9	Sulphate	mg/kg	283.0	257.0	411.0	182.0	338.0	209.0	494.7
10	Nitrite	mg/kg	0.12	0.11	0.12	0.12	0.11	0.1	0.11
11	Nitrate	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
12	Calcium	mg/kg	364.7	152.3	505.0	76.2	325.0	225.0	177.0
13	Magnesium	mg/kg	260.0	241.0	158.0	175.0	308.0	58.3	228.4

14	Sodium	mg/kg	1819.0	2881.0	876.0	1858.0	4022.0	3159.0	8637.0
15	Potassium	mg/kg	119.0	166.0	102.0	113.0	263.0	283.0	1036.7
16	Chromium	mg/kg	60	46.6	51.2	43.2	58	46.40	65.00
17	Nickel	mg/kg	32.1	33.7	24.9	28	32.5	28.00	45.60
18	Copper	mg/kg	39.9	14.6	33	16.8	31.8	26.80	21.00
19	Zinc	mg/kg	81.90	52.70	60.80	42.70	68.70	64.30	65.90
20	Cadmium	mg/kg	2.0	BQL	BQL	BQL	BQL	BQL	BQL
21	Lead	mg/kg	18.50	5.4	9.0	5.70	11.4	10.90	5.20
22	Mercury	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
23	Arsenic	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL

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

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

Sr. No.	Parameters	Unit	KPT - 1	KPT - 2	KPT - 3	KPT - 4	KPT - 5	Jetty	SPM
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	1.12	1.50	2.88	1.41	0.69	1.43	1.69
3	Organic Carbon	mg/kg	0.65	0.87	1.67	0.82	0.40	0.83	0.98
4	Inorganic Phosphate	mg/kg	118.0	126.0	120.0	130.0	128.0	112.0	130.0
5	Moisture	%	17.76	22.98	20.4	14.01	22.6	34.3	32.16
6	Aluminium	mg/kg	ND	ND	ND	ND	ND	ND	ND
7	Silica	mg/kg	12.0	11.3	10.5	11.3	9.8	11.4	12.60
8	Phosphate	mg/kg	17.14	2.91	7.83	0.49	2.54	15.65	2.20
9	Sulphate	mg/kg	255.0	427.0	290.0	440.0	390.0	564.0	595.0
10	Nitrite	mg/kg	0.1	0.11	0.1	0.11	0.12	0.1	0.11
11	Nitrate	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
12	Calcium	mg/kg	180.0	188.0	172.0	180.0	176.0	116.0	140.0
13	Magnesium	mg/kg	38.9	102.1	82.6	150.7	58.3	158.0	179.8

Sr. No.	Parameters	Unit	KPT - 1	KPT - 2	KPT - 3	KPT - 4	KPT - 5	Jetty	SPM
14	Sodium	mg/kg	325.0	853.6	743.8	656.1	414.0	1895.0	1810.0
15	Potassium	mg/kg	25.7	72.3	52.3	52.3	40.0	248.0	307.0
16	Chromium	mg/kg	25.7	38.6	28.6	27.3	31.3	51.90	56.20
17	Nickel	mg/kg	18.0	29.2	20.1	18.4	17.8	32.40	72.70
18	Copper	mg/kg	12.30	20.30	6.70	9.40	7.90	22.20	41.10
19	Zinc	mg/kg	24.90	57.40	32.80	27.90	25.50	46.40	1511.00
20	Cadmium	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
21	Lead	mg/kg	4.60	6.7	7.5	3.70	3.3	24.70	29.60
22	Mercury	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
23	Arsenic	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL

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

REPORT

ON

ECOLOGICAL MONITORING

OF MARINE ENVIRONMENT

IN

DPTHARBOURAREA, NEAR BY CREEKS

AND

VADINAR JETTY AND SPM

FOR

DEENDAYAL PORT TRUST

November, 2021

INTRODUCTION:

Sampling Stations:

The monitoring of marine environment for the study of biological and ecological Parameters was carried out on19thNovember, 2021 in harbour region of DPT at Kandla Creek, and on 20thNovember, 2021 in creeks near by the port during spring tide. The monitoring of marine environment for the study of biological and ecological parameters was repeated again on 26thNovember, 2021 in harbour region of DPT at Kandla Creek and on27thNovember 2021 in creeks near by the port during neap tidal condition.

Plankton samples from sub surface layer was collected both during high tide period and low tide period from 3 water quality monitoring stations of KPT harbour area and one stations in Nakti creek and one station in Khori creek. Sampling at second sampling station of Nakti creek was possible only during high tide period. The same sampling schedule was repeated during consecutive Neap tide and spring tide in same month.

Plankton samples from sub surface layer were collected during high tide period and low tide period from monitoring station near Vadinar jetty at Path Finder Creek during neap tide on 11/11/2021 and spring tide period on 26/11/2021 Collected water samples were processed for estimation of Chlorophyll- a, Pheophytin- a, qualitative &quantitative evaluation of phytoplankton, qualitative &quantitative evaluation zooplanktons (density and their population).

TABLE #1 SAMPLING LOCATIONS

monitoring requirement	**Number of locations**
Kandla creek	3 in Kandla creek
Nakti creek	2 in Nakti creek
Khori Creek	1 in Khori creek
Vadinar jetty	1 near Vadinar Jetty
SPM	1 near I stSPM
Total Number of locations	**8**

Sampling methodology adopted:

A marine sampling is an estimation of the body of information in the population. The theory of the sampling design is depending upon the underlying frequency distribution of the population of interest. The requirement for useful water sampling is to collect a representative sample of suitable volume from the specified depth and retain it free from contamination during retrieval.

50 litres of the water sample were collected from Sub surface by using bucket. From the collected water sample 1 litres of water sample were taken in an opaque plastic bottle for chlorophyll estimation, thereafter plankton samples were collected by using filtration assembly with nilyobolt cloth of 20µm mesh size.

Samples Processing for chlorophyll estimation:

Samples for the chlorophyll estimation were preserved in ice box on board in darkness to avoid degradation in opaque container covered with aluminium foil. Immediately after reaching the shore after sampling, 1 litre of collected water sample was filtered through GF/F filters (pore size 0.45 µm) by using vacuum filtration assembly. After vacuum filtration the glass micro fiber filter paper was grunted in tissue grinder, macerating of glass fiber filter paper along with the filtrate was done in 90% aqueous Acetone in the glass tissue grinder with glass grinding tube. Glass fiber filter paper will assist breaking the cell during grinding and chlorophyll content was extracted with 10 ml of 90% Acetone, under cold dark conditions along with saturated magnesium carbonate solution in glass screw cap tubes. After an extraction period of 24 hours, the samples were transferred to calibrated centrifuge tubes and adjusted the volume to original volume with 90% aqueous acetone solution to make up the evaporation loss. The extract was clarified by using centrifuge in closed tubes. The clarified extracts were then decanted in clean cuvette and optical density was observed at wavelength 664, 665 nm. By using corrected optical density, Chlorophyll-a value was calculated as given in (APHA, 1998).

PLANKTON:

The entire area open water in the sea is the pelagic realm. Pelagic organisms live in the open sea. In contrast to the pelagic realm, the benthic realm comprises organisms and zone of the bottom of the sea. Vertically the pelagic realm can be dividing into two zones based on light penetration; upper photic or euphotic zone and lower dark water mass, aphotic zone below the photic zone.

The term plankton is general term for organisms have such limited powers of locomotion that they are at the mercy of the prevailing water movement. Plankton is subdivided to phytoplankton and zooplankton. Phytoplankton is free floating organisms that are capable of photosynthesis and zooplankton is the various free floating animals.

Pelagic zone, represents the entire ocean water column from the surface to the deepest depths, is home to a diverse community of organisms. Differences in their locomotive ability categorize the organisms in the pelagic realm into two, ***plankton*** and ***nekton*** (Lalli and Parsons, 1997). ***Plankton*** consists of all organisms drifting in the water and is unable to swim against water currents, whereas ***Nekton*** includes organisms having strong locomotive power. Ecological studies on the plankton community, which form the base of the aquatic food chain, help in the better understanding of the dynamics and functioning of the marine ecosystem. The term ‘Plankton’ first coined by Victor Hensen (1887), Plankton, (Greek word: *planktos*meaning “passively drifting or wandering”) is defined as drifting or free-floating organisms that inhabit the pelagic zone of water. Based on their mode of nutrition planktonic organisms are categorised into phytoplankton (organisms having an autotrophic mode of nutrition) and zooplankton (organisms having a heterotrophic mode of nutrition).

Phytoplankton in the marine environment:

Phytoplankton is free floating unicellular, filamentous and colonial eutrophic organisms that grow in aquatic environments whose movement is more or less dependent upon water currents. These micro flora acts as primary producers as well as the basis of food chain, source of protein, bio purifier and bio indicators of the aquatic ecosystems of which diverse array of the life depends .They are considered as an important component of aquatic flora, play a key role in maintaining equilibrium between abiotic and biotic components of aquatic ecosystem.

The phytoplankton includes a wide range of photosynthetic and phototrophic organisms. Marine phytoplankton is mostly microscopic and unicellular floating flora, which are the primary producers that support the pelagic food-chain. The two most prominent groups of phytoplankton are diatoms (Bacillariophyceae) and dinoflagellates (Dinophyceae).The phytoplankton those normally captured in the net from the Gulf of Kutch is normally dominated by these two major groups; diatoms and dinoflagellates. Phytoplankton also include numerous and diverse collection of extremely small, motile algae which are termed micro flagellates (naked flagellates) as well as and Cyanophytes (blue-green algae).

Algae are an ecologically important group in most aquatic ecosystems and have been an important component of biological monitoring programs. Algae are ideally suited for water quality assessment because they have rapid reproduction rates and very short life cycles, making them valuable indicators of short-term impacts.

Aquatic populations are impacted by anthropogenic stress, resulting in a variety of alterations in the biological integrity of aquatic systems. Algae can serve as an indicator of the degree of deterioration of water quality, and many algal indicators have been used to assess environmental status.

Zooplankton in the marine environment:

Zooplankton includes a taxonomically and morphologically diverse community of heterotrophic organisms that drift in the waters of the world's oceans. Qualitative and quantitative studies on zooplankton community are a prerequisite to delineate the ecological processes active in the marine ecosystem. Zooplankton community plays a pivotal role in the pelagic food web as the primary consumers of phytoplankton and act as the food source for organisms in the higher trophic levels, particularly the economically essential groups such as fish larvae and fishes. They also function in the cycling of elements in the marine ecosystem. The dynamics of the zooplankton community, their reproduction, and growth and survival rate are all significant factors determining the recruitment and abundance of fish stocks as they form an essential food for larval, juvenile and adult fishes (Beaugrand et al., 2004). Zooplankton grazing in the marine environment controls the primaryProduction and helps in determining the pelagic ecosystem (Banse, 1995). Through grazing in surface waters and following the production of sinking faecal matters and also by the active transportation of dissolved and particulate matter to deeper waters via vertical migration, they help in the transport of organic carbon to deep ocean layers and thus act as key drivers of biological pump' in the marine ecosystem. Zooplankton grazing and metabolism also, transform particulate organic matter into dissolved forms, promoting primary producer community, microbial demineralization, and particle export to the ocean's interior.

The categorisation of zooplankton into various ecological groups is based on several factors such as duration of planktonic life, size, food preferences and habitat. As they vary significantly in size from microscopic to metazoic forms, the classification of zooplankton based on size has paramount importance in the field of quantitative plankton research.

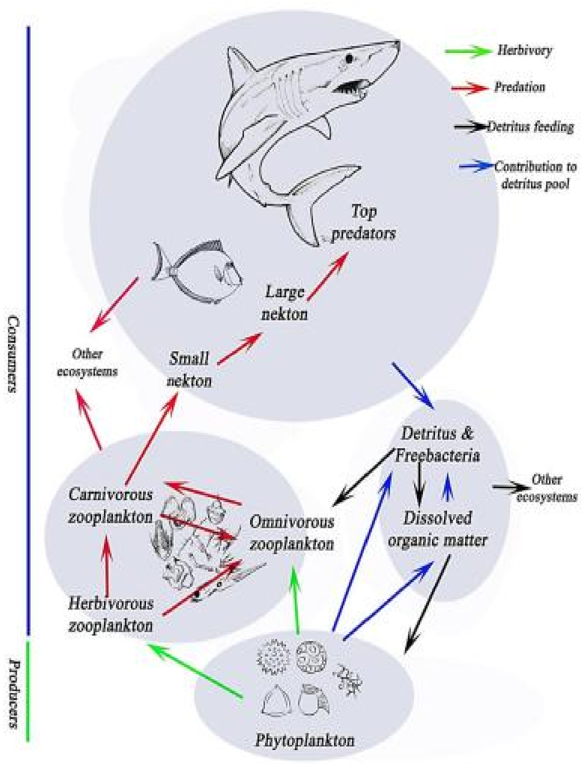
Based on the duration of planktonic life, zooplankton are categorised into Holoplankton (organisms which complete their entire lifecycle as plankton) and Meroplankton (organisms which are planktonic during the early part of their lives such as the larval stages of benthic and nektonic organisms). Tychoplankton are organisms which live a brief planktonic life, such as the benthic crustaceans (Cumaceans, mysids, isopods) which ascend to the water column at night for feeding and certain ectoparasitic copepods, they leave the host and spend their life as plankton during their breeding cycle.

Zooplankton can be subdivided into holoplankton, i.e., permanent members of the plankton (e.g., Calanoid copepods), and meroplankton, i.e., temporary members in the plankton e.g., larvae of fish, shrimp, and crab). The meroplankton group consists of larval and young stages of animals that will adopt a different lifestyle once they mature. In contrast to phytoplankton which consist of a relatively smaller variety of organisms, Zooplankton are extremely divers, consist of a host of larval and adult forms representing many animal phylum.

Among the zooplankton one group always dominate than others; members of sub class copepods (Phylum Athropoda) and Tintinids (Phylum Protozoa) among the net planktons. These small animals are of vital importance in marine ecosystem as one of the primary herbivores animals in the sea, and it is they provide vital link between primary producer (autotrophs) and numerous small and large marine consumers.

As their community structure and function are highly susceptible to changes in the environmental conditions regular monitoring of their distribution as well as their interactions with various physicochemical parameters is inevitable for the sustainable management of the ecosystem (Kusum et al., 2014). Of all the marine zooplankton groups, copepods mainly Calanoid copepods are the dominant groups in marine subtropical and tropical waters and exhibit considerable diversity in morphology and habitats they occupy (Madhupratap, 1991;)

It has been well established that potential of pelagic fishes viz. finfishes, crustaceans, molluscs and marine mammals either directly or indirectly depend on zooplankton. The herbivorous zooplankton is efficient grazers of the phytoplankton and is referred to as living machines transforming plant material into animal tissue. Hence they play an essential role as the intermediaries for nutrients/energy transfer between primary and tertiary trophic levels. Due to their large density, shorter lifespan, drifting nature, high group/species diversity and different tolerance to the stress, they used as the indicator organisms for the physical, chemical and biological processes in the aquatic ecosystem (Ghajbhiye, 2002).



Simplified marine food web

Spatial distribution of Plankton:

A characteristic of plankton population is that they tend to occur in patches, which are varying spatially on a scale of few meters to far as few kilometres in distance. They also vary in time scale, season as well as vertically in the water column. It is this patchiness and its constant changes in time and spot, that has made it so difficult for plankton biologist to learn about the ecology of plankton. The biological factors that causes this patchiness is due to the ability of zooplankton to migrate vertically and graze out the phytoplankton at a rapid rate that can create patchiness. Similarly the active swimming ability by certain zooplankton organisms can cause to aggregate in dense group.

At its most extreme, because the water in which plankton is suspended is constantly moving, each sample taken by the plankton biologists remain a different volume of water, so each sample is unique and replicate does not exist.

Plankton may also exhibit vertical patchiness. Physical factors contribute to this type of patchiness include light intensity, nutrients and density gradients in the water column.

Phytoplankton in particular tends to be unequally distributed vertically, which leads to the existence of different concentration of a chlorophyll value between photic zone and below the photic zone.

Methodology adopted for Plankton sampling:

Mixed plankton sample were obtained from the sub surface layer at each sampling locations by towing the net horizontally with the weight .After the tow of about 15-30minutes, plankton net was pulled up and washed down to the tail and collected the plankton adhered to plankton net in the collection bucket at the bottom by springing outer and inner surface of the net with sea water, while the net was hanging with the mouth upward. For quantitative evaluation 50 L water samples were collected from subsurface layer and filtered through 20µm mesh size net by using bucket and filtration assembly.

Preservation and storage:

Both filtered plankton and those collected from the plankton net were preserved with 5% buffered formalin and stored in 1L plastic container for further processing in the laboratory.

Sample concentration:

The collected plankton samples were concentrated by using centrifuge and made up to 50 ml with 5% formalin -Glycerine mixture.

Taxonomic evaluation:

Before processing, the sample was mixed carefully and a subsample was taken with a calibrated Stempel-pipette. 1 ml of the concentrated plankton samples were transferred on a glass slide with automatic pipette. The plankton sample on the glass slides were stained by using Lugol's iodine and added glycerine to avoid drying while observation. The plankton samples were identified by using Labex triangular Research microscope with photographic attachment. Microphotographs of the plankton samples were taken for record as well as for confirming the identification. The bigger sized zooplankton was observed through dissecting stereomicroscope with magnification of 20-30 x. Plankton organisms in the whole slide were identified to the lowest axon possible. A thorough literature search was conducted for the identification of the different groups of zooplankton that were encountered

Cell counts by drop count method:

The common glass slide mounted with a 1ml of concentrated phytoplankton/zooplankton sample in glycerol and covered with cover slip 22x 60mm was placed under the compound microscope provided with a mechanical stage. The plankton was then counted from the microscopic field of the left top corner of the slide. Then slide is moved horizontally along the right side and plankton in each microscopic field was thus counted. When first microscopic field row was finished the next consecutive row was adjusted using the mechanical device of the stage. In this way all the plankton present in entire microscopic field are counted. From this total number in 1ml of the concentrated plankton, total number of plankton in the original volume of sample filtered was calculated as units/L.

BENTHIC ORGANISMS:

Benthos is those organisms that are associated with the sea bed or benthic habitats. Epi- benthic organisms live attached to a hard substratum or rooted to a shallow depth below the surface. In fauna organisms live below the sediment–water interface. Interstitial organisms live and move in pore water among sedimentary grains.

Because the benthic organisms are often collected and separated on sieves, a classification based on the overall size is used. Macro benthos include organisms whose shortest dimension is greater than or equal to 0.5 mm. Meio benthos are smaller than 0.5mm but larger than 42µ in size.

The terms such as macro fauna and Meio fauna generally have little relevance with taxonomic classification. The terms Meio fauna and macro fauna depend on the size. Meio fauna were considered as good bioassay of community health and rather sensitive indicators of environmental changes

SAMPLING METHODOLOGY ADOPTED FOR SUB TIDAL REGION:

Van veen sampler (0.09m^2) was used for sampling bottom sediments. Two sets of sediments were sampled from each location, one for macro fauna and other for Meio fauna. The macro fauna in the sediments were sieved on board to separate out the organisms. The fixation of Meio fauna is normally done by bulk fixation of the sediment sample. The bulk fixation is done by using 10% formalin (Buffered with borate). The organisms were preserved with seawater as diluting agent.

Sample sieving:

Sediments samples were sieved to extract the organisms. Sieving was performed carefully as possible to avoid any damage to the animals. The large portion of the sediment was split in to smaller portions and mixed with sea water in a bucket. The cohesive lumps were broken down by continuous stirring. The disaggregated sediments were then passed through the sieves.

Sample staining:

Sorting of the Meio fauna from the sieve is difficult task especially in the preserved material, because organisms are not easily detectable. To facilitate the animal detection the entire sample retained on the sieve after sieving operation were stained by immersing the sieve in a flat bottom tub with 1% Rose Bangal stain; a protein stain. A staining period of 10-30 minutes is sufficient for sample detection.

DIVERSITY INDICES:

On the whole, diversity indices provide more information about community composition than simply species richness (number of species present); they also, take the relative abundances of different species into account. Based on this fact, diversity indices therefore depend not only on species richness but on the evenness, or equitability, with which individuals are distributed among the different species (Magurram, A. E. (1988)

A diversity index is a measure of species diversity within a community that consists of co-occurring populations of several (two or more) different species. It includes two components: richness and evenness. Richness is the measure of the number of different species within a sample showing that more the types of species in a community, the higher is the diversity or greater is the richness. Evenness is the measure of relative abundance of the different species with in a community.

The basic idea of diversity index is to obtain a quantitative estimate of biological variability that can be used to compare biological entities composed of discrete components in space and time (Carol H.R. *etal*. 1998). Biodiversity is commonly expressed through indices based on species richness and species abundances (Whittaker 1972, Lande 1996, Purvis and Hector 2000). Biodiversity indices are a non-parametric tool used to describe the relationship between species number and abundance. The most widely used bio diversity indices are Shannon Weiner index and Simpson’s index.

A diversity Index is a single statistic that incorporates in formation on richness and evenness. The diversity measures that incorporate the two concepts may be termed heterogeneity measures (Magurran, 2004).

Any study intended to interpret causes and effect of adverse impact on Biodiversity of communities require suitable measures to evaluate specie richness and Diversity. The former is number of species in community, while latter is a function of relative frequency of different species. Species richness is the iconic measure of biological diversity (Magurran, 2004). Several indices have been created to measure the diversity of species; however, the most widely used in the last decades are the Shannon (1948) and Simpson (1949) (Buzas and Hayek 1996; Gorelick 2006), with the components of diversity: richness (*S)* and evenness (*J)*

Simpson's diversity index

Simpson's index (**D**) is a measure of diversity, which takes into account both species richness, and evenness of abundance among the species present.. The Simson index is one of the meaningful and robust biodiversity measures available.(Magurran ,2004).

The formula for calculating D is presented as:

$$D = \frac{\sum n_i(n_i - 1)}{N(N-1)}$$

Where n_i = the total number of organisms of each individual species

N = the total number of organisms of all species

The value of D ranges from 0 to 1. With this index, 0 represents infinite diversity and, 1, no diversity. When D increases diversity decreases. Simpson's index is therefore usually expressed as 1-D or 1/D. (Magurran, 2004)

Low species diversity suggests:

relatively few successful species in the habitat

the environment is quite stressful with relatively few ecological niches and only a few organisms are really well adapted to that environment

food webs which are relatively simple

change in the environment would probably have quite serious effects

High species diversity suggests:

a greater number of successful species and a more stable ecosystem

more ecological niches are available and the environment is less likely to be hostile complex food webs

environmental change is less likely to be damaging to the ecosystem as a whole

Species richness indices

The species richness***(S)*** is simply the number of species present in an ecosystem. Species richness Indices of species richness are widely used to quantify or monitor the effects of anthropogenic disturbance. A decline in species richness may be concomitant with severe or chronic human-induced perturbation (Fair Fair weather 1990,) Species richness measures have traditionally been the mainstay in assessing the effects of environmental degradation on the biodiversity of natural assemblages of organisms (Clarke &Warwick, 2001)

Species richness is the iconic measure of biological diversity (Magurran, 2004). The species richness ***(S)*** is simply the number of species present in an ecosystem. This index makes no use of relative abundances. The term species richness was coined by McIntosh (1967) and oldest and most intuitive measure of biological diversity (Magurran, 2004).

Margalef's diversity index is a species richness index. Margalef's Species richness index (d), or indices that describe the evenness of the distribution of the numbers of individuals among species, were derived.

The value of a diversity index increases both when the number of types increases and when evenness increases. For a given number of types, the value of diversity index is maximised when all types are equally abundant (Rosenzweig, M. L. (1995).

Shannon-Wiener's index:

An index of diversity commonly used in plankton community analyses is the Shannon-Wiener's index **(H),** which emphasizes not only the number of species (richness or variety), but also the apportionment of the numbers of individuals among the species (Odum 1971 and Reish 1984). Shannon-Wiener's index (**H**) reproduces community parameters to a single numberby using an equation.

Shannon and Weiner index represents entropy. It is a diversity index taking into account the number of individuals as well as the number of taxa. It varies from 0 for communities with only single taxa to high values for community with many taxa each with few individuals. This index can also determine the pollution status of a water body. Normal values range from 0 to 4. This index is a combination of species present and the evenness of the species. Examining the diversity in the range of polluted and unpolluted ecosystems, Wilham and Dorris (1968) concluded that the values of the index greater than 3 indicate clean water, values in the range of 1 to 3 are characterized by moderate pollution and values less than 1 are characterized as heavily polluted

$$H' = -\sum_{j=1}^{s} \frac{n_j}{N} \ln\left(\frac{n_j}{N}\right)$$

RESULTS:

CHLOROPHYLL-a:

Water Samples for the chlorophyll estimation were collected from sub surface layer during high tide and low tide period of the tidal cycle for each sampling locations and analysed for Chlorophyll -a and after acidification for Pheophytin –a. Chlorophyll- a value was used as algal biomass indicator (APHA,1998) Algal biomass was estimated by converting Chlorophyll value.

In the sub surface water chlorophyll-a was varying from 0.559 -0.868 mg/m^3.in harbour region of DPT in Kandla Creek during sampling done in spring tide period of November, 2021. In the nearby creeks chlorophyll-a was varying from 0.246 -0.954 mg/m^3.Pheophytin –a level was below detectable limit- the all the sampling stations during springtide

In the sub surface water chlorophyll-a was varying from 0.535 -0.921mg/m^3.in harbour region of DPT in Kandla Creek during sampling done in neap tide period of November , 2021 . In the nearby creeks chlorophyll-a was varying from 0.425 –1.923 mg/m^3.·Pheophytin –a level was below detectable limit- the all the sampling stations except KPT-4 Khori-I during low tide and high tide and KPT-5 Nakti-I during High tide period.

In the sub surface water chlorophyll-a was varying from 0.393 -0.338 mg/m^3.in harbour region of DPT OOT in path finder Creek during sampling done in spring tide period ofNovember, 2021. In the sub surface water chlorophyll-a was varying from 1.356 -0.500 mg/m^3.in harbour region of DPT OOT in path finder Creek during sampling done in Neap Tide period of November, 2021

In the sub surface water chlorophyll-a was varying from 0.424 -0.290 mg/m^3.in SPM region of DPT OOT in path finder Creek during sampling done in spring tide period of November, 2021. In the sub surface water chlorophyll-a was varying from 0.703 -0.409 mg/m^3.in SPM region of DPT OOT in path finder Creek during sampling done in Neap Tide period of November, 2021

TABLE #2 VARIATIONS IN CHLOROPHYLL –a PHEOPHYTIN- a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPT HARBOUR AREA IN KANDLA CREEK ,NEAR BY CREEKS AND DPT OOT JETTY IN PATH FINDER CREEK AND SPM NEAR VADINAR DURING SPRING TIDE IN NOVEMBER,2021

Sr. No.	Station	Tide	Chlorophyll-a (mg/m³)	Pheophytin-a (mg/m³)	Algal Biomass (Chlorophyll method) mg/m³
DPT HARBOUR AREAKANDLA CREEK					
1	KPT1	High tide	0.748	BDL	50.15
		Low tide	0.559	BDL	37.45
2	KPT 2	High tide	0.677	BDL	45.36
		Low tide	0.764	BDL	51.19
3	KPT 3	High tide	0.835	BDL	55.94
		Low tide	0.868	BDL	58.16
CREEKS					
4	KPT-4 Khori-I	High tide	0.661	BDL	44.29
		Low tide	0.720	BDL	48.24
5	KPT-5 Nakti-I	High tide	0.848	BDL	56.82
		Low tide	0.954	BDL	63.92
6	KPT-5 Nakti-II	High tide	0.246	BDL	16.48
PATHFINDER CREEK VADINAR					
7	VADINAR-I jetty	Low tide	0.393	BDL	26.33
8		High tide	0.338	BDL	22.65
9	SPM	High tide	0.424	BDL	28.41
10	SPM	Low tide	0.290	BDL	19.43

BDL: Below Detectable Limit.

TABLE #3 VARIATIONS IN CHLOROPHYLL –a PHEOPHYTIN- a AND ALGAL BIOMASS FROM SAMPLING STATIONS IN DPT HARBOUR AREA , NEAR BY CREEKS AND DPT OOT JETTY IN PATH FINDER CREEK AND SPM NEAR VADINARDURING NEAP TIDE IN NOVEMBER,2021

Sr. No.	Station	Tide	Chlorophyll-a (mg/m^3)	Pheophytin-a (mg/m^3)	Algal Biomass (Chlorophyll method) mg/m^3
DPTHARBOUR AREAKANDLA CREEK					
1	KPT1	High tide	0.748	BDL	50.12
		Low tide	0.535	BDL	35.85
2	KPT 2	High tide	0.713	BDL	47.77
		Low tide	0.713	BDL	47.77
3	KPT 3	High tide	0.882	BDL	59.09
		Low tide	0.921	BDL	61.71
CREEKS					
4	KPT-4 Khori-I	High tide	1.669	0.484	111.82
		Low tide	1.178	0.380	78.93
5	KPT-5 Nakti-I	High tide	1.923	0.570	128.84
		Low tide	0.882	BDL	59.09
6	KPT-5 Nakti-II	High tide	0.425	BDL	28.47
PATHFINDER CREEK VADINAR					
7	VADINAR-I jetty	Low tide	1.356	0.415	90.85
8		High tide	0.500	BDL	33.50
9	SPM	High tide	0.703	BDL	47.10
10	SPM	Low tide	0.409	BDL	27.40

BDL: Below Detectable Limit.

PHYTOPLANKTON POPULATION:

For the evaluation of the Phytoplankton population in DPT harbour area and within the immediate surroundings of the port, sampling was conducted from 5 sampling locations (3 in harbour area and two in Nakti creek) during high tide period and low tide period of spring tide and neap tide.

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by; Diatoms blue green algae and dinoflagellatesduring spring tide period.Diatoms were represented by 16genera. Blue green were represented by 2 genera and dinoflagellates were represented by two generaduring the sampling conducted in spring tide in November,2021. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 43-198 units/ L during high tide period and133-220 units/ L during low tide of Spring Tide.

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by Diatoms, Blue green algae and Dinoflagellates duringNeap tide period. Diatoms were represented by 20genera Blue green algae were represented 1genera and Dinoflagellates with two genera during the sampling conducted in Neap tide in November, 2021. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from83-327 units/ L during high tide period and 108 -252 units/ L during low tide of Neap Tide.

For the evaluation of the Phytoplankton population in DPT OOT jetty area in Path Finder creek sampling was conducted from one sampling locations ; jetty area during high tide period and low tide of spring tide. For the evaluation of the Phytoplankton population in DPTOOT jetty area in Path Finder creek in Vadinar sampling was conducted from 2 sampling locations ; jetty area and one near SPM during high tide period and low tide of Neap tide.

The phytoplankton community of the sub surface water in the path finder creeks was represented by only Diatoms spring tide period. Diatoms were represented by 11 genera during the sampling conducted in spring tide in November, 2021. Phytoplankton of the sampling stations at sub surface layer in the harbour area was varying from 162 units/ L during high tide period and 178 units/ L during low tide of Spring Tide. Phytoplankton of the sampling stations at sub surface layer in the SPM area was varying from 154 units/ L during high tide period and 130 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,and Dinoflagellatesduring Neap tide period.Diatoms were represented by 15 generaand dinoflagellates by two genera during the sampling conducted in Neap tide in November, 2021. Phytoplankton of the sampling stations at sub surface path finder creek nearOOT Jetty was varying from 227 units/ L during high tide period and 182 -744 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 158 units/ L during high tide period and 158 units/ L during low tide of Neap Tide.

Species Richness Indices and Diversity Indices:

Margalef’s diversity index (Species Richness)S

At the organismal level, the most widely used biodiversity measures are those based on the number of species present, perhaps adjusted for the number of individuals sampled, Here Margalef's Species richness index (d), or indices that describe the evenness of the distribution of the numbers of individuals among species, are derived.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek and nearby creeks sampling stations was varying from 1.595-3.091 with an average of 2.396during the sampling conducted in High tide period of spring tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek region and nearby creeks was varying from2.236 -2.863 with an average of 2.554 during the consecutive low tide period.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations in Kandla creek and nearby creeks was varying from 2.339-2.984 with an average of 2.696 during the sampling conducted in High tide period of Neaptide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek region and nearby creeks was varying from2.450-2.713 with an average of 2.624 during consecutive low tide.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations was 1.769 at OOT jetty area and 1.588 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 creeknear OOT jetty was 1.737 and 1.644 at SPM during the consecutive low tide period.

Margalef's diversity index (Species Richness) S of phytoplankton communities in the stations was 2.561 at OOT jetty area and 2.370 at SPM area during the sampling conducted in High tide period of Neap tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the path finder creek near OOT jetty was 2.114 and SPM area was 2.195 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 0.727-0.907 (H'(log10)) between selected sampling stations with an average value of 0.805 during high tide period of spring tide at Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 0.787 -0.895 (H'(log10)) between selected sampling stations with an average value of 0.853 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 0.695 -0.931 (H'(log10)) between selected sampling stations with an average value of 0.823 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 0.759-0.867 (H'(log10)) between selected sampling stations with an average value of 0.810 during consecutive low tide at Kandla creek and nearby creeks.

Shannon-Wiener's Index (H) of phytoplankton communities in the stations was 0.798 atOOT jetty area and 0.7551 at SPM area during the sampling conducted in High tide period of spring tide. While Shannon-Wiener's Index (H) of phytoplankton communities in the path finder creek near OOT jetty was 0.715 and 0.771 at SPM during the consecutive low tide period.

Shannon-Wiener's Index (H) of phytoplankton communities in the stations was 0.787 at OOT jetty area and 0.7330 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 0.729 and at SPM area was 0.712 during the consecutive low tide period.

Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon-Wiener's index increases as both the richness and the evenness of the community increase. This result indicates that diversity of phytoplankton of Kandla Harbour region and nearby creeks is less but with abundant population of few, with relatively few ecological niches and only very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson's diversity index:

Simpson's index (D) is a measure of diversity, which takes into account both species richness, and an evenness of abundance among the species present. The Simson index is one of the meaningful and robust biodiversity measures available. (Magurran,2004).

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in the Kandla Harbour region and nearby creeks, which was varying from 0.742- 0.830 between selected sampling stations with an average of 0.788 during high tide period of spring tide. Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stationsin the Kandla Harbour region and nearby creeks, which was varying from 0.786- 0.832

between selected sampling stations with an average of 0.809during consecutive low tide .

Simpson diversity index (1-D) of phytoplankton communities was below 0.9 at all sampling stations in Kandla Harbour region and nearby creeks, during high tide period and low tide period during neap tide also, which was varying from 0.664-0.841 with an average value of 0.774 between selected sampling stations during high tide period and varying from 0.732-0.824 with an average value of 0.771 between selected sampling stations during consecutive low tide period Low species diversity suggests a relatively few successful species in this habitat.

Simpson diversity index (1-D) of phytoplankton communities in the stations was 0.813 atOOT jetty area and 0.779 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 0.753 and 0.794 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 0.765 at OOT jetty area and 0.737 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 0.738 and at SPM area was 0.708 during the consecutive low tide period.

Low species diversity suggests a relatively few successful species in this habitat. The environment is quite stressful with relatively few ecological niches and only a few organisms are really well adapted to that environment. Any change in the environment would probably have quite serious effects.

Table # 4PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND ,NEAR BY CREEKS DURING SPRING TIDE IN NOVEMBER,2021

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	177	17/20	85	3.091	0.9004	0.8193
	2	152	16/20	80	2.986	0.9067	0.8305
	3	192	11/20	55	1.902	0.7268	0.7421
	4	167	13/20	65	2.345	0.7525	0.7454
	5	198	14/20	70	2.458	0.7886	0.7683
	6	43	7/20	35	1.595	0.7583	0.825
LOW TIDE	1	133	15/20	75	2.863	0.8948	0.8214
	2	153	15/20	75	2.783	0.893	0.832
	3	190	14/20	70	2.478	0.8679	0.8106
	4	137	12/20	60	2.236	0.8213	0.7966
	5	220	14/20	70	2.41	0.7872	0.786

Table # 5 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND ,NEAR BY CREEKS DURING NEAP TIDE IN NOVEMBER,2021

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	1	131	15/24	62.5	2.872	0.9308	0.8406
	2	120	13/24	54.16	2.507	0.8561	0.8136
	3	213	17/24	70.83	2.984	0.8315	0.7733
	4	259	14/24	58.33	2.339	0.7394	0.7223
	5	327	17/24	70.83	2.763	0.6955	0.6641
	6	83	13/24	54.16	2.716	0.8861	0.8316
LOW TIDE	1	108	13/24	54.16	2.563	0.791	0.7606
	2	134	13/24	54.16	2.45	0.8677	0.8239
	3	177	15/24	62.5	2.705	0.7892	0.7325
	4	252	16/24	66.66	2.713	0.7591	0.7444
	5	182	15/24	62.5	2.69	0.8458	0.7939

Table # 6 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND , NEAR BY CREEKS DURING SPRING TIDE IN NOVEMBER, 2021

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	DIATOMS	41-197	16/20	80
			BLUE GREEN	0-4	2/20	10
			DINOFLAGELLATES	0-3	2/20	10
			TOTAL PHYTO PLANKTON	**43-198**	**20**	-
LOW TIDE	Sub surface	5	DIATOMS	129-216	16/20	80
			BLUE GREEN	0-4	2/20	10
			DINOFLAGELLATES	0-2	2/20	10
			TOTAL PHYTO PLANKTON	**133-220**	**20**	-

Table # 7 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND , NEAR BY CREEKS DURING NEAP TIDE IN NOVEMBER,2021

Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	DIATOMS	81-326	21/24	87.6
			BLUE GREEN	0-2	1/24	4.16
			DINOFLAGELLATES	0-2	2/24	8.33
			TOTAL PHYTO PLANKTON	**83-327**	**24**	
LOW TIDE	Sub surface	5	DIATOMS	108-251	21/24	87.6
			BLUE GREEN	0-2	1/24	4.16
			DINOFLAGELLATES	0-1	2/24	8.33
			TOTAL PHYTO PLANKTON	**108-252**	**24**	

Table # 8 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT OOTAT PATH FINDER CREEK , VADINAR &NEAR BY SPM, DURING SPRING TIDE IN NOVEMBER, 2021

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	162	10/11	90.90	1.769	0.7989	0.8132
	SPM	178	10/11	90.90	1.737	0.7149	0.7536
LOW TIDE	jetty	154	9/11	81.82	1.588	0.7441	0.7796
	SPM	130	9/11	81.82	1.644	0.7712	0.7937

Table # 9 PHYTOPLANKTON VARIATIONS IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT OOTAT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING NEAP TIDE IN NOVEMBER, 2021

Tide	Sampling Station	Abundance In units/L	No of Species observed /total species	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	227	15/17	88.24	2.581	0.7875	0.7647
	SPM	182	12/17	70.59	2.114	0.7288	0.7383
LOW TIDE	Jetty	158	13/17	76.47	2.37	0.733	0.7374
	SPM	150	12/17	70.59	2.195	0.7123	0.7087

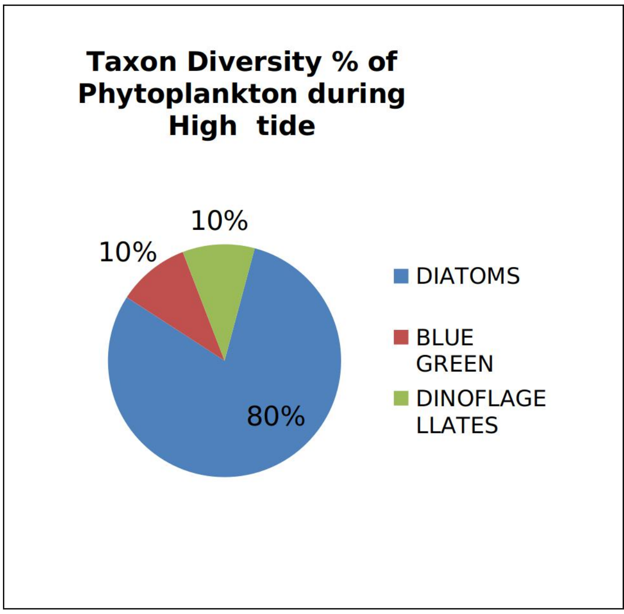
Table # 10 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT DPTOOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING SPRING TIDE IN NOVEMBER, 2021

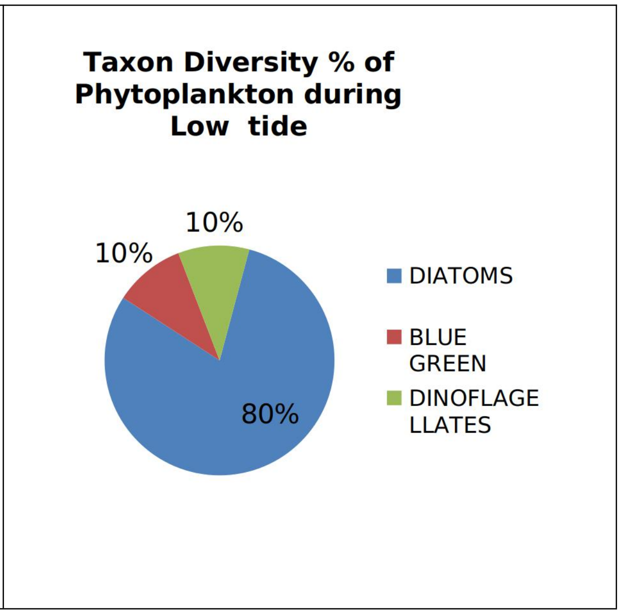
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	1	DIATOMS	162-178	11/11	100
			TOTAL PHYTO PLANKTON	162-178	**11**	
LOW TIDE	Sub surface	1	DIATOMS	130-154	11/11	100
			TOTAL PHYTO PLANKTON	130-154	**11**	

Table # 11 ABUNDANCE OF PHYTOPLANKTON SUBSURFACE SAMPLING STATIONS IN DPT DPTOOT AT PATH FINDER CREEK , VADINAR & NEAR BY SPM, DURING NEAP TIDE IN NOVEMBER, 2021

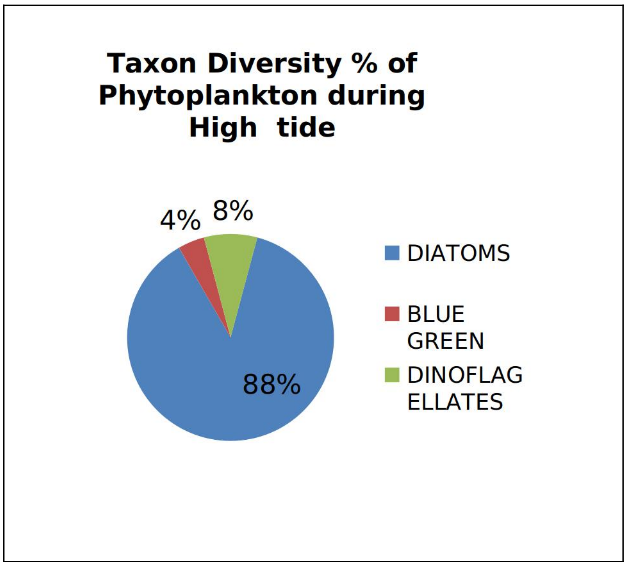
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	DIATOMS	182-226	15/17	88.24
			DINOFLAGELLATES	0-1	2/17	11.76
			TOTAL PHYTO PLANKTON	**182-227**	**17**	
LOW TIDE	Sub surface	2	DIATOMS	148-157	15/17	88.24
			DINOFLAGELLATES	0-1	2/17	11.76
			TOTAL PHYTO PLANKTON	148-158	**17**	

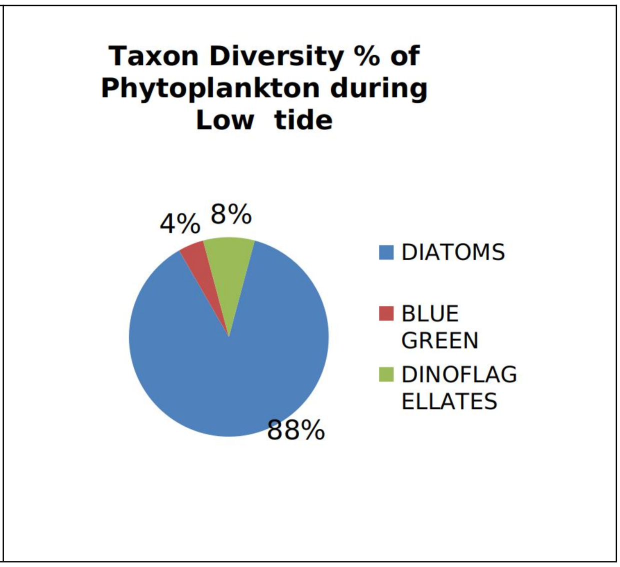
Taxon Diversity % of Phytoplankton during High tide and Low tide period during spring tide in Kandala creek and nearby creeks



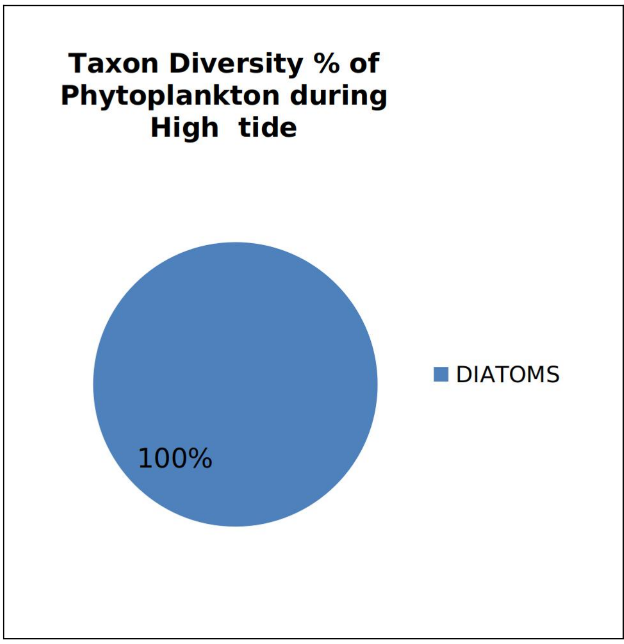


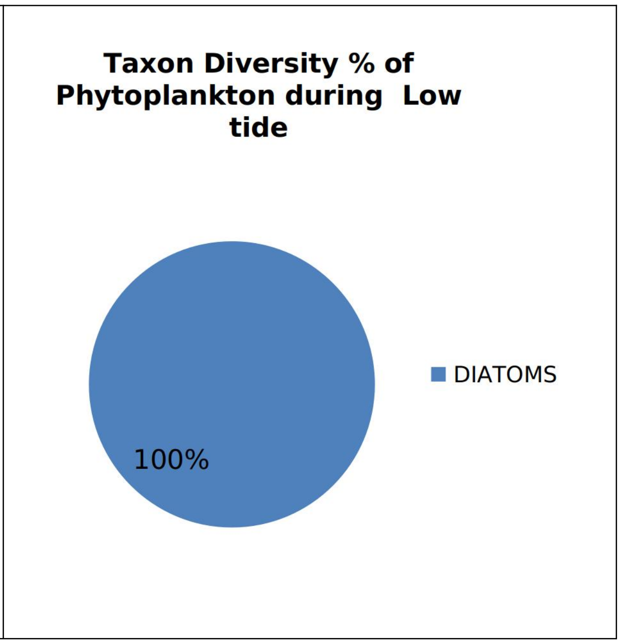
Taxon Diversity % of Phytoplankton during High tide and Low tide period during Neap tide in Kandala creek and nearby creeks



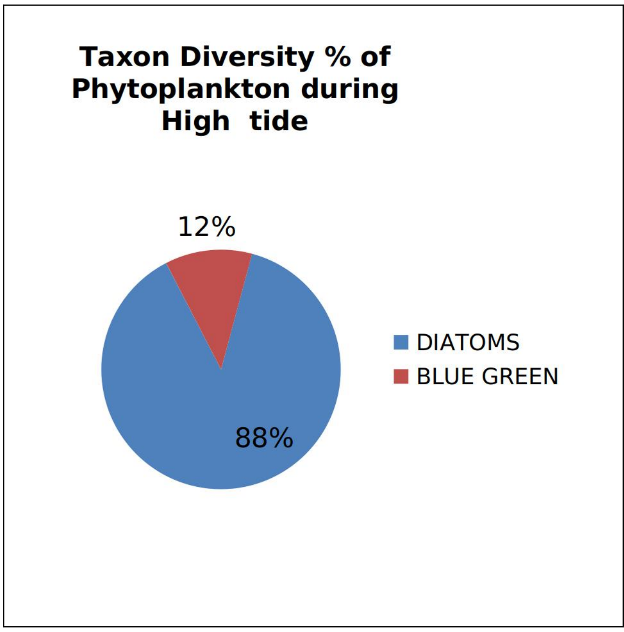


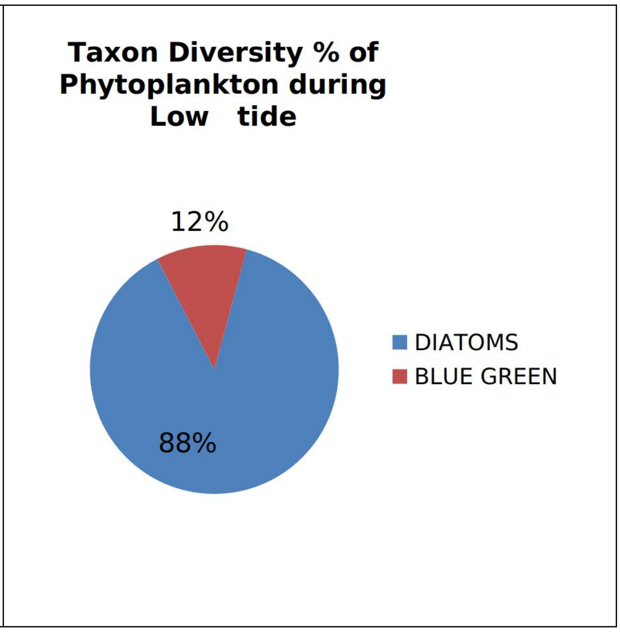
Taxon Diversity % of Phytoplankton during High tide and Low tide period during spring tide in Path Finder Creek, Vadinar





Taxon Diversity % of Phytoplankton during High tide and Low tide period during Neap tide in Path Finder Creek, Vadinar





ZOOPLANKTON POPULATION:

For the evaluation of the Zooplankton population in DPT harbour area and within the immediate surroundings of the port sampling was conducted from 6 sampling locations (3 in harbour area and two in Nakti creek and one in Khoricreek) during high tide period and low tide period of spring tide and Neap tide in November,2021. The Zooplankton community of the sub surface water in the harbour and nearby creeks during spring tide was represented by mainly 4 groups, and 5 larval forms; Tintinids, Copepods,Rotifers, Urochordatesand larval forms represented from the group of Crustacea, Molluscansand Polychaetes. The Zooplankton community of the sub surface water in the harbour and nearby creeks during neap tide was represented by mainly Six groups, Tintinids, Copepods, Arrow worms, Mysids, Urochordata, Ciliates and unidentified Cnidarian member and larval forms of Crustacea Molluscans and Echinodermata Larvae Polychaete Larvae..,

Zooplankton of the sampling stations at sub surface layer in the DPT harbour area and nearby creek was varying from 25-106x10^3 N/ m^3 during high tide and 58-85x10^3 N/ m^{3}during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPT harbour area and nearby creek was varying from 40-143 x10^3 N/ m^3 during high tide and83-129x10^3 N/ m^{3}during low tide of Neap Tide period.

For the evaluation of the Zoo plankton population in DPT OOT jetty area in Path Finder creek and SPM in Vadinar selected 2 sampling locations (1 in jetty area and one near SPM) Duringspring tide sampling plankton sample were collected only at Jetty area during consecutive high tide period and low tide period. During Neap tide sampling Plankton samples were collected from jetty area and SPM during consecutive high tide period and low tide period.
The Zooplankton community of the sub surface water in the path finder creek creeks during spring tide was represented by mainly Titinids , Copepods and larval forms of Crusracens, Molluscs and Polychaetes .The Zooplankton community of the sub surface water in the path Finder creeks at Jetty region and SPM during neap tide was represented by mainly three groups, Tintinids, Copepods , Urochordates and , five Larval forms were represented from the major group of Crustaceans , Molluscans , and Polychaetes,.

Zooplankton of the sampling stations at sub surface layer in the DPT OOTjetty area of path finder creek was 87 x103 N/ m^3 during high tide and 117 x103 N/ m^3 during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPT SPM area of path finder creek was 85 x10^3 N/ m^3 during high tide and 109 x10^3 N/ m^3 during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPT OOT jetty area in path finder creekwas recorded 54x10^3 N/ m^{3}during high tide and 86x10^3 N/ m^3 during consecutive low tide period of Neap . Zooplankton of the sampling stations at sub surface layer in the DPT SPM area in path finder creek was recorded 72 x10^3 N/ m^3during high tide and 92 x10^3 N/ m^3 during consecutive low tide period of Neap Tide .

Species Richness Indices and Diversity Indices:

Margalef’s diversity index (Species Richness)S

At the organismal level, the most widely used biodiversity measures are those based on the number of species present, perhaps adjusted for the number of individuals sampled, Here Margalef’s Species richness index (d), or indices that describe the evenness of the distribution of the numbers of individuals among species, are derived.

Margalef’s diversity index (Species Richness) S of Zooplankton communities in the stations Kandla creek region and nearby creeks was varying from 1.733-2.796 with an average of 2.196 during the sampling conducted in High tide period. Margalef’s diversity index (Species Richness) S of Zooplankton communities varying from.1.871-2.217 with an average of 2.026 during the sampling conducted in low tide period during Spring tide.

Margalef’s diversity index (Species Richness) S of Zooplankton communities in the Kandla creek region and nearby creeks sampling stations was varying from2.771-3.983with an average of 3.445 during the sampling conducted in high tide and varying from2.635- 3.054 with an average of 3.049 during the sampling conducted in low tide during Neap tide period

Margalef’s diversity index (Species Richness) S of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted inconsecutive High tide period and low tide of spring tide was recorded as 1.769 and 1. 588 respectively..

Margalef’s diversity index (Species Richness) S of Zooplankton communities near SPmat Path finder creek was varying from 2.256-2.572 during the sampling conducted in High tide period of Neap tide. While Margalef’s diversity index (Species Richness) S of Zooplankton communities in the two stations at Path finder creek was varying from2.020- 1.769 during the consecutive 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 0.725-0.945 (H'(log10)) between selected sampling stations with an average value of 0.811 (H'(log10)) during high tide period of spring tide. Shannon-Wiener’s Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.703-0.884 (H'(log10)) between selected sampling stations with an average value of 0.780 (H'(log10)) during consecutive low tide period.

Shannon-Wiener’s Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.782-1.119 (H'(log10)) between selected sampling stations with an average value of 1.000 (H'(log10)) during high tide period of Neap tide. Shannon-Wiener’s Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.855-1.059 (H'(log10)) between selected sampling stations with an average value of 0.950(H'(log10)) during consecutive low tide period.

Shannon-Wiener’s Index (H) of Zooplankton communities in the sampling station near jetty at Path Finder Creek, Vadinar during the sampling conducted in consecutive High tide period and low tide of spring tide was recorded as 0.799 and 0.7441 respectively.. 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 Neap tide was recorded as 0.742 and 0.709 respectively

Shannon-Wiener’s Index (H) of Zooplankton communities in the two stations at Path finder creek was varying from 0.715-0.798 during the sampling conducted in High tide period of Spring tide. While Shannon-Wiener’s Index (H)of Zooplankton communities in the two stations at Path finder creek was varying from -0.771-0.7441during the consecutive low tide period.

Shannon-Wiener’s Index (H) of Zooplankton communities in the two stations at Path finder creek was varying from 0.743-0.849 during the sampling conducted in High tide period of Neap tide. While Shannon-Wiener’s Index (H) of Zooplankton communities in the two stations at Path finder creek was varying from -0.641 - 0.709 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 Zooplankton of Kandla Harbour region and nearby creeks stations is slightly high with very minimum diverse population but very few opportunist organisms are really well adapted to this environment and thrive better than other species.

Simpson’s diversity index:

Simpson’s index (D) is a measure of diversity, which takes into account both species richness, and an evenness of abundance among the species present. The Simson index is one of the meaningful and robust biodiversity measures available. (Magurran, 2004).

Simpson diversity index (1-D) of Zooplankton communities was below 0.9 most of sampling stations in the Kandla Harbour region and nearby creeksduring high tide and low tide of spring tide period, which was varying from 0.751- 0.910between selected sampling stations with an average of 0.804 during high tide period and was varying from 0.722- 0.854 with an average value of 0.780 between selected sampling stations during low tide

Simpson diversity index (1-D) of Zooplankton communities was blow 0.9 at all sampling stationsin the Kandla Harbour region and nearby creeks except few during high tide and low tide period, which was varying from 0.766 - 0.912 between selected sampling stations with an average of 0.863 during high tide period and was varying from 0.795- 0.896with an average value of 0.843 between selected sampling stations during consecutive low tide

This low species diversity suggests a relatively few of successful species in this habitat during November, 2021 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 0.813and 0.779 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 0.753 and 0.779 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 0.778 - 0.729 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 0.817 and 0.697 respectively.

Table # 12 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREA AT KANDLA CREEK AND NEAR BY CREEKS DURING SPRING TIDE IN NOVEMBER,2021

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	75	10/16	62.5	2.085	0.7569	0.751
	2	82	11/16	68.75	2.269	0.8385	0.8154
	3	66	10/16	62.5	2.148	0.8294	0.8224
	4	106	11/16	68.75	2.144	0.7752	0.7641
	5	101	9/16	56.25	1.733	0.7251	0.7651
	6	25	10/16	62.5	2.796	0.9451	0.91
LOW TIDE	1	69	9/16	56.25	1.889	0.8145	0.809
	2	58	10/16	62.5	2.217	0.8838	0.8542
	3	72	9/16	56.25	1.871	0.7031	0.7218
	4	69	10/16	62.5	2.126	0.7896	0.7899
	5	85	10/16	62.5	2.026	0.7112	0.7272

Table # 13 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT HARBOUR AREAAT KANDLA CREEK AND NEAR BY CREEKS DURING NEAP TIDE IN NOVEMBER,

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	118	20/28	71.42	3.983	1.119	0.9122
	2	102	17/28	60.71	3.459	0.9987	0.875
	3	108	19/28	67.86	3.844	1.085	0.8974
	4	143	18/28	64.29	3.425	1.118	0.9087
	5	101	16/28	57.14	3.25	0.9028	0.8212
	6	40	11/28	39.29	2.711	0.7823	0.7667
LOW TIDE	1	83	13/28	46.43	2.716	0.8552	0.7949
	2	128	18/28	64.29	3.504	1.059	0.8958
	3	129	18/28	64.29	3.498	1.055	0.8815
	4	89	14/28	50	2.896	0.8648	0.7975
	5	95	13/28	46.43	2.635	0.9189	0.8434

2021

Table # 14 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREAATKANDLA CREEK AND ,NEAR BY CREEKS DURING SPRING TIDE IN NOVEMBER,2021

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton x10^3 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinids	3-13	3/16	18.75
			Copepods	11-40	6/16	37.5
			Rotifers	0-2	1/16	6.25
			Urochordata	1-4	1/16	6.25
			Larval forms	5-52	5/16	31.25
			TOTAL ZOOPLANKTON N/ M^3	**25-106**	**16**	
LOW TIDE	Sub surface	5	Tintinids	5-9	3/16	18.75
			Copepods	20-27	6/16	37.5
			Rotifers	0	1/16	6.25
			Urochordata	0-4	1/16	6.25
			Larval forms	30-53	5/16	31.25
			TOTAL ZOOPLANKTON N/M^3	**58-85**	**16**	

Table # 15 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT HARBOUR AREA IN KANDLA CREEK AND , NEAR BY CREEKS DURING NEAP TIDE IN NOVEMBER, 2021

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton x10^3 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	Tintinids	7-36	5/28	17.86
			Copepods	11-49	8/28	28.58
			Mysids	0-1	2/28	7.14
			Arrow worms	0-2	1/28	3.57
			Urochordata	0-2	1/28	3.57
			Ciliates	0-4	1/28	3.57
			Medusa	0-4	1/28	3.57
			Larval forms	20-58	7/28	25
			Foraminiferans	0-4	2/28	7.14
			TOTAL ZOOPLANKTON N/M^3	**40-143**	**28**	
LOW TIDE	Sub surface	5	Tintinids	10-32	5/28	17.86
			Copepods	17-54	8/28	28.58
			Mysids	0-2	2/28	7.14
			Arrow worms	0-1	1/28	3.57
			Urochordata	0-2	1/28	3.57
			Ciliates	0-1	1/28	3.57
			Medusa	0-1	1/28	3.57
			Larval forms	50-62	7/28	25

			Foraminiferans	**0-3**	2/28	7.14
			Total Zooplankton N/M3		**28**	

Table # 16 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING SPRING TIDE IN NOVEMBER,2021

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	87	11/13	84.62	2.239	0.6821	0.6864
	SPM	85	12/13	92.31	2.476	0.7967	0.788
LOW TIDE	Jetty	117	10/13	76.92	1.89	0.7264	0.7265
	SPM	109	10/13	76.92	1.918	0.6599	0.6624

Table # 17 ZOOPLANKTON VARIATION IN ABUNDANCE AND DIVERSITY IN SUB SURFACE SAMPLING STATIONS IN DPT OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING NEAP TIDE IN NOVEMBER,2021

Tide	Sampling Station	Abundance In Nx10^3/ m^3	No of Species/groups observed /total species/group	% of diversity	Margalef's diversity index (Species Richness S)	Shannon Weiner index H (log_{10})	Diversity Index (Simpson's Index) 1-D
HIGH TIDE	Jetty	227	15/17	88.23	2.581	0.7875	0.7647
	SPM	182	12/17	70.59	2.114	0.7288	0.7383
LOW TIDE	Jetty	158	13/17	76.47	2.37	0.733	0.7374
	SPM	150	12/17	70.59	2.195	0.7123	0.7087

Table # 18 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT OOT AREAAT PATH FINDER CREEK AND NEAR BY SPM DURING SPRING TIDE IN NOVEMBER,2021

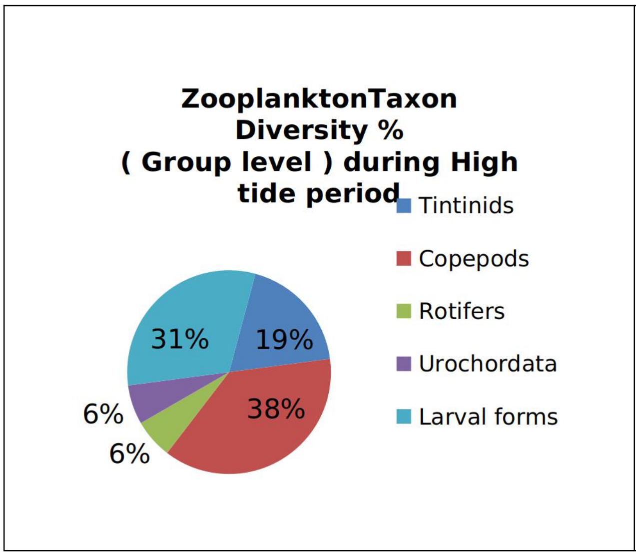
Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton x10^3 Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	Tintinids	6-7	3/13	23.08
			Copepods	30-39	6/13	46.15
			Larval forms	39-51	4/13	30.77
			TOTAL ZOOPLANKTON NO/L	**85-87**	**13**	
LOW TIDE	Sub surface	2	Tintinids	15-16	3/13	23.08
			Copepods	30-35	6/13	46.15
			Larval forms	67-73	4/13	30.77

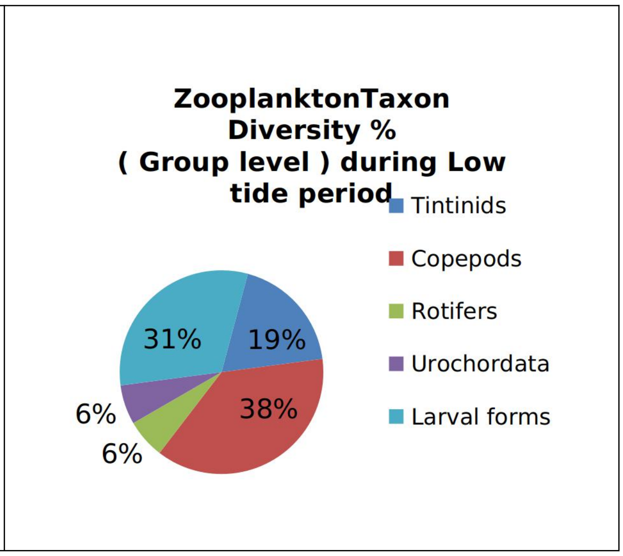
			TOTAL ZOOPLANKTON NO/M3	**109-117**	**13**	

Table # 19 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPT OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING NEAP TIDE IN NOVEMBER, 2021

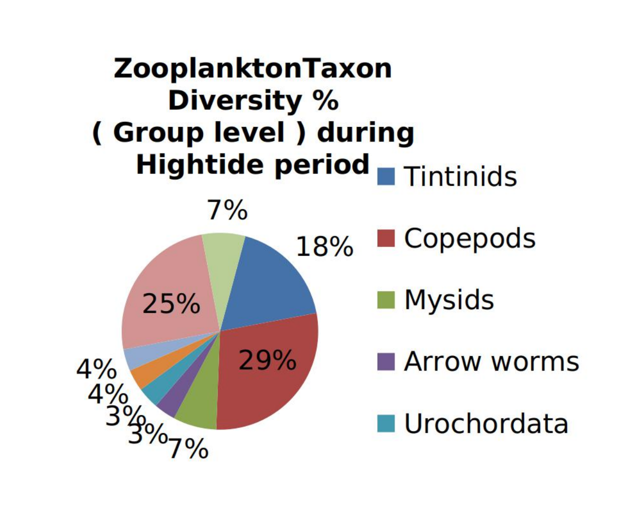
Tide	**Surface**	**No of Sampling locations**	**Group of Zooplankton**	**Abundance of Zooplankton x10^3 Group Range**	**Genera or species /total Zooplankton**	**Taxon Diversity % (Group level)**
HIGH TIDE	Sub surface	2	Tintinids	6-9	4/17	23.53
			Copepods	25-31	7/17	41.18
			Urochordata	0-1	1/17	5.88
			Larval forms	23-41	5/17	29.41
			TOTAL ZOOPLANKTON	**48-63**	**17**	
LOW TIDE	Sub surface	2	Tintinids	9-10	4/16	25
			Copepods	43-47	7/16	43.75
			Urochordata	0	0	0
			Larval forms	43-47	5/16	31.25
			TOTAL ZOOPLANKTON NO/M3	**77-83**	**16**	

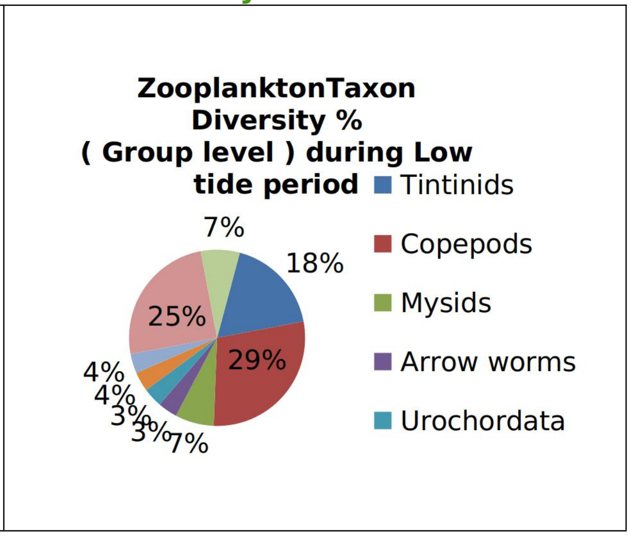
Taxon Diversity % of Zooplankton during High tide and Low tide period of Spring tide In Kandla Creek and near by Creeks



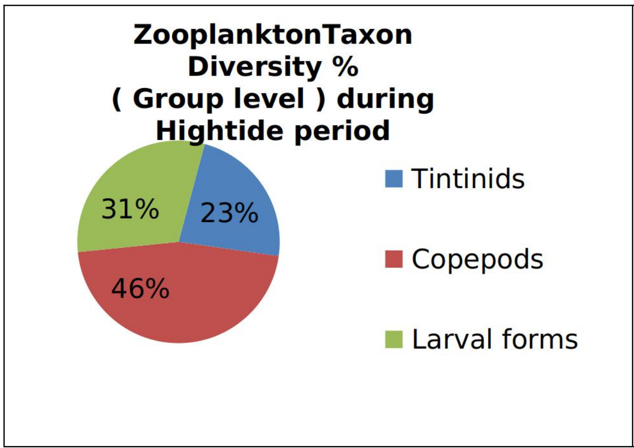


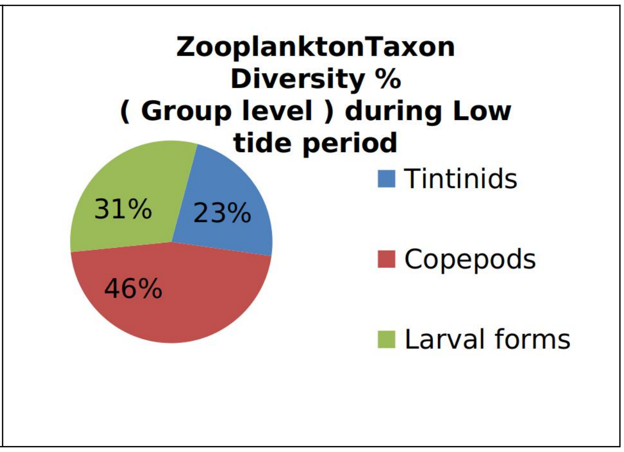
Taxon Diversity % of Zooplankton during High tide and Low tide period of Neap tide In Kandla Creek and nearby Creeks



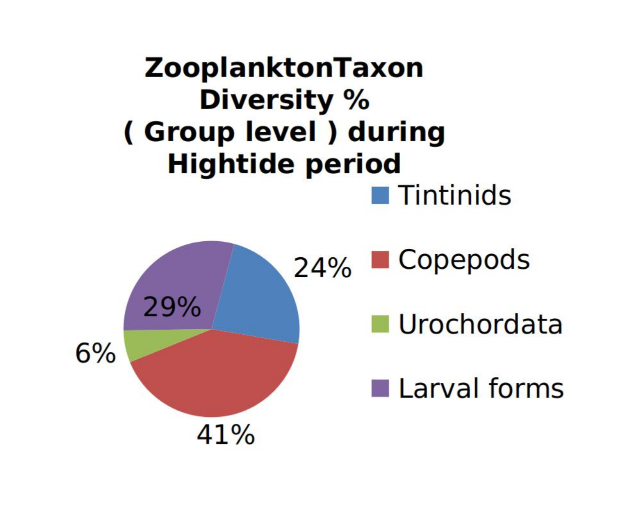


Taxon Diversity % of Zooplankton during High tide and Low tide period of Spring tide In Path Finder Creek and near Jetty





Taxon Diversity % of Zooplankton during High tide and Low tide period of Neap tide In Path Finder Creek near jetty and nearby SPM



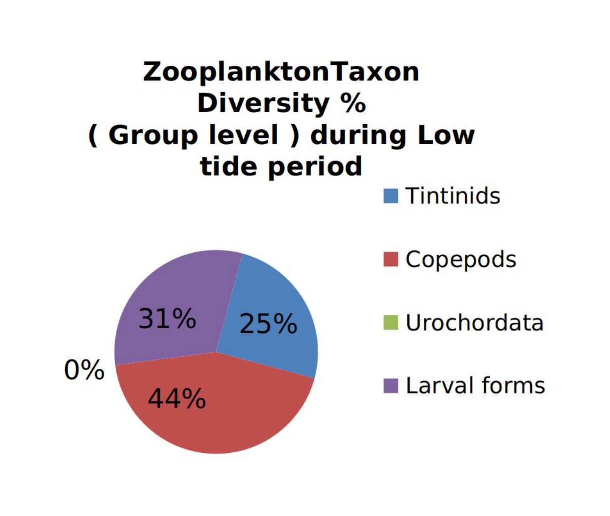


TABLE # 20SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS OF DPT HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURINGSPRING TIDE OF NOVEMBER 2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAE	Cyanophyta	Cyanophyceae	Nostocales	Oscillatoriaceae	*Oscillatoria* sp.	B1	Rare
					Arthrospira sp.	B2	Rare
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Thalassiosirales	Thalassiosiraceae	*Planktoniella*sp	D1	Rare
			Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D2	Abundant
			Triceratiales	Triceratiaceae	*Odontella*sp	D3	Occasional
					*Triceratium*sp.	D4	Occasional
			Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D5	Dominant
			Hemiaulales	Bellerocheaceae	*Bellerochea*sp	D6	Rare
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D7	Occasional
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros*sp	D8	Occasional
			Leptocylindrales	Leptocylindraceae	*Leptocylindrussp*	D9	Occasional
			Lithodesmiales	Lithodesmiaceae	*Ditylumsp*	D10	Frequent
		Bacillariophyceae	Naviculales	Pleurosigmataceae	*Pleurosigma*sp	D11	Occasional
		Fragilariophyceae	Thalassionematales	Thalassionemataceae	*Thalassiothrix sp.*	D12	Frequent
					Thalassionema sp.	D13	Rare
			Fragilariales	Fragilariaceae	*Fragilaria*sp	D14	Frequent
					*Synedra*sp	D15	Rare
			Tabellariales	Tabellariaceae	*Tabellaria*sp	D16	Rare
DINO FLAGELLATES	Dinoflagellata / Dinozoa	Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium sp.*	DF1	Rare
			Gonyaulacales	Ceratiaceae	*Ceratiumfurca*	DF2	Rare

TABLE # 21 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPT HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKS DURING AND NEAP TIDE OF NOVEMBER,2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
BLUE GREEN ALGAE	Cyanophyta	Cyanophyceae	Nostocales	Oscillatoriaceae	*Oscillatoria* sp.	B1	Rare
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Thalassiosirales	Thalassiosiraceae	*Planktoniella*sp	D1	Occasional
					Thalassiosirasp	D2	Occasional
			Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D3	Frequent
			Triceratiales	Triceratiaceae	*Odontellasp*	D4	Rare
					*Triceratium*sp.	D5	Occasional
			Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D6	Dominant
			Hemiaulales	Bellerocheaceae	*Bellerochea*sp	D7	Rare
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D8	Occasional
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros*sp	D9	Rare
			Leptocylindrales	Leptocylindraceae	*Leptocylindrussp*	D10	Rare
			Lithodesmiales	Lithodesmiaceae	*Ditylumsp*	D11	Frequent
		Bacillariophyceae	Bacillariales	Bacillariaceae	*Bacillaria*sp.	D12	Occasional
					*Nitzschia*sp	D13	Rare
			Naviculales	Naviculaceae	*Naviculasp*	D14	Rare
				Pleurosigmataceae	*Pleurosigma*sp	D15	Rare
			Surirellales	Entomoneidaceae	*Entomoneissp*	D16	Rare
		Fragilariophyceae	Thalassionematales	Thalassionemataceae	*Thalassiothrix sp.*	D17	Abundant
					Thalassionema sp.	D18	Occasional
			Fragilariales	Fragilariaceae	*Fragilaria*sp	D19	Frequent
					*Synedra*sp	D20	Rare
			Tabellariales	Tabellariaceae	*Tabellaria*sp	D21	Rare
DINO FLAGELLATES	Dinoflagellata / Dinozoa	Dinophyceae	Gonyaulacales	Ceratiaceae	*Ceratiumfurca*	DF1	Rare
					Ceratiumtripos	DF2	Rare

TABLE # 22 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPT OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING SPRING TIDE OF NOVEMBER 2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D1	Dominant
			Triceratiales	Triceratiaceae	*Triceratium*sp.	D2	Rare
			Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D3	Abundant
			Hemiaulales	Bellerocheaceae	*Bellerochea*sp	D4	Rare
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D5	Occasional
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros*sp	D6	Frequent
			Lithodesmiales	Lithodesmiaceae	*Ditylumsp*	D7	Occasional
		Bacillariophyceae	Naviculales	Pleurosigmataceae	*Pleurosigma*sp	D8	Rare
			Bacillariales	Bacillariaceae	*Bacillaria*sp.	D9	Rare
					*Pseudo-Nitzschia*sp	D10	Occasional
		Fragilariophyceae	Thalassionematales	Thalassionemataceae	*Thalassiothrix sp.*	D11	Frequent

TABLE # 23 SYSTEMATIC ACCOUNT OF PHYTOPLANKTON IN THE SAMPLING LOCATIONS IN OF DPT OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING AND NEAP TIDE OF NOVEMBER, 2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	Relative Abundance
DIATOMS	Bacillariophyta	Coscinodiscophyceae	Thalassiosirales	Thalassiosiraceae	*Planktoniella*sp	D1	Occasional
					Thalassiosirasp	D2	Rare
			Coscinodiscales	Coscinodiscaceae	*Coscinodiscus sp.*	D3	Dominant
			Triceratiales	Triceratiaceae	*Triceratium*sp	D4	Rare
			Biddulphiales	Biddulphiaceae	*Biddulphia*sp	D5	Abundant
			Hemiaulales	Bellerocheaceae	*Bellerochea*sp	D6	Occasional
			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia sp.*	D7	Occasional
			Chaetocerotales	Chaetocerotaceae	*Chaetoceros*sp	D8	Rare
			Lithodesmiales	Lithodesmiaceae	*Ditylumsp*	D9	Frequent
		Bacillariophyceae	Naviculales	Pleurosigmataceae	*Pleurosigma*sp	D10	Rare
			Bacillariales	Bacillariaceae	*Bacillaria*sp.	D11	Occasional
					*Nitzschia*sp	D12	Rare
					*Pseudo-Nitzschia*sp	D13	Frequent
		Fragilariophyceae	Fragilariales	Fragilariaceae	*Synedra sp.*	D14	Rare
			Thalassionematales	Thalassionemataceae	*Thalassiothrix sp.*	D15	Occasional
DINO FLAGELLATES	Dinoflagellata / Dinozoa	Dinophyceae	Gonyaulacales	Ceratiaceae	*Ceratiumfusus*	DF1	Rare
					Ceratiumfurca	DF2	Rare

TABLE #24 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPT HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKSDURING SPRING TIDE OF NOVEMBER,2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnussp.*	T1	Rare
				Codonellidae	*Tintinnopsis radix*	T2	Rare
					Tintinnopsisfailakkaensis	T3	Occasional
COPEPODS	ATHROPODA	Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Frequent
				Clausocalanidae	*Clausocalanus sp.*	C2	Rare
			Cyclopoida	Oithonidae	*Oithona sp.*	C3	Abundant
			Harpacticoida	Ectinosomatidae	*Microsetella*sp.	C4	Rare
				Euterpinidae	*Euterpina sp.*	C5	Occasional
			Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C6	Rare
ROTIFERS	ROTIFERA	Rotifera Subclass: Eurotatoria	Superorder: Monogononta Order:Ploimida	Brachionidae	*Brachionusplicatilis*	R1	Rare
UROCHORDATA	CHORDATA SUB PHYLUM UROCHORDATA	Appendicularia		Oikopleuridae	*Oikopleura sp.*	U1	Rare
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of Copepods	L1	Dominant
BRACHYURA LARVAE	ARTHROPODA (CRUSTACEA)	Malacostraca Decapoda			Brachyuran Zoea larvae	L2	Occasional

MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L3	Rare
POLYCHAETE LARVAE	ANNELIDA	Polychaeta			Trochophore larvae	L4	Occasional
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of Bivalves	L5	Rare

TABLE # 25 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING OF DPT HARBOUR AREA AT KANDLA CREEK AND NEARBY CREEKSDURING NEAP TIDE OF NOVEMBER,2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnussp.*	T1	Frequent
				Codonellidae	*Tintinnopsisgracilis*	T2	Occasional
					Tintinnopsis radix	T3	Frequent
					Tintinnopsisfailakkaensis	T4	Occasional
				Tintinnidae	*Amphorides sp.*	T5	Rare
COPEPODS	ATHROPODA	Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Occasional
				Eucalanidae	*Pareucalanus sp.*	C2	Rare
				Clausocalanidae	*Clausocalanus sp.*	C3	Rare
				Centropagidae	*Centropages sp.*	C4	Rare
			Cyclopoida	Oithonidae	*Oithona sp.*	C5	Abundant
			Harpacticoida	Ectinosomatidae	*Microsetella*sp.	C6	Frequent
				Euterpinidae	*Euterpina sp.*	C7	Occasional
			Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C8	Rare
ARROW WORMS	CHAETOGNATHA	Sagittoidea	Aphragmophora	Sagittidae	*Sagitta sp.*	A1	Rare

MYSIDS	ATHROPODA CRUSTACEA	Malacostraca	Mysida, Decapoda	Solenoceridae	*Solenocerasp.*	M1	Rare
				Luciferidae	*Lucifer sp.*	M2	Rare
UROCHORDATA	CHORDATA SUB PHYLUM UROCHORDAT A	Appendicularia		Oikopleuridae	*Oikopleura sp.*	U1	Rare
CILIATES	CILIOPHORA	Oligohymenoph orea	Sessilida	Zoothamniidae	*Zoothamniumsp.*	CI1	Rare
MEDUSA	PHYLUM CNIDARIA	Hydrozoa			Unidentified medusa	ME 1	Rare
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of Copepods	L1	Dominant
BRACHYURA LARVAE	ARTHROPODA (CRUSTACEA)	Malacostraca Decapoda			Brachyuran Zoea larvae	L2	Frequent
GROUP	**PHYLUM**	**CLASS**	**ORDER**	**FAMILY**	**GENUS/SPECIES**	**#**	**RELATIVE ABUNDAN CE**
BARNACLE LARVAE	ATHROPODA CRUSTACEA	Maxillopoda Thecostraca			Cirripede larvae	L3	Occasional
CYPHONAUTES LARVAE	BRYOZOA				Cyphonautes larvae	L4	Occasional
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L5	Rare
ECHINODERMAT A LARVAE	ECHINODERMA TA				Ophipluutes larvae/ Echinoplutes larvae	L6	Rare
POLYCHAETE LARVAE	ANNELIDA	Polychaeta			Trochophore larvae	L7	Occasional
FORAMINIFERA	FORAMINIFERA	Globothalamea	Rotaliida	Globigerinidae	*Globigerina* sp.	F1	Rare
				Rotalliidae	*Rotalia* sp.	F2	Rare

TABLE # 26 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPT OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING SPRING TIDE OF NOVEMBER,2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnussp.*	T1	Occasional
				Codonellidae	*Tintinnopsisgracilis*	T2	Rare
					Tintinnopsis radix	T3	Occasional
COPEPODS	ATHROPODA	Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Frequent
				Clausocalanidae	*Clausocalanus sp.*	C2	Rare
			Cyclopoida	Oithonidae	*Oithona sp.*	C3	Abundant
			Harpacticoida	Euterpinidae	*Euterpina sp.*	C4	Rare
			Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C5	Rare
				Corycaeidae	*Corycaeus sp.*	C6	Rare
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of Copepods	L1	Dominant
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of Bivalves	L2	Occasional
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L3	Occasional
POLYCHAETE LARVAE	ANNELIDA	Polychaeta			Trochophore larvae	L4	Occasional

TABLE # 27 SYSTEMATIC ACCOUNT OF ZOOPLANKTON FROM THE SAMPLING LOCATIONS OF DPT OOT AREA AT PATH FINDER CREEK AND NEARBY SPM AT VADINAR DURING NEAP TIDE OF NOVEMBER,2021

GROUP	PHYLUM	CLASS	ORDER	FAMILY	GENUS/SPECIES	#	RELATIVE ABUNDANCE
TINTINIDS	PROTOZOA CILIOPHORA	Spirotrichea	Tintinnida	Tintinnidiidae	*Leprotintinnussp.*	T1	Occasional
				Codonellidae	*Tintinnopsisgracilis*	T2	Rare
					Tintinnopsis radix	T3	Occasional
				Codonellopsidae	*Codonellopsis* sp.	T4	Rare
COPEPODS	ATHROPODA	Crustacea Subclass: Copepoda	Calanoida	Paracalanidae	*Acrocalanus* sp.	C1	Abundant
				Eucalanidae	*Subeucalanus sp.*	C2	Rare
				Clausocalanidae	*Clausocalanus sp.*	C3	Occasional
			Cyclopoida	Oithonidae	*Oithona sp.*	C4	Frequent
			Harpacticoida	Euterpinidae	*Euterpina sp.*	C5	Rare
			Poicilostomatatoida	Oncaeidae	*Oncaea sp.*	C6	Rare
				Corycaeidae	*Corycaeus sp.*	C7	Rare
UROCHORDATA	CHORDATA SUB PHYLUM UROCHORDATA	Appendicularia		Oikopleuridae	*Oikopleura sp.*	U1	Rare
CRUSTACEAN LARVAE	ARTHROPODA (CRUSTACEA)	Copepoda			Nauplius larvae of Copepods	L1	Dominant
BRACHYURA LARVAE	ARTHROPODA (CRUSTACEA)	Malacostraca Decapoda			Brachyuran Zoea larvae	L2	Rare
MOLLUSCAN LARVAE	MOLLUSCA	Gastropoda Streptoneura			Opisthobranchia larvae	L3	Rare
POLYCHAETE LARVAE	ANNELIDA	Polychaeta			Trochophore larvae	L4	Occasional
BIVALVE LARVAE	MOLLUSCA	Pelecypoda			Veliger larvae of Bivalves	L5	Rare

BENTHIC ORGANISMS:

Few Benthic organismswere observed in the collected sediments by using the Van-veen grabs during the sampling conducted during spring tide period andNeap tide period from DPT harbour region and nearby creek.The meiobenthic organisms during spring tide were represented by Polychaetes,and Nematodes. The polychaetes were representedby *Scyphoproctus sp. Notomastus*sp,*Dasybranchus.* The meiobenthic organisms in the collected samples were varying from 50-180N/M ^{2}during spring tide and 60-130 N/M

Table # 28BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPT HARBOUR AREA CREEKS DURING SPRING TIDE IN NOVEMBER ,2021

Benthic fauna	ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS REPRESENTATION BY GROUP						
	DPT HARBOUR			CREEKS			
POLYCHAETES	KPT-1	KPT-2	KPT-3	KPT-4	KPT-5	KPT-6	
Family : Capitellidae *c*	0	40	0	20	20	NS	
Family : Capitellidae *Notomastus* sp.	40	60	40	80	30	NS	
Total Polychates N/M^2	40	100	40	120	50		
Un identified Nematode worms	10	20	40	60	20	NS	
TOTAL Benthic Fauna NUMBER/ M^2	50	120	80	180	70	-	

NS : No sample

Table # 29 BENTHIC FAUNA IN THE SAMPLING LOCATIONS IN DPT HARBOUR AREA CREEKS DURING NEAP TIDE IN NOVEMBER ,2021

Benthic fauna	ABUNDANCE IN NO/M ^{2} DIFFERENT SAMPLING STATIONS REPRESENTATION BY GROUP						
	DPT HARBOUR			CREEKS			
POLYCHAETES	KPT-1	KPT-2	KPT-3	KPT-4	KPT-5	KPT-6	
Family : Capitellidae *Dasybranchus sp.*	10	20	10	10	20	NS	
Family : Capitellidae *Notomastus* sp.	50	60	20	40	20	NS	
Family : Glyceridae Glycera	10	20	10	0	0	NS	

Total Polychates N/M^2	70	100	40	50	40		
Un identified Nematode worms	20	30	30	30	20	NS	
TOTAL Benthic Fauna NUMBER/ M^2	90	130	70	80	60	-	

NS : No sample

Meteorological Data

Automatic Weather station have been installed in Seva Sadan -3 at the Deendayal Port which records the data on Temperature (°C), Humidity (%),Wind (mph), Dew Point (°C), Wind Direction (°), Pressure, Solar radiation, heat Index and UVI.

Temperature

The mean day time temperature for Deendayal Port was 30.3 °C. The day-time maximum temperature was 38.6 °C. The mean night time temperature was 26.5 °C. The minimum mean night time temperature recorded was 30.6 °C.

Air Pressure

The mean absolute air pressure for the month of November was 1009.9 hpa, whereas the mean relative pressure was 1009.3 hpa. The maximum absolute air pressure recorded for the month of November was 1016.5 hpa.

Heat Index

The mean day-time heat index for the month of November was 33.8 ^oC. The maximum heat index recorded was 55^oC.

Solar Radiation

The mean Solar Radiation in November was 252.2 w/m^2. The maximum solar radiation recorded in the month of November was 746.6 w/m^2.

Humidity

The mean day-time humidity was 60.0 % for the month of November and mean night time humidity was 72.4%. Maximum humidity recorded during day-time was 94.0 % and maximum humidity recorded during night-time was 93.0%.

Wind Velocity and Wind Direction

The mean wind velocity for the entire month of November was 4.6 km/hour. Maximum wind velocity recorded was 29.2 Km/hr . The wind direction was mostly S to N.

Conclusive Summary and Remedial measures Suggested

The AAQ monitoring at six locations of Deendayal Port indicates that the mean PM_{10} values at four locations viz. Coal storage area, Marine Bhavan and Oil Jetty area were found above the permissible standards (100 µg/m^3)and$PM_{2.5}$was above permissible limits at Coal storage location(Limit 60 µg/m^3).

Drinking water at all the twenty locations was found potable and was within permissible limits of BIS standards (IS 10500).

Noise quality was also within the set permissible standards of an Industrial Area. The noise level observed during day time was >75 dB (A) and at night time was >70 dB (A) during the entire monitoring period.

The sewage treated water of Deendayal Port Colony (Gopalpuri) was in line with the standards set by the Gujarat Pollution Control Board.

Reasons for higher Values of PM_{10}

Large amount of coal is handled at Berth No. 6, 7, 8 and 9. The unloading of coal directly in the truck, using grabs cause coal to spread in air as well as coal dust to fall on ground. This settled coal dust again mixes with the air while trucks travel through it.

Also, the coal laden trucks are not always covered with tarpaulin sheets and these results in spillage of coal from trucks/dumpers during its transit from vessel to yard or storage site. This also increased PM values around marine Bhavan & Coal storage area.

Remedial Measures

The values of PM_{10} during the month of November, 2021 were observed beyond the permissible limit at four locations mentioned above. Given below are the remedial measures suggest to minimize the Air pollution at Deendayal Port.

Guidelines for Coal Handling by GPCB should be strictly followed. (http://gpcb.gov.in/pdf/coal-handling-guidelines.pdf)

Except for the higher values of PM_{10} at Coal storage site, Oil Jetty, Tuna Port and Marine Bhavan locations, the monitoring results for the present month suggest that the overall Environment Quality of Deendayal Port is satisfactory.

SOURCE OF LITERATURE AND ADDITIONAL REFERENCE FOR ECOLOGICAL STUDY

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ANNEXURE D

DEENDAYAL PORT TRUST
(Erstwhile: KANDLA PORT TRUST)

Administrative Office Building
Post Box NO. 50
GANDHIDHAM (Kutch).
Gujarat: 370 201.
Fax: (02836) 220050
Ph.: (02836) 220038

www.deendayalport.gov.in

EG/WK/4751/Part (CCA Renewal)/ 13

Date: 30/04/2021
04/05/21

To,
The Member Secretary
Gujarat Pollution Control Board
Paryavaran Bhavan,
Sector 10A, Gandhinagar - 382010

Sub: Submission of Annual Return of Hazardous waste in format form IV for the financial year 2020-21 reg.

Ref.: 1) KPT letter no. EG/WK/4660(EC)/549 dated 20/6/2012
2) KPT letter no. MR/GN/1527(Part I)/2012 dated 20/5/2013
3) KPT letter no. MR/GN/1527(Part I)/336 dated 17/05/2014
4) KPT letter no. MR/GN/1527/ (Part I)/dated 27/04/2015
5) KPT letter no. EG/WK/EMC/CCA (Part II)/217 dated 27/6/2016
6) KPT letter no. EG/WK/EMC/CCA (Part II)/213 dated 19/6/2017
7) DPT letter no. EG/WK/EMC/CCA (Part II)/294 dated 13/6/2018
8) DPT letter no. EG/WK/EMC/CCA (Part II) dated 27/5/2019
9) DPT letter no. EG/WK/EMC/CCA (Part III) dated 22/5/2020

Sir,

It is requested to kindly refer above cited references for the said subject.

In this connection, it is to state that, the GPCB has renewed the Consolidated Consent & Authorization granted to Deendayal Port Trust and issued CCA Order No. AWH-110594 vide no. PC/CA-KUTCH-812 (5)/GPCB ID 28494/581914 dated 22/1/2021, valid up to 22/07/2025 .

In this regard, as per statutory requirement, the DPT has regularly submitted Annual Returns (as mentioned in references above) in format Form IV to the GPCB.

Now please find the enclosed herewith Annual Return of Hazardous Waste in Form IV for the year 2020-21.

This is for kind information and record please.

Encl: As above

Yours faithfully,
3/5/21
SE(PL) & EMC (I/C)
Deendayal Port Trust

Enclosure – A

Annual Return of Hazardous waste Return (Form IV)
For Deendayal Port Trust, Kandla
For the FY @ 2020-2021

"FORM-IV"

[(See rule 6(%), 13(8), 16(6) and 20(21)

(To be submitted to State Pollution Control Board by 30th day of June of every year for the preceding period April 20 to March 21)

Sr. No.	Particulars	Details
1.	Name and Address of the Facility	**Deendayal Port Trust** Administrative Office Building Post Box No. 50 Gandhidham Dist.: Kutch- 370201 Gujarat State Tel. No.: 02836-233192 Fax No.: 02836-220050
2.	Authorization No. and Date of issue	Consent order no. AWH – 110594 granted by the GPCB dated 8/12/2020 and detailed order issued dated 22/01/2021.
3.	Name of Authorized Person and full address with telephone, Fax number and E-Mail	**Mr. R Murugadoss** **Chief Engineer** **Deendayal Port Trust** Administrative Office Building Post Box No. 50 Gandhidham Dist.: Kutch- 370201 Gujarat State Tel. No.: 02836-233192 Fax No.: 02836-220050
4.	Production during the year (product wise) wherever applicable	NA. Only loading & unloading activities for dry cargo as well as liquid cargo. During FY 2020-21 Total Cargo Handled is 117.558 MMTPA

PART A. To be filled by Hazardous Waste Generator

1.	Total quantity of waste generated category wise	Used oil/Waste residue containing oil 9874.84 MTA
2.	Quantity Dispatched a. To disposal Facility b. To recycler or co-processor or pre-processor c. Others	Used Oil/Waste residue containing oil has been disposed of through CPCB/GPCB authorized vendor (Annexure-1)
3.	Quantity utilized inhouse -if any	NA
4.	Quantity in storage at the end of the year	NA

PART B To be filled Treatment, Storage and Disposal Facility Operator

1.	Total Quantity Received 1. Direct Landfill 2. Incineration 3. Land fill after treatment	NA
2.	Quantity at stock at the beginning of the year 1. Direct Landfill 2. Incineration 3. Land fill after treatment	
3.	Quantity treated (Landfill) Land fill after Treatment	
4.	Quantity disposed in landfill as such and after treatment 1. Direct Landfill 2. Land fill after treatment 3. Incineration Ash 4. Salts from Spray Dryer 5. Total	
5.	Quantity incinerated (if applicable)	
6.	Quantity processed other than specified above	
7.	Quantity in storage at the end of the year 1. Incineration 2. Landfill after treatment	

PART C To be filled by recyclers or co-processor or other users

1.	Quantity of the waste received during the year 1. Domestic sources 2. Imported (if applicable)	NA
2.	Quantity in stock at the beginning of the year	
3.	Quantity recycled or co processed or used	
4.	Quantity of products dispatched (wherever applicable)	
5.	Quantity of waste generated	
6.	Quantity of waste disposed	
7.	Quantity re-exported (wherever Applicable)	
8.	Quantity in storage at the end of the year	

3/5/21

SE(PL) & EMC(I/C)

Deendayal Port Trust

Date: 3/5/21
Place: Gandhidham

Annexure – 1

MARINE DEPARTMENT

Sub : Annual Return Showing the collection & disposal of Hazardous and Non-Hazardous wastes carried out by various parties for the year 20-21.

With reference to the above subject, the annual return showing the collection and disposal of Hazardous and Non-Harzardous Wastes carried out by various parties for the year FY 20-21 of Marine Department is enclosed herewith.

Encl : As above

Deputy Conservator

Environmental Cell – thru' SE(D) & EMC (I/C)

No. MR/WK/1124/ dated 29.04.2021

DEENDAYAL PORT TRUST
MARINE DEPARTMENT

Statement of Hazardous & Non Hazardous Waste disposal from the vessels at Kandla & Vadinar Port

YEAR 2020-21

Sr. No.	MONTH	YEAR	Hazardous (Sludge) in MT	Non Hazardous (Garbage) in MT
1	APRIL	2020	125.81	14.25
2	MAY	2020	521.71	2.24
3	JUNE	2020	852	72.32
4	JULY	2020	779.46	70.666
5	AUGUST	2020	1080.96	112.71
6	SEPTEMBER	2020	692.59	79.48
7	OCTOBER	2020	899.92	0.3
8	NOVEMBER	2020	963.29	45.62
9	DECEMBER	2020	1092.877	124.43
10	JANUARY	2021	1022.63	104.44
11	FEBRUARY	2021	715.62	67.67
12	MARCH	2021	1127.97	123.81
	TOTAL		**9874.837**	**817.936**

Deputy Conservator
Deedayal Port Trust

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Annexure – 2

Marine Department

Statement showing the Collection and disposal of Hazardous and Non-Harardous Wastes carried out by various parties from 04/2020 to 03/2021

Sr. No.	Name of Party	Type of Licence	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-21	Feb-21	Mar-21	Total
1	Alicid Organic Industries Limited	Hazardous	-	-	46.96	-	-	-	-	-	-	-	-	-	46.96
2	Atlas Organics Pvt. Ltd	Hazardous	-	-	-	-	225.09	37.25	97.95	-	23.20	24.82	-	40.21	448.52
3	Fine Refiners Pvt. Ltd	Hazardous	16.25	102.88	-	42.46	53.38	-	30.87	31.16	9.70	68.20	34.10	59.99	448.99
4	Industrial Esters & Chemicals Pvt. Ltd	Hazardous	-	-	285.10	-	-	-	-	-	-	-	-	-	285.10
5	Kutch Petrochem Pvt. Ltd	Hazardous	-	-	-	-	-	-	-	-	-	-	-	-	-
6	Priyansi Corporation	Hazardous	-	21.02	64.12	-	28.71	-	-	-	-	-	-	-	113.85
7	Shana Oil Process	Hazardous	-	-	-	-	23.26	-	-	-	-	-	-	-	23.26
8	United Shipping Company	Hazardous	-	92.58	44.08	215.05	161.81	-	112.41	211.65	561.06	314.05	329.26	244.60	2,286.55
9	Revolution Petrochem LLP	Hazardous	109.56	305.23	411.74	521.95	588.71	655.34	658.69	720.48	498.92	615.56	352.26	783.17	6,221.61
10	R V BIO Coal	Hazardous	-	-	-	-	-	-	-	-	-	-	-	-	-
11	Chitrakut Trading & Industries	Non-Hazardous	7.77	-	-	-	-	-	-	-	-	0.10	-	-	7.87
12	Golden Shipping Services	Non-Hazardous	-	-	38.00	28.38	20.62	70.55	-	-	32.95	28.40	29.23	32.84	280.97
13	Harish A. Pandya	Non-Hazardous	-	-	-	3.38	-	8.93	0.30	2.42	8.81	0.71	-	4.31	28.86
14	Naaz Shipping Services Enterprise	Non-Hazardous	-	2.24	-	30.41	15.20	-	-	-	-	14.25	8.20	-	70.30
15	Omega Marine Services	Non-Hazardous	-	-	10.70	5.76	70.92	-	-	-	48.11	39.74	16.20	35.49	226.92
16	Vishwa Trade-link Inc.	Non-Hazardous	-	-	23.62	2.74	5.97	-	-	-	-	21.24	14.04	17.29	84.90
17	Shana Oil Process	Non-Hazardous	6.48	-	-	-	-	-	-	43.20	34.56	-	-	33.88	118.12
		Hazardous - Total	**125.81**	**521.71**	**852.00**	**779.46**	**1,080.96**	**692.59**	**899.92**	**963.29**	**1,092.88**	**1,022.63**	**715.62**	**1,127.97**	**9,874.84**
		Non-Hazardous - Total	**14.25**	**2.24**	**72.32**	**70.67**	**112.71**	**79.48**	**0.30**	**45.62**	**124.43**	**104.44**	**67.67**	**123.81**	**817.94**

Deputy Conservator
Deedayal Port Trust

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Annexure – 3

Marine Department

STATEMENT SHOWING DEENDAYAL PORT REGISTERED PARTIES FOR REMOVAL OF GARBAGE, USED OIL/WASTE OIL ETC.

Sr. No.	Name of Party	Licensce of Removal	Last Validity of License	Remarks
1	**M/s. Alicid Organic Industries Ltd** Office No. 35, First Floor, Grain Marchan Association Building, Plot No. 297, Ward 12/B, Near Old Court, Gandhidham Email: naazshipping service@yahoo.com Phone: 02836- 237106	Hazardous	24-Sep-21	
2	**M/s. Atlas Organics Pvt. Ltd** Office No. 204-206, Elisbridge Shopping Center, Opp. Town Hall, Ashram Road, Ahmedabad - 380006 Email : atlasorganics@yahoo.com Mobile : 9825063459 / 9909723532	Hazardous	13-Sep-21	
4	**M/s. Fine Refiners Pvt. Ltd** Plot No. 40, GIDC, Chitra Vartej, Bhavanagar - info@finerefiners.com Mobile : 9825209314 / 9979898686	Hazardous	23-Jun-21	
5	**M/s. Industrial Esters & Chemicals Pvt. Ltd** Plot No. BF, 102 -Nr. Nehru Park, Bharat Nagar, Gandhidham - Kutch Email: sludgeoil16@yahoo.co.in Mob: 09879072262 - 9904897422	Hazardous	**22-Jan-21**	
6	**M/s. Kutch Petrochem Pvt. Ltd.** Office : Plot No. 121, Sector No. 9/C, Behind Ashok Leyland, Post Box No. 166 Gandhidham - Kutch 370201 Email: kutchppl@rediffmail.com Mob: 9638141414	Hazardous	**27-Jun-20**	
7	**M/s. Priyansi Corporation** C-1, 804 - 806, GIDC, Bamanbore, Ta. Chotila, Dist - Surendranagar Email: operation.priyansicorporation@gmail.com Mob: 09825226095	Hazardous	19-Oct-21	

Marine Department

STATEMENT SHOWING DEENDAYAL PORT REGISTERED PARTIES FOR REMOVAL OF GARBAGE, USED OIL/WASTE OIL ETC.

Sr. No.	Name of Party	Licensce of Removal	Last Validity of License	Remarks
8	**M/s. SHANA OIL PROCESS** New Good Luck Market, Nr. Aksha Masjid Chandola Lake, Narol Raod, Ahmedabad Email: kandla_sludgeremoval35@gmail.com Mob : 09824286952	Hazardous	11-Feb-22	
9	**M/s. United Shipping Company** Rising House -I, Ground Floor, Plot No. 82, Sector No. 1/A, Gandhidham - Kutch 370201 Email: sunil@risinggroup.co Phone : 02836 - 233060	Hazardous	30-Aug-21	
10	**M/s. Revolution Petrochem LLP** Office No. C-214, 2nd Floor, Shop No. 234-235, Kutch Arcade Platinum, Mithirohar **Gandhidham - 370201**	Hazardous	21-Mar-22	
11	**M/s. R. V. Bio Coal,** Shop No. 205, Paike, 8-B, National Highway, Opposite Hotel Allkh, Gomta, Taluka Gondal, Dist: Rajkot **Gujarat – 360311.**	Hazardous	**19-Mar-21**	
12	**M/s. Chitrakut Trading & Industries** 15, Brahm Samaj Building, Plot No. 106, Sector No. 8, Behind OSLO Cinema, Gandhidham - Kutch 370201. Email: info@harishpandya.com Mob: 09426218125	Non-Hazardous	19-Oct-21	
13	**M/s. Golden Shipping Services** Kidana Nirmal Nagar, Survey No. 133, Plot No. 83 Gandhidham - Kutch	Non-Hazardous	07-Jun-21	

Marine Department

STATEMENT SHOWING DEENDAYAL PORT REGISTERED PARTIES FOR REMOVAL OF GARBAGE, USED OIL/WASTE OIL ETC.

Sr. No.	Name of Party	Licensce of Removal	Last Validity of License	Remarks
14	**M/s. Harish A. Pandya** 15, Brahm Samaj Building, Plot No. 106, Sector No. 8, Behind OSLO Cinema, Gandhidham - Kutch 370201. Email: info@harishpandya.com Mob: 09426218125	Non-Hazardous	11-Feb-21	
15	**M/s. Naaz Shipping Services Enterprise** Office No. 35, First Floor, Grain Marchan Association Building, Plot No. 297, Ward 12/B, Near Old Court, Gandhidham Email: naazshipping service@yahoo.com Phone: 02836- 237106	Non-Hazardous	15-Jun-21	
16	**M/s. Omega Marine Services** Reg. Office No. 2, Plot NO. 106, Sector - 8, Braham Samaj Building Gandhidham - Kutch Email: operations@omegamarineservices.com Mob: 9537329203 - 9727589185	Non-Hazardous	01-Jul-21	
17	**M/s. VISHWA TRADE-LINK INC.** 214, 2nd Floor, "Kutch Arcade" - Platinium Building Mithi Rohar Road, NH 8/A, GANDHIDHAM Email : vishwatradelink@gmail.com Mob: 09879595087 - 02836-283261	Non-Hazardous	19-Oct-21	
18	**M/s. SHANA OIL PROCESS** New Good Luck Market, Nr. Aksha Masjid Chandola Lake, Narol Raod, Ahmedabad Email: kandla_sludgeremoval35@gmail.com Mob : 09824286952	Non-Hazardous	21-Mar-22	

Deputy Conservator
Deedayal Port Trust

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