



# DEENDAYAL PORT AUTHORITY (Erstwhile Deendayal Port Trust)

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EG/WK/4751/(EC- Stage II) /291

Date 03/04/2023  
05

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

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

**Ref.:** 1) MoEF&CC, GOI vide letter No. F. No. 11-13/2015-IA-III dated 19/02/2020  
2) Regional Office, Western Zone MoEF&CC, GOI Bhopal Letter dated 30/05/2020 (received by DPA on 26/6/2020).  
3) DPT letter EG/WK/4751/Part/988 dated 29/08/2020 – Submission of Detail asked by Regional Office, Western Zone MoEF &CC, GOI Bhopal Letter dated 30/05/2020.  
4) DPT letter No. EG/WK/4712/EC/Part II/52 dated 29/07/2021 – Submission of compliance report of stipulated conditions of EC & CRZ Clearance.  
5) DPT letter No. EG/WK/4712/EC/Part II/143 dated 08/02/2022 – Submission of compliance report of stipulated conditions of EC & CRZ Clearance.  
6) DPA letter No. EG/WK/4751/(EC-Stage II)/139 dated 11/07/2022 – Submission of compliance report of stipulated conditions of EC & CRZ Clearance

Sir,

Kindly refer above cited references for the said subject.

In this regard, it is to state that, DPA vide above mentioned letter dated 29/08/2020 (Ref.3 above) had submitted details/information (including point-wise compliance of stipulated conditions & duly filled in data sheet) asked by the Regional Office (Integrated), Gandhinagar, MoEF&CC, GoI, Bhopal in connection with the EC & CRZ Clearance granted by the MoEF&CC, GoI dated 19/2/2020 for the subject mentioned above. Further, DPA vide above referred letters had submitted compliance reports of stipulated conditions of EC & CRZ Clearance dated 19/2/2020.

.....cont.....

Now, as directed in the Regional Office (Integrated), Gandhinagar, MoEF&CC, GoI, Bhopal above mentioned letter dated 30/05/2020 (Ref. 2 above), kindly find enclosed herewith compliance report of stipulated conditions mentioned in the EC & CRZ Clearance granted by the MoEF&CC, GoI dated 19/2/2020 (**Annexure 1**) & Monitoring Report in Data Sheet (**Annexure 2**) for the period up to November, 2022, for kind information and record please.

Further, as per the MoEF&CC, Notification S.O.5845 (E) dated 26.11.2018, which 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 compliance report in CD as well as through e-mail ID : [ecompliance-guj@gov.in](mailto:ecompliance-guj@gov.in).

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

Thanking you.

Yours faithfully,

  
Manager (Env.)

Deendayal Port Authority

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

Shri Amardeep Raju,  
Scientist E,  
Ministry of Environment  
Forests & Climate change, GoI,  
Indira Paryavaran Bhavan,  
3<sup>rd</sup> floor, Vayu wing,  
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Shri Prasoon Gargav,  
Scientist E & Regional Director,  
Central Pollution Control Board,  
Parivesh Bhawan,  
Opp. VMC Ward Office No.10,  
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Vadodara - 390 023.  
Email: [prasoon.cpcb@nic.in](mailto:prasoon.cpcb@nic.in)

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](mailto:kut-uh-gpcb@gujarat.gov.in)

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

# **Annexure -1**

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

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

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



## **Annexure 1**

### **Compliance report for the period up to November, 2022**

**Subject: Point wise compliance of conditions stipulated in EC & CRZ Clearance granted by MoEF&CC, GoI for "Development of Integrated facilities (Stage-II) within the existing Deendayal Port Trust (Erstwhile Kandla Port Trust) at District Kutch, Gujarat. (1. Setting up of Oil Jetty No.7. 2. Setting up of Barge jetty at Jafarwadi 3. Setting up of Barge port at Veera; 4. Administrative office building at Tuna Tekra; 5. Road connecting from Veera barge jetty to Tuna gate by Deendayal Port Authority (Erstwhile Deendayal Port Trust) - Environmental & CRZ Clearance - reg."**

**Reference: MoEF&CC, GoI issued EC & CRZ Clearance vide F. No. 11-13/2015-IA-III dated 19/02/2020**

<b>Sr. No.</b>	<b>Stipulated Conditions</b>	<b>Compliance</b>
i	Construction activity shall be carried out strictly according to the provisions of the CRZ Notification, 2011. No construction work other than those permitted in Coastal Regulation Zone Notification shall be carried out in Coastal Regulation Zone area.	The work of project at Sr. No. 1 i.e. "Setting up of oil jetty no. 7" is in progress.  However, construction activities are being carried out strictly as per the provisions of the CRZ notification, 2011 and also no activity other than those permissible in Coastal Regulation Notification is being carried out in CRZ area.
ii	All the recommendations and conditions specified by the Gujarat Coastal Zone Management Authority vide letter No. ENV-10-2015-231-E (T Cell) dated 29.06.2016 shall be complied with	The compliance report of CRZ Recommendation issued by the GCZMA dated 29/06/2016 is attached herewith as <b>Annexure I</b> .
iii	The project proponent shall ensure that the project is in consonance with the new CZMP prepared by the State Government under the provisions of the CRZ Notification, 2011	The MoEF&CC, GoI accorded EC & CRZ Clearance for the subject proposal of DPA dated 19/2/2020. Accordingly, implementation of the project is being carried out as per the EC & CRZ Clearance accorded by the MoEF&CC, GoI.
iv	The Project proponent would submit a certificate from Gujarat Water Supply and Sewerage Board (GWSSB) for providing required water. This should be submitted with the first compliance report.	For construction phase, as per the tender clause, the required water for construction activities will be supplied by the contractor. For operational requirement, required water supply will be purchased from GWSSB and accordingly, the certificate in this regard will be obtained from GWSSB in due course.
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.	During the construction activities due care is being taken to comply with the condition stipulated.
vi	Dredging shall not be carried out during the fish breeding season.	Point noted for compliance. No dredging activity started yet.

vii	Dredging, etc shall be carried out in the confined manner to reduce the impacts on marine environment.	Point noted for compliance. No dredging activity started yet.
viii	Dredged material shall be disposed safely in the designated areas.	Dredged Material will be disposed of at designated location as identified by the CWPRS, Pune.
ix	Shoreline should not be disturbed due to dumping. Periodical study on shore line changes shall be conducted and mitigation carried out, if necessary. The details shall be submitted along with the six-monthly monitoring report.	Dredging material will be disposed of at designated location as identified by the CWPRS, Pune.  DPA issued work order vide no. EG/WK/4751/Part (EC- Shoreline study) Dated: 12/10/2021 to NCSCM, Chennai for Shoreline Change Study for Deendayal Port Trust , Kandla, Kachchh District, Gujarat, to Study the Effect of Dumping, if any reg. Final Report submitted by the NCSCM, Chennai has already been submitted with the last six-monthly compliance report communicated vide letter dated 11/07/2022.
x	The ground water shall not be tapped within the CRZ areas by the PP to meet with the water requirement in any case.	It is assured that, no ground water will be tapped. The water will be purchased through GWSSB or private tankers.
xi	While carrying out dredging, an independent monitoring shall be carried out by Government Agency/Institute to check the impact and necessary measures shall be taken on priority basis if any adverse impact is observed.	Point noted for compliance. No dredging activity started yet.
xii	Mitigative measures as given in the Marine Bio-diversity Management Plan prepared by CSIR-NIO for protection of marine environment shall be complied with in letter and spirit.	Point noted for the compliance.
xiii	A copy of the Marine and riparian biodiversity management plan duly validated by the State Biodiversity Board shall be submitted before commencement of implementation.	A copy of Report entitled "Holistic Marine Ecological Monitoring of Deendayal Port Environment with Special Reference to Biodiversity and Preparation of Management Plan" prepared by M/s GUIDE,Bhuj and validated by Gujarat State Biodiversity Board vide letter dated 24/12/2019 had already been submitted vide DPA letter dated 29/8/2020 - Submission of Detail asked by Regional Office, Western Zone MoEF&CC, GOI Bhopal vide letter dated 30/05/2020.
xiv	A continuous monitoring programme covering all the seasons on various aspects of the coastal environs need to be undertaken by a competent organization available in the State or by entrusting to	DPA has entrusted the work to M/s GUIDE, Bhuj for continuous monitoring of Marine Ecology since the year 2017 and the reports in this regard have already

	<p>the National Institutes/renowned Universities with rich experiences in marine science aspects. The monitoring should cover various physico-chemical parameters coupled with biological indices such as microbes, plankton, benthos and fishes on a periodic basis during construction and operation phase of the project. Any deviations in the parameters shall be given adequate care with suitable measures to conserve the marine environment and its resources</p>	<p>been submitted to the Regional Office, MoEF&amp;CC, GoI, Bhopal &amp; to the MoEF&amp;CC, GoI, New Delhi along with six monthly compliance reports submitted.</p> <p>Further, DPA assigned work to M/s GUIDE, Bhuj, vide work order dated 3/5/2021 for <b>"Regular Monitoring of Marine Ecology in and around the Deendayal Port Authority and Continuous Monitoring Programme covering all seasons on various aspects of the Coastal Environs covering Physico-chemical parameters of marine water and marine sediment samples coupled with biological indices, as per the requirements of EC &amp; CRZ Clearances reg.</b> (for three years (2021-2024)). The copy of the final report has already been submitted with the last six-monthly compliance report communicated vide letter dated 11/07/2022. The first season report for the year 2022-2023 submitted is attached herewith as <b>Annexure II.</b></p>
xv	<p>Marine ecology shall be monitored regularly also in terms of sea weeds, sea grasses, mudflats, sand dunes, fisheries, echinoderms, shrimps, turtles, corals, coastal vegetation, mangroves and other marine biodiversity components as part of the management plan. Marine ecology shall be monitored regularly also in terms of all micro, macro and mega floral and faunal components of marine biodiversity.</p>	<p>DPA had entrusted the work to M/s GUIDE, Bhuj for continuous monitoring of Marine Ecology since the year 2017 and the reports in this regard have already been submitted from time to time to the Regional Office, MoEF&amp;CC, GoI, Bhopal/Gandhinagar &amp; to the MoEF&amp;CC, GoI, New Delhi along with six monthly compliance reports submitted.</p> <p>Further, DPA assigned work to M/s Guide, Bhuj vide work order dated 03/05/2021 for <b>"Regular monitoring of Marine Ecology in and around the Deendayal Port Trust and Continuous Monitoring programme covering all seasons on various aspects of the Coastal Environs covering Physico-Chemical parameters of marine water and marine sediment samples coupled with biological indices, as</b></p>

		<b>per the requirement of EC &amp; CRZ Clearances</b> reg. (for three years 2021 - 2024)). The copy of the final report has already been submitted with the last six-monthly compliance report communicated vide letter dated 11/07/2022. The first season report for the year 2022-2023 submitted is attached herewith as <b>Annexure II.</b>
xvi	The project proponents would also draw up and implement a management plan for the prevention of fires due to handling of coal.	DPA will implement Coal Handling Guidelines issued by the GPCB for handling of coal. Further, DPA is already having Disaster Management Plan. The copy of the Disaster Management Plan has already been submitted with the last six-monthly compliance report communicated vide letter dated 11/07/2022.
xvii	Spillage of fuel / engine oil and lubricants from the construction site are a source of organic pollution which impacts marine life, particularly benthos. This shall be prevented by suitable precautions and also by providing necessary mechanisms to trap the spillage.	DPA is already having Oil Spill contingency plan & accordingly, necessary precautions will be taken to prevent spillage of Fuel/Engine oil and lubricants.
xviii	Necessary arrangements for the treatment of the effluents and solid wastes must be made and it must be ensured that they conform to the standards laid down by the competent authorities including the Central or State Pollution Control Board and under the Environment (Protection) Act, 1986.	No industrial effluent is generated in the port area. The domestic sewage generated is treated in the STP (1.5 MLD) at Kandla. The treated wastewater from STP is utilized for gardening purpose. Moreover, DPA has been conducting regular Monitoring of environmental parameters including STP monitoring since the year 2016 through NABL Accredited laboratories. The latest Environmental Monitoring Report is enclosed herewith as <b>Annexure III.</b>  Further, for projects at Sr. No. 2 to 5, construction activity not yet started. However, the stipulated condition will be complied with.
xix	All the recommendations mentioned in the rapid risk assessment report, disaster management plan and safety guidelines shall be implemented	All the recommendations mentioned in the Rapid Risk Assessment Report, Disaster Management Plan & safety Guidelines will be implemented
xx	Measures should be taken to contain, control and recover the accidental spills of fuel and cargo handle.	DPA already has an Oil Spill Contingency Plan. The copy of the same has already been communicated with earlier compliance reports. In addition to it, DPA also has equipment for Oil Spill Response

		System.
xxi	Necessary arrangement for general safety and occupational health of people should be done in letter and spirit.	The work of project at Sr. No. 1 i.e. "Setting up of oil jetty no. 7" is in progress. In this regard, DPA has included tender clause regarding the safety of all activities on the site.
xxii	The commitments made during the Public Hearing conducted in 2013 for earlier project and recorded in the Minutes shall be complied with letter and spirit. A hard copy of the action taken shall be submitted to the Ministry	The commitments made during the Public Hearing are being complied with letter & spirit. In this regard, the details of CSR Activities implemented as well as proposed are enclosed herewith as <b>Annexure IV.</b>
xxiii	All the mitigation measures submitted in the EIA report shall be prepared in a matrix format and the compliance for each mitigation plan shall be submitted to the RO, MoEF&CC along with half yearly compliance report.	Compliance of the mitigation measures suggested in the EIA report in the matrix format is attached herewith as <b>Annexure V.</b>
xxiv	As per the Ministry's Office Memorandum F.No. 22-65/2017-IA.III dated 1 <sup>st</sup> May, 2018, the project proponent has proposed that an amount of Rs. 2.97 Crore (@ 0.75% of project Cost) shall be earmarked under Corporate Environment Responsibility (CER) for the activities such as Drinking water, Sanitation, Health, Education, Skill Development Roads, Electrification including Solar Power, Scientific support and awareness to local farmers to increase yield of crop and fodder, Rain water harvesting, Soil Moisture Conservation work and Avenue plantation and plantation in community areas. The activities proposed under CER shall be restricted to the affected area around the project. The entire activities proposed under the CER shall be treated as project and shall be monitored. The monitoring report shall be submitted to the Regional Office as a part of half yearly compliance report, and to the District Collector. It should be posted on the website of the project proponent	Out of 5 projects, only work of Oil Jetty no. 7 is in progress. Other 4 projects are under planning stage.  It is assured that, DPA will earmark Rs. 2.97 crore under CER for various activities to be undertaken.
<b>B.GENERALCONDITIONS:</b>		
i.	Appropriate measures must be taken while undertaking digging activities to avoid any likely degradation of water quality.	Point noted

ii	Full support shall be extended to the officers of this Ministry/Regional Office at Bhopal by the project proponent during inspection of the project for monitoring purposes by furnishing full details and action plan including action taken reports in respect of mitigation measures and other environmental protection activities.	It is assured that full support will be extended to the officers of this Ministry/Regional Office at Bhopal/Gandhinagar by the project proponent during inspection of the project for monitoring purposes.
iii	A six-Monthly monitoring report shall need to be submitted by the project proponents to the Regional Office of this Ministry at Bhopal regarding the implementation of the stipulated conditions.	DPA has been regularly submitting six monthly monitoring report to the Regional Office at Bhopal/Gandhinagar regarding implementation of the stipulated conditions, regularly.
iv	Ministry of Environment, Forest and Climate Change or any other competent authority may stipulate any additional conditions or modify the existing ones, if necessary, in the interest of environment and the same shall be complied with.	Point noted
v	The Ministry reserves the right to revoke this clearance if any of the conditions stipulated are not complied with the satisfaction of the Ministry	Point noted
vi	In the event of a change in project profile or change in the implementation agency, a fresh reference shall be made to the Ministry of Environment, Forest and Climate Change.	Point Noted.
vii	The project proponents shall inform the Regional Office as well as the Ministry, the date of financial closure and final approval of the project by the concerned authorities and the date of start of land development work.	For one of the project out of 5 projects i.e. Construction of Oil Jetty No. 7, the Board of Trustees of DPA vide Resolution No. 25 in its meeting held on 08/06/2015 approved the project (Block estimate - 72 Crores). Accordingly, the work for construction of the Oil Jetty No. 7 started on 24/03/2020 and is currently in progress.
viii	A copy of the clearance letter shall be marked to concerned Panchayat/local NGO, if any, from whom any suggestion/representation has been made received while processing the proposal.	No such representations have been received. Hence, not applicable.
ix	A copy of this clearance letter shall also be displayed on the website of the concerned State Pollution Control Board. The Clearance letter shall also be displayed at the Regional Office, District Industries centre and Collector's Office/ Tehsildar's office for 30 days.	--



6.	Consent to Establish/Operate for the project shall be obtained from the State Pollution Control Board as required under the Air (Prevention and Control of Pollution) Act, 1981 and the Water (Prevention and Control of Pollution) Act, 1974.	The Consent to Establish (CTE) from the GPCB had already been obtained vide CTE No. 74134 granted by the GPCB vide letter no. PC/CCA-KUTCH 1319/GPCB ID 48573 dated 27/11/2015. Subsequently, DPA obtained EC to CTE (PCB ID 48573) vide GPCB Order dated 13/10/2020 after obtaining Environmental and CRZ Clearance from MoEF&CC, GoI vide F. No. 11-13/2015-IA-III dated 19/02/2020. The copy of EC to CTE obtained from the GPCB is attached herewith as <b>Annexure VI</b> .
7.	All other statutory clearances such as the approvals for storage of diesel from Chief Controller of Explosives, Fire Department, Civil Aviation Department, Forest Conservation Act, 1980 and Wildlife (Protection) Act, 1972 etc. shall be obtained, as applicable by project proponents from the respective competent authorities.	Point Noted for the compliance.
8.	The project proponent shall advertise in at least two local Newspapers widely circulated in the region, one of which shall be in the vernacular language informing that the project has been accorded Environmental and CRZ Clearance and copies of clearance letters are available with the State Pollution Control Board and may also be seen on the website of the Ministry of Environment, Forest and Climate Change at <a href="http://www.envfor.nic.in">http://www.envfor.nic.in</a> . The advertisement should be made within Seven days from the date of receipt of the Clearance letter and a copy of the same should be forwarded to the regional office of this Ministry at Bhopal.	DPA has already given advertisement in two local news papers viz. KUTCHMITRA (In Gujarati) dated 23/2/2020 and in the Indian Express (In English) dated 23/02/2020 and also forwarded to the Regional Office , MoEF&CC, Bhopal vide letter dated 28/2/2020 (Copy of the advertisements has already been communicated with the last six-monthly compliance report submitted vide letter dated 11/07/2022).
9.	This clearance is subject to final order of the Hon'ble Supreme Court of India in the matter of Goa Foundation Vs. Union of India in Writ Petition (Civil) No.460 of 2004 as may be applicable to this project.	Point noted.
10.	Any appeal against this clearance shall lie with the National Green Tribunal, if preferred, within a period of 30 days as prescribed under Section 16 of the National Green Tribunal Act, 2010.	---

11.	Status of compliance to the various stipulated environmental conditions and environmental safeguards will be uploaded by the project proponent in its website	DPA has been uploading the status of compliance of stipulated environmental conditions on its website <a href="http://www.deendayalport.gov.in">www.deendayalport.gov.in</a> .
12.	A copy of the clearance letter shall be sent by the proponent to concerned Panchayat, Zilla Parishad/Municipal Corporation, Urban Local Body and the Local NGO, if any, from whom suggestions/representations, if any, were received while processing the proposal. The clearance letter shall also be put on the website of the company by the proponent.	No suggestions/representation received. Public Hearing exempted.  Copy of the EC letter has been uploaded in the website of DPA <a href="http://www.deendayalport.gov.in">www.deendayalport.gov.in</a> .
13.	The proponent shall upload the status of compliance of the stipulated Clearance conditions, including results of monitored data on their website and shall update the same periodically. It shall simultaneously be sent to the Regional Office of MoEF&CC, the respective Zonal Office of CPCB and the SPCB	DPA has been regularly uploading the status of compliance of the stipulated clearance conditions including results of monitored data on the website <a href="http://www.deendayalport.gov.in">www.deendayalport.gov.in</a> . Simultaneously, DPA has been submitting the six-monthly compliance report to the Regional Office of MoEF&CC, GoI and GPCB..
14.	The project proponent shall also submit six monthly reports on the status of compliance of the stipulated Clearance conditions including results of monitored data (both in hard copies as well as by e-mail) to the respective Regional Office of MoEF&CC, the respective Zonal Office of CPCB and the SPCB.	DPA has been submitting the six-monthly compliance report on the status of compliance with the stipulated Clearance conditions, including the monitored data, to the Regional Office of MoEF&CC, GoI and GPCB.
15.	The environmental statement for each financial year ending 31 <sup>st</sup> March in Form-V as is mandated to be submitted by the project proponent to the concerned State Pollution Control Board as prescribed under the Environment (Protection) Rules, 1986, as amended subsequently, shall also be put on the website of the company along with the status of compliance of Clearance conditions and shall also be sent to the respective Regional Office of MoEF&CC by e-mail.	For project at Sr. No. 1, work for "Setting up of Oil Jetty No. 7" is under progress. However, the stipulated EC condition will be complied with.
16.	The above stipulations would be enforced among others under the provisions of Water (Prevention and Control of Pollution) Act 1974, the Air (Prevention and Control of Pollution) Act 1981, the Environment (Protection) Act, 1986, the Public Liability (Insurance) Act, 1991 and EIA Notification 1994, including the	Point noted.

	amendments and rules made thereafter.	
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# **Annexure -I**

## **Annexure 1**

### **COMPLIANCE REPORT (up to November, 2022)**

**Subject: Point-wise Compliance of the conditions stipulated in CRZ recommendation issued by GCZMA, GoG for the project "Developing Integrated facilities (Phase-II)- within the existing Kandla Port at Kandla Dist: Kutch by M/s. Kandla Port Trust – 1. Setting up of Oil Jetty No.7; 2. Setting up of Barge jetty at Jafarwadi; 3. Setting up of Barge port at Veera; 4. Administrative office building at Tuna Tekra; 5. Road connecting from Veera barge jetty to Tuna gate by Deendayal Port Authority (Erstwhile Deendayal Port Trust)**

**Ref No: - GCZMA issued CRZ recommendation vide Letter No- ENV-10-2015-251-E (T Cell) dated 29.06.2016**

<b>S. No.</b>	<b>CRZ Conditions</b>	<b>Compliance Status</b>
	<b>SPECIFIC CONDITIONS</b>	
1.	The provision of the CRZ notification 2011 shall be strictly adhered to by the KPT. No activity in contradiction to the provision of the CRZ notification shall be carried out by the KPT.	<p>The work of project at Sr. No. 1 i.e. "Setting up of oil jetty no. 7" is in progress.</p> <p>The provisions of the CRZ Notification, 2011 is being strictly adhered to by DPA.</p>
2.	All necessary permissions under various laws/Rules/Notifications issued thereunder from different Government Department/agencies shall be obtained by M/s. KPT before commencing any enabling activities for proposed project.	The Consent to Establish (CTE) from the GPCB had already been obtained vide CTE No. 74134 granted by the GPCB vide letter no. PC/CCA-KUTCH 1319/GPCB ID 48573 dated 27/11/2015. Subsequently, DPA obtained EC to CTE (PCB ID 48573) vide GPCB Order dated 13/10/2020 after obtaining Environmental and CRZ Clearance from MoEF&CC, GoI vide F. No. 11-13/2015-IA-III dated 19/02/2020 <b><u>(Copy Annexure A).</u></b>
3.	The KPT shall have to ensure that there shall not be any damage to the existing mangrove area.	It is hereby assured that, there will not be any damage to the existing mangrove area
4.	The KPT shall effectively implement the mangrove Development, Protection & Management plan for control of indirect impacts on mangrove habitat	<p>DPA had already undertaken Mangrove Plantation in an area of 1500 Ha. till date since the year 2005. A statement showing details of the mangrove plantation and the cost incurred is again placed in <b>Annexure B</b>.</p> <p>Further, DPA is carrying out an additional mangrove plantation of 100 ha. with the consultation of the Gujarat Ecology Commission vide Work Order No. DD/WK/3050/Pt-I/GIM/PC-44 dated 02/06/2022 <b>(Annexure C)</b>.</p> <p>In addition to the above, DPA appointed M/s GUIDE, Bhuj, for "Regular Monitoring of Mangrove Plantation carried out by DPA" (period 15/9/2017 to 14/9/2018 vide work</p>

S. No.	CRZ Conditions	Compliance Status
		order dated 1/9/2017 and 24/5/2021 to 23/5/2022 vide work order dated 3/5/2021). The final report submitted by M/s GUIDE, Bhuj for the year 2021 to 2022 is attached herewith as <b>Annexure D</b> .
5.	The KPT shall have to make a provision that mangrove areas get proper flushing water and free flow of water shall not be obstructed	The necessary arrangement had already been made in compliance with the condition.
6.	The KPT shall have to dispose of the dredged material only after scientific study to be carried out by the Institute of National repute and at a location suggested by them	Dredged Material will be disposed of at the designated location as identified by the CWPRS, Pune.
7.	The KPT shall have to maintain the record for generation and disposal of capital dredging and maintenance dredging.	Point noted for compliance
8.	No dredging, reclamation or any other project related activities shall be carried out in the CRZ area categorized as CRZ I (i) 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	<p>It is hereby assured that DPA will undertake only activities recommended by the GCZMA vide letter dated 29/06/2016 and EC &amp; CRZ clearance accorded by the MoEF&amp;CC, GOI vide letter dated 18/02/2020. DPA has already prepared a mangrove preservation plan for the entire Kandla area.</p> <p>In addition to the above, DPA appointed M/s GUIDE, Bhuj, for "Regular Monitoring of Mangrove Plantation carried out by DPA" (period 15/9/2017 to 14/9/2018 vide work order dated 1/9/2017 and 24/5/2021 to 23/5/2022 vide work order dated 3/5/2021). The final report submitted by M/s GUIDE, Bhuj, for the years 2017 to 2018 has been submitted in the earlier compliance report, and the final report for the year 2021 to 2022 is attached herewith as <b>Annexure D</b>.</p> <p>Further, DPA had authorised the work to M/s GUIDE, Bhuj for "Regular Monitoring of Marine Ecology in and around the Deendayal Port Authority and Continuous Monitoring Programme covering all seasons on various aspects of the Coastal Environs covering Physico-chemical parameters of marine water and marine sediment samples coupled with biological indices, as per the requirements of EC &amp; CRZ Clearances reg. (for three years (2021-2024)). The final report for the year 2021-22 has already been communicated with the last compliance report submitted</p>



S. No.	CRZ Conditions	Compliance Status
		<p>vide letter 11/07/2022. The first season report for the year 2022-2023 submitted is attached herewith as <b>Annexure E</b>.</p> <p>It is relevant to mention here that, DPA has already undertaken Mangrove Plantation in an area of 1500 Ha. till date since the year 2005. A statement showing details of the mangrove plantation and the cost incurred is again placed in <b>Annexure B</b>.</p> <p>Further, DPA is carrying out an additional mangrove plantation of 100 ha. with the consultation of the Gujarat Ecology Commission vide Work Order No. DD/WK/3050/Pt-I/GIM/PC-44 dated 02/06/2022 (<b>Annexure C</b>).</p>
9.	The KPT shall participate financially for installing and operating the vessel traffic management system in the Gulf of Kutch and shall also take lead in preparing and operational sing the Regional Oil Spill Contingency plan in the Gulf of Kutch	DPA had already contributed an amount of Rs. 98.955 crores i.e., 25% of the total project cost of 395.82crores for installing and operating VTMS in the Gulf of Kachchh
10.	The KPT shall strictly ensure that no creeks or rivers are blocked due to any activity at Kandla	Point noted for compliance
11.	Mangrove plantation in an area of 50 ha shall be carried out by the KPT within 2 years in a time bound manner on Gujarat coastline either within or outside the Kandla port Trust area and six-monthly compliance report along with the satellite images shall be submitted to the ministry of Environment and Forest as well as to this Department without fail.	<p>DPA has signed MoU with Gujarat Ecology Commission, Gandhinagar to carry out mangrove plantation through PPP mode for the year 2020-2021. Copy of the MoU is placed at <b>Annexure F</b>.</p> <p>DPA (Erstwhile KPT) had already DPA had already undertaken Mangrove Plantation in an area of 1500 Ha. till date since the year 2005. A statement showing details of the mangrove plantation and the cost incurred is again placed in <b>Annexure B</b>.</p> <p>Further, DPA is carrying out an additional mangrove plantation of 100 ha. with the consultation of the Gujarat Ecology Commission vide Work Order No. DD/WK/3050/Pt-I/GIM/PC-44 dated 02/06/2022 (<b>Annexure C</b>).</p> <p>In addition to the above, DPA appointed M/s GUIDE, Bhuj, for "Regular Monitoring of Mangrove Plantation carried out by DPA" (period 15/9/2017 to 14/9/2018 vide work order dated 1/9/2017 and 24/5/2021 to 23/5/2022 vide work order dated 3/5/2021).</p>

S. No.	CRZ Conditions	Compliance Status
		The final report submitted by M/s GUIDE, Bhuji, for the year 2021 to 2022 is attached herewith as <b>Annexure D.</b>
12.	No activity other than those permitted by the competent authority under the CRZ Notification Shall be carried out in the CRZ area.	It is assured that no activity other than those permitted by the competent authority under the CRZ Notification will be carried out by the DPA.
13.	No ground water shall be tapped for any purpose during the proposed expansion/modernization activities.	It is assured that no groundwater will be tapped. The water will be purchased through GWSSB.
14.	All necessary permissions from different Government Departments/agencies shall be obtained by the KPT before commencing the expansion activities.	DPA had already obtained the necessary EC & CRZ clearance for the project on dated 19/02/2020. Further, Consent to establish from GPCB had already been obtained from GPCB for the same. Subsequently, DPA obtained EC to CTE (PCB ID 48573) vide GPCB Order dated 13/10/2020 after obtaining Environmental and CRZ Clearance from MoEF&CC, GoI vide F. No. 11-13/2015-IA-III dated 19/02/2020.
15.	No effluent or sewage shall be discharged into the sea/creek or in the CRZ area and it shall be treated to conform to the norms prescribed by the Gujarat Pollution Control Board and would be reused/recycled with in the plant premises.	<p>In this regard, it is to state that, DPA is already having a sewage treatment plant capacity of 1.5MLD for the treatment of domestic sewage. The treated sewages from STP of DPA are utilized for plantation / Gardening.</p> <p>In addition to the above, DPA appointed has been conducting regular Monitoring of environmental parameters including STP monitoring through NABL Accredited laboratories since the year 2016. The Environmental Monitoring Reports is enclosed herewith as <b>Annexure G.</b></p> <p>Further, necessary provisions will be made for the projects at Sr. No. 2 – 5 to not discharge effluent or sewage into the sea/creek or in CRZ area.</p>
16.	All the recommendations and suggestions given by the Mantec Consultant Pvt. Ltd. New Delhi in their Comprehensive Environment Impact Assessment report for conservation/protection and betterment of environment shall be implemented strictly by the KPT.	<p>DPA has installed Mist Canon at the Port area to minimize the dust.</p> <p>Further, DPA has already installed continuous sprinkling system to prevent dust pollution. Further, to control dust pollution in other area, regular sprinkling through tankers on roads and other staking yards is being done. Regular sweeping of spilled cargo from roads is done by parties on regular basis.</p> <p>DPA appointed has been conducting regular Monitoring of environmental parameters</p>

S. No.	CRZ Conditions	Compliance Status
		<p>including STP monitoring through NABL Accredited laboratories since the year 2016. The Environmental Monitoring Reports is enclosed herewith as <b>Annexure G</b>.</p> <p>For ship waste management, DPA issued Grant of License/Permission to carry out the work of collection and disposal of "Hazardous Waste/Sludge/ Waste Oil" and "Dry Solid Waste (Non- Hazardous)" from Vessels calling at Deendayal Port" through DPA contractors.</p> <p>Further, it is to state that, all ships are required to follow DG Shipping circulars regarding the reception facilities at Swachh Sagar portal.</p> <p>DPA assigned work to M/s GUIDE, Bhuj, for regular monitoring of Marine Ecology since the year 2017 (From 2017 – 2021), and reports of the same are being submitted regularly to the Regional Office, MoEF&amp;CC, GoI, Gandhinagar as well as to the MoEF&amp;CC, GoI, New Delhi along with compliance reports submitted.</p> <p>The final report for the Holistic Marine Ecological Monitoring for the period up to May 2021 was submitted on 22.05.2021. Copy of the report was communicated vide earlier compliance report submitted vide letter dated 29/6/2021.</p> <p>Further, it is to submit that DPA issued a work order to M/s GUIDE vide its letter no. EG/WK/ 4751 /Part (Marine Ecology Monitoring) /11 dated 03/05/2021 for Regular monitoring of Marine Ecology in and around Deendayal Port Authority (Erstwhile Deendayal Port Trust) and continuous Monitoring Program covering all seasons on various aspects of the Coastal Environs for the period 2021-24. The copy of the final report submitted by M/s GUIDE for the year 2021-22 has already been communicated with the last six-monthly compliance report submitted vide letter dated 11/07/2022. The first season report for the year 2022-2023 submitted is attached herewith as <b>Annexure E</b>.</p> <p>As already informed, DPA entrusted work of green belt development in and around the</p>

S. No.	CRZ Conditions	Compliance Status
		<p>Port area to the Forest Department, Gujarat at Rs. 352 lakhs (Area 32 hectares). The work is completed.</p> <p>Further, DPA has appointed the Gujarat Institute of Desert Ecology (GUIDE) for "Green belt development in Deendayal Port Authority and its Surrounding Areas, Charcoal site' (Phase-I)" vide Work Order No.EG/WK/4757/Part [Greenbelt GUIDE, dated 31st May 2022 (<b>Annexure H</b>).</p> <p>For dredged material management, DPA assigned work to M/s GUIDE, Bhuj for analysis of dredged material since the year 2017 and the reports are being submitted from time to time along with compliance reports submitted.</p> <p>The second Season Report submitted by M/s GUIDE, Bhuj for the period 2021-2022 is attached herewith as <b>Annexure I</b>.</p> <p>Further, Dredged Material will be disposed of at designated location as identified by the CWPRS, Pune.</p> <p>For energy conservation measures, DPA is already generating 20 MW of Wind energy. In addition to it, DPA has commissioned a 45 kWp Solar Plant at Gandhidham. Further, it is relevant to mention that, two out of four Nos. of Harbour Mobile Crane (HMC) made electric operated. Balance 02 Nos. shall be made electric operated by 2023-2024. Four Nos. of Deisel operated RTGs converted to e-RTGs. Retrofitting of hydrogen fuel cell in Tug Kalinga and Pilot Boat Niharika to be done as a pilot project under the guidance of MoPSW. Also, 14 Nos. of EV cars to be hired in this year and 03 Nos. EV Bus to be procured by the year 2023-24.</p> <p>Further, for Oil Spill Management, DPA is already having Oil Spill Contingency Plan in place and Oil Response System as per the NOS-DCP guidelines.</p>
17.	The construction and operational activities shall be carried out in such a way that there is no negative impact on mangrove and other coastal/marine habitats. The construction activities and dredging shall be carried out only under	The work of project at Sr. No. 1 i.e. "Construction of Oil Jetty No. 7" is in progress and due care is being taken for so that, there is no negative impact on mangrove and other coastal/marine habitats.

S. No.	CRZ Conditions	Compliance Status
	the constant supervision and guidelines of the Institute of National repute like NIOT	Further, for project at Sr. No. 2 to 5 (Construction not yet started); however, the specified condition will be complied with.
18.	The KPT shall contribute financially for any common study or project that may be proposed by this Department for environmental management/conservation /improvement for the Gulf of Kutch	Point noted for compliance.
19.	The construction debris and/or any other type of waste shall not be disposed of into the sea, creek or in the CRZ areas. The debris shall be removed from the construction site immediately after the construction is over.	DPA had already issued general circular vide dated 3/9/2019 (Copy – <b>Annexure J</b> ) regarding Construction and Demolition Waste Management for strict implementation in DPA.
20.	The construction camps shall be located outside the CRZ area and the construction 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 construction labours.	Point noted or compliance
21.	The KPT shall regularly update their Local oil spill contingency and disaster management plan in consonance with the National oil Spill and Disaster Contingency plan and shall submit the same to this Department after having it vetted through the Indian Coast Guard.	<p>DPA already has updated Disaster management plan and Local oil spill contingency plan. The copy of the same has already been submitted with the last compliance report communicated vide letter dated 11/07/2022.</p> <p>DPA has also executed MOU with Oil companies, i.e., IOCL, HPCL, BPCL etc, for setting up of Tier I facility for combating the Oil Spill at Kandla.</p>
22.	The KPT 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.	Point noted for compliance.
23.	The KPT shall take up massive green belt development activities in and around Kandla and also within the KPT limits.	<p>DPA assigned work for green belt development in an area of about 32 hectares to the Forest Department, Govt. of Gujarat, in August 2019 at the cost of Rs. 352.32 lakhs. The work is completed. Further, DPA also undertook massive green belt development in and around the Port area and at the Gandhidham area.</p> <p>Further, DPA has appointed the Gujarat Institute of Desert Ecology (GUIDE) for</p>

S. No.	CRZ Conditions	Compliance Status
		"Green belt development in Deendayal Port Authority and its Surrounding Areas, Charcoal site' (Phase-I)" vide Work Order No.EG/WK/4757/Part [Greenbelt GUIDE, dated 31st May 2022 ( <b>Annexure H</b> ).
24.	The KPT 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.	DPA has already been undertaking CSR activities. The details of CSR Activities implemented as well as proposed are enclosed herewith as <b>Annexure K</b> .
25.	A separate budget shall be earmarked for environmental management and socio-economic activities and details there of shall be furnished to this Department as well as the MoEF,GOI. The details with respect to the expenditure from this budget head shall also be furnished.	DPA has already kept Rs. 345 lakhs in B.E. 2022-23 under the scheme "Environmental Services & Clearance thereof".
26.	A separate environmental management cell with qualified personnel shall be created for environmental monitoring and management during construction and operational phases of the project.	DPA already has an Environment Management Cell. Further, DPA has also appointed an expert agency to provide Environmental Experts from time to time. Recently, DPA appointed M/s Precitech Laboratories, Vapi, vide work order dated 5/2/2021 (Copy of work order & scope of work attached as <b>Annexure L</b> ).  Further, DPA has appointed a Manager Environment on a contractual basis for a period of 3+2 years. A copy of the office order is attached herewith as <b>Annexure M</b> .
27.	An Environmental report indicating the changes if any, with respect to the baseline environmental quality in the coastal and marine environment shall be submitted every year by the KPT to this Department as well as to the MoEF&CC,GOI	DPA has been conducting regular Monitoring of environmental parameters since the year 2016 through NABL Accredited laboratories. The Environmental Monitoring Reports is enclosed herewith as <b>Annexure G</b> .  DPA has been submitting the environmental monitoring report along with the compliance report to IRO, MoEF&CC, GoI.
28.	The KPT shall have to contribute financially to support the National Green Corps Scheme being implemented in Gujarat by the GEER foundation. Gandhinagar in consultation with Forests and Environment Department.	Point noted for compliance.
29.	A six monthly report on compliance of the conditions mentioned in this letter shall have to be furnished by the KPT on	DPA has been regularly submitting a six-monthly report in compliance with the conditions mentioned to GCZMA and



<b>S. No.</b>	<b>CRZ Conditions</b>	<b>Compliance Status</b>
	regular basis to this Department/MoEF&CC,GOI	MoEF&CC, GOI.
30.	Any other condition that may be stipulated by this Department and MoEF&CC,Gol from time to time for environmental protection / management purpose shall also have to be complied with by DPT.	Point noted.

# **Annexure -II**

**Second Year Monsoon Report  
(June 2022 to September 2022)**

**Regular Monitoring of Marine Ecology in and  
around the Deendayal Port Authority and Continuous  
Monitoring Programme**

**Submitted to**



**DEENDAYAL PORT AUTHORITY**  
Administrative Office Building  
Post Box No. 50, Gandhidham (Kachchh)  
Gujarat-370201

**Submitted by**



**GUJARAT INSTITUTE OF DESERT ECOLOGY**  
P.B. No. 83, Mundra Road, Opp. Changleshwar Temple  
Bhuj-Kachchh, Gujarat-370001

**October 2022**



**Second Year Monsoon Report  
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**October 2022**



## **Project Team**

### **Project Coordinator**

**Dr. V. Vijay Kumar, Director**

### **Principal Investigator**

<b>Dr. Durga Prasad Behera</b>	Project Scientist	Phytoplankton & Zooplankton, Physico-chemical parameters, Seaweed, Seagrass & Marine Fisheries
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### **Co-Principal Investigator**

<b>Dr. R. Ravinesh</b>	Project Scientist	Marine Biodiversity & Taxonomy
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### **Core Team**

<b>Dr. Jaikumar, M.</b>	Senior Scientist	Mangrove & Mudflat
<b>Dr. L. Prabha Devi</b>	Advisor	Management Plan
<b>Dr. Nikunj B. Gajera,</b>	Scientist	Avifauna
<b>Dr. Kapilkumar Ingle</b>	Project Scientist	Mangrove Ecology
<b>Dr. Dhara Dixit</b>	Project Scientist	Halophytes

### **Team members**

<b>Mr. Dayesh Parmar</b>	Project officer	GIS & Remote sensing
<b>Mr. Sai Vineeth Perla</b>	Senior Research Fellow	Sediment, Water & Benthic Fauna
<b>Ms. Pallavi V. Joshi</b>	Junior Research Fellow	Phytoplankton and Zooplankton
<b>Miss. Bhagavati N. Kannad</b>	Junior Research Fellow	Mangrove ecology

Monsoon (June 2022 to September 2022)

S. No	Components of the Study	Remarks
1	MoEF & CC sanction letter and details	<p>(i). EC &amp; CRZ clearance granted by the MoEF &amp;CC, GoI dated 19/12/16 Dev. Of 7 integrated facilities – specific condition no. xviii.</p> <p>(ii). EC &amp; CRZ clearance granted by the MoEF &amp;CC, GoI dated 18/2/2020 Dev. Remaining 3 integrated facilities – specific condition no. xxiii.</p> <p>(iii). EC &amp; CRZ clearance granted by the MoEF &amp;CC, GoI dated 19/2/2020 Dev. integrated facilities (Stage II-5 -specific condition no. xv.</p> <p>(iv). EC &amp; CRZ clearance granted by the MoEF &amp;CC, GoI dated 20/11/20 – Creation of waterfront facilities (OJ 8 to 11- Para VIII Marine Ecology, specific condition iv.</p>
2	Deendayal Port letter sanctioning the project	DPA work Order: WK/4751/Part/ (Marine Ecology Monitoring)/11 date 03.05.2021
3	Duration of the project	Three years-from 24.05.2021 to 23.05.2024
4	Period of the survey carried	Second Year Monsoon season (June 2022 to September 2022)
5	Survey area within the port limit	All major and minor creek systems from Tuna to Surajbari and Vira coastal area.
6	Number of sampling locations	Fifteen sampling locations in and around the DPA port jurisdiction
7	<b>Components of the report</b>	
7a	Mangroves	The overall average density was 4602 trees/ha of <i>A. marina</i> during monsoon 2022. The highest tree density was reported at the S-12 station in the Tuna creek area (7359 plants/ha). The lowest average tree density (2935 plants/ha) was reported in Phang creek. However, the lowest density in the individual site was recorded in site S-5 at Phang creek. The highest regeneration (140,000 plants/ha) at S-9 of Navlakhi creek and recruitment (31,500 plants/ha) class density were recorded at Kharo creek (S-7).
7b	Mudflats	The highest TOC value (0.83%) was recorded at station S-4 followed by S-2 site. The lowest TOC value was reported at S-12. It is observed that TOC values varied significantly among the sampling stations, which means that organic carbon depends on the living life forms and the type of life forms in the mudflats.

## Snapshot

<b>7c</b>	Zooplankton	The zooplankton identified from the 15 stations falls under 10 phyla and 41 genera which are described 16 groups. The phylum Arthropoda was the predominant represented with 25 genera, including copepods, crabs, shrimps and their larvae. The highest percentage was due to the calanoid copepods (36.9%) followed by Decapoda (13.2%) and Gastropoda (8.2%).
<b>7d</b>	Phytoplankton	The generic number recorded during the monsoon period ranged from 24 to 33 at the sampling stations with remarkable variations concerning the composition. The maximum number (33 genera) was observed at S-11, and the minimum from S-15 represented 24 genera. The percentage composition of the various groups varied from 5 % to 47 %, of which the centrales and pennales are the dominant, constituting 47% and 27%, respectively.
<b>7e</b>	Intertidal Fauna	The intertidal fauna and the species diversity of the invertebrates showed the maximum for phylum Arthropoda (8 species), followed by Mollusca (6 species). The phylum Chordata was represented by two species. The overall percentage composition of the four groups of intertidal fauna at the 15 sites revealed the Arthropoda (50%), Mollusca (37%), and Chordata (13%).
<b>7f</b>	Sub-tidal Macrobenthos	The DPA port environment revealed that Mollusca (14 species) and Annelida (2 species) were the major constituents, followed by Arthropoda (1 species) and Cnidaria (1 species). The phylum Mollusca constituted the maximum (78%) share of the subtidal Fauna, followed by Annelida (11%), Arthropoda (5.5%) and Cnidaria (5.5%) in the total benthic samples collected.
<b>7g</b>	Seaweeds	No seaweed is reported in the DPA area.
<b>7h</b>	Seagrass	No seagrass is reported in the DPA area.
<b>7i</b>	Marine reptiles	One species of reptile was recorded from the DPA area.
<b>7j</b>	Marine mammals	One species of marine mammal was recorded from the DPA area.
<b>7k</b>	Halophytes	Four halophytes were recorded along the selected Deendayal Port Authority sites during the Monsoon sampling; among the halophyte species recorded, <i>Salicornia brachiata</i> alone was found in the 3 sampling locations. The percentage of <i>Salicornia brachiata</i> was found to be the highest at stations S-8 (78%) and the lowest at S-11.
<b>7l</b>	Avifauna	A total of 49 species belonging to 6 orders, 25 families and 38 genera were recorded from the coastal area of Deendayal Port Authority during the Monsoon season study.

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# **1. Introduction**

Deendayal Port is located at the inner end of Gulf of Kachchh on the Kandla creek (22°59'4.93N and longitude 70°13'22.59 E) in the Kachchh district of Gujarat state, operated by Deendayal Port Authority (DPA). Being the India's busiest major port in recent years, is gearing to add substantial cargo handling capacity with private participation. Since its formation in the 1950s, the Deendayal Port provides the maritime trade requirements of states such as Rajasthan, Madhya Pradesh, Uttar Pradesh, Haryana and Gujarat. Because of its proximity to the Gulf countries, large quantities of crude petroleum are imported through this port. About 35% of the country's total export takes place through the ports of Gujarat in which the Deendayal port has a considerable contribution. Assortments of liquid and dry cargo are being handled at DPA Port. The dry cargo includes fertilizers, iron and steel, food grains, metal products, ores, cement, coal, machinery, sugar, wooden logs, etc. The liquid cargo includes edible oil, crude oil and other petroleum products. Cargo handling has increased from 117.5 MMT to 127 MMT during 2021-2022. Presently, the Port has total 1-16 dry cargo berths for handling dry cargo, 6 oil jetties, and one barge jetty at Bunder basin, dry bulk terminal at Tuna Tekra, barge jetty at Tuna and two SPMs at Vadinar for handling oil. Regular expansion or developmental activities such as the addition of jetties, allied SIPC and ship bunkering facilities are underway in order to cope with the increasing demand for cargo handling during the recent times.

A developmental initiative of this magnitude is going on since past 7 decades, which will have its own environmental repercussions. Being located at the inner end of Gulf of Kachchh, Deendayal Port Authority encompasses a number of fragile marine ecosystems that includes a vast expanse of mangroves, mudflats, creek systems and associated biota. Deendayal Port is a natural harbour located on the eastern bank of North-South trending Kandla creek at an aerial distance of 90 km from the mouth of Gulf of Kachchh. The Port's location is marked by a network of major and minor mangrove lined creek systems with a vast extent of mudflats. Coastal belt in and around the port has an irregular and dissected configuration. Due to its location at the inner end of the Gulf, the tidal amplitude is elevated, experiencing 6.66 m during mean high-water spring (MHWS) and 0.78 m during mean low water spring (MLWS) with MSL of 3.88 m. Commensurate with the increasing tidal amplitude, vast intertidal expanse is present in and around the port environment. Thus, the occurrence of mudflats on the intertidal zone enables mangrove formation to an extensive

area. Contrary to the southern coast of Gulf of Kachchh, the coral formations, seaweed and seagrass beds are absent in the northern coast due to high turbulence induced suspended sediment load in the water column, a factor again induced due to the conical Gulf geomorphology and surging tides towards its inner end.

### **1.1. Rationale of the present study**

The ongoing developmental activities at Deendayal Port Authority has been intended for the following.

- i. The development of 3 remaining integrated facilities (Stage 1) within the existing Port at Kandla which includes development of a container terminal at Tuna off Tekra on BOT base T shaped jetty, construction of port craft jetty and shifting of SNA section of Deendayal port and railway line from NH-8A to Tuna port.
- ii. EC & CRZ clearance granted by the MoEF &CC, GoI dated 18/2/2020 Dev. Remaining 3 integrated facilities – specific condition no. xxiii.
- iii. EC & CRZ clearance granted by the MoEF &CC, GoI dated 19/2/2020 Dev. integrated facilities (Stage II-5 -specific condition no. xv.
- iv. EC & CRZ clearance granted by the MoEF &CC, GoI dated 20/11/20 – Creation of water front facilities (OJ 8 to 11- Para VIII Marine Ecology,specific condition iv).

As per the environmental clearance requirements to these developmental initiatives, by MoEF & CC, among other conditions, has specified to conduct the continuous monitoring of the coastal environment on various aspects covering the three the seasons. The regular monitoring shall include physico-chemical parameters coupled with biological indices such as mangroves, seagrasses, macrophytes and plankton on a periodic basis during the construction and operation phase of the project. Besides, the monitoring study also includes assessment of Mudflats, Fisheries, and Intertidal fauna including the macrobenthos as components of the management plan. The regular marine ecology monitoring includes Micro, Macro and Mega floral and fauna components of marine biodiversity of the major intertidal ecosystems, the water and sediment characteristics. In accord with MoEF&CC directive, DPA has consigned the project on ‘Regular Monitoring of Marine Ecology in and around the Deendayal Port Authority and Continuous Monitoring Programme” to Gujarat Institute of Desert Ecology (GUIDE), Bhuj during May, 2021. Further, Deendayal Port authorities has entrusted Gujarat Institute of Desert Ecology (GUIDE) to continue the study for another three years, i.e., 2021 – 2024. The study covers all the seasons as specified

by the specific condition of the Ministry of Environment, Forest and Climate Change (MoEF&CC). The present study is designed considering the scope of the work given in the EC conditions.

## **1.2. Scope of work**

The scope of the present investigation includes physico-chemical and marine biological components as mentioned in the specific conditions of MoEF&CC, EC & CRZ clearance dated 19.12.2016, 18.2.2020, 19.2.2022 and 20.11.2020 with specific conditions xviii, xxiii, xv & iv respectively. A detailed holistic approach to different components of the study such as marine physico-chemical parameters of water and sediment and marine biodiversity within the Deendayal Port area will be carried out. Based on the results obtained during the project period, a detailed management plan will be drawn at the end of the project period. The biological and physico-chemical variables will be investigated during the present study on a seasonal basis i.e., monsoon, post monsoon and pre-monsoon as follows.

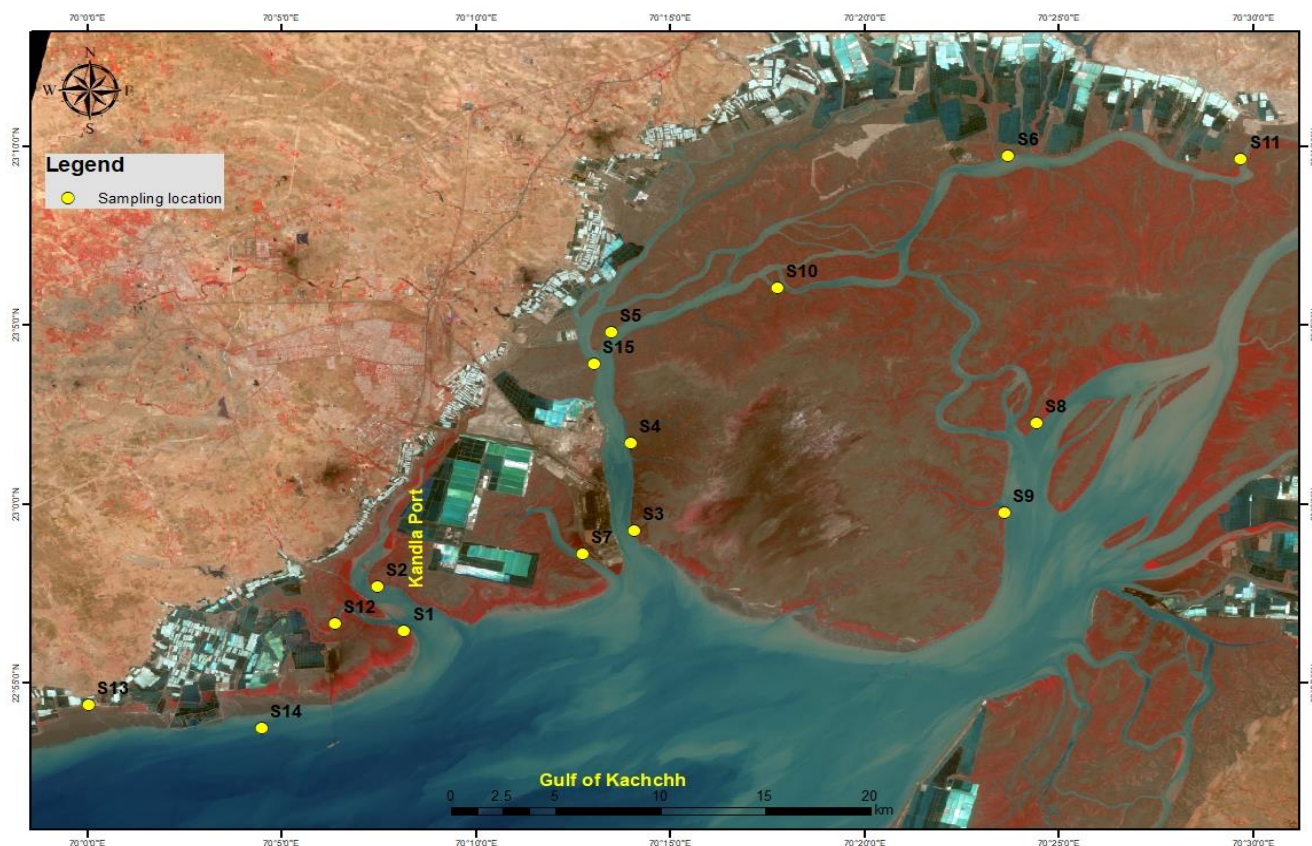
- ✓ Physico-chemical characteristics of water and sediment
- ✓ Detailed assessment of mangrove vegetation structure including density, diversity, height, canopy, and other vegetation characteristics.
- ✓ GIS and RS studies to assess different ecological sensitive land use and land cover categories within the Port area such as the extent of dense and sparse mangroves, mudflats, creek systems, and other land cover categories within the port limits.
- ✓ Quantitative and qualitative assessment of the intertidal fauna, composition, distribution, diversity, density, and other characteristics.
- ✓ Data collection on the species composition, distribution, diversity and density of sub-tidal benthic fauna.
- ✓ Estimation of primary productivity at the selected sampling sites located in around the DPA area.
- ✓ Investigation of the species composition, distribution, density, and diversity of phytoplankton and zooplankton.
- ✓ Recording the occurrence, diversity and distribution of halophytes, seagrasses, seaweeds and other coastal flora. Investigations on the Avifaunal density, diversity, composition, habitat, threatened and endangered species and characters. Fishery



Resources – Species composition, diversity, Catch Per Unit Effort (CPUE) and other socio-economic information.

### **1.2.1. Study Area**

The coastal belt in and around Deendayal Port Authority jurisdiction is characterized by a network of creek systems and mudflats which are covered by sparse halophytic vegetation like scrubby to dense mangroves, creeks and salt-encrusted landmass which form the major land components. The surrounding environment in 10 km radius from the port includes built-up areas, salt pans, human habitations and port related structures on the west and north creek system, mangrove formations and mudflats in the east and south. The nearest major habitation is Gandhidham town located about 12 km away on the western part with population of 2,48,705 (as per 2011 census).



**Figure 1: Map showing the sampling locations 2021-2024**

## 2. Sampling of water and sediment samples

Sampling was carried out for the coastal water (surface) and sediment to determine physical and chemical characteristics from the prefixed sampling sites. The biological parameters (benthic and pelagic fauna, flora and productivity) were also estimated (Table.1).

**Table 1: Physico-chemical and biological parameters analysed**

<b>Parameters</b>	
<b>Water</b>	<b>Mangrove &amp; Other Flora</b>
• pH	<b>Mangrove</b>
• Temperature	• Vegetation structure, density
• Salinity (ppt)	• Diversity
• Petroleum Hydrocarbons-PHC	• Height
• Dissolved oxygen	• Canopy and other vegetation characteristics
• Total Suspended Solids (TSS)	
• Total Dissolved solids (TDS)	<b>Halophytes:</b>
<b>Nutrients</b>	• Percentage of distribution
Nitrate (NO <sub>3</sub> )	• Diversity
• Nitrite (NO <sub>2</sub> )	
• Total Nitrogen	<b>Seagrass and Seaweed</b>
• <b>Sediment</b>	• Occurrence, distribution, and diversity.
• Texture	<b>Intertidal fauna</b>
• Total organic carbon (TOC)	• Composition, distribution, diversity, density and other characteristics.
• <b>Biological Parameters</b>	<b>Avifauna</b>
Phytoplankton- Genera, abundance, diversity and biomass	• Density, diversity, composition, habitat,
• Productivity-Chlorophyll a	• Threatened and endangered species and characters
• Zooplankton – Species, abundance, diversity	
• Macrobenthos - genera, abundance, diversity	
• Fishery Resources	
• Common fishes available	
• composition, diversity	
• Catch Per Unit Effort (CPUE)	

The water samples were collected from each pre-designated site in pre-cleaned polyethylene bottles. Prior to sampling, the bottles were rinsed with sample water to be collected and stored in an ice box for transportation to laboratory and refrigerated at 4°C till further analysis. The analysis of the water quality parameters was carried out by following standard methods (APHA, 2017). All extracting reagents were prepared using metal-free, AnalaR grade chemicals (Qualigens Fine Chemicals Division of Glaxo SmithKline Pharmaceuticals Limited, Mumbai) and double distilled water prepared from quartz double distillation assembly.

## **2.1. Methodology**

### **Physico-chemical Parameters**

#### **pH and Temperature**

A Thermo fisher pH / EC / Temperature meter was used for pH and temperature measurements. The instrument was calibrated with standard buffers just before use.

#### **Salinity**

A suitable volume of the sample was titrated against Silver nitrate (20 g/l) with Potassium chromate as an indicator. The chlorinity was estimated, and from that, salinity values were derived using a formula (Strickland and Parsons, 1972).

#### **Total Suspended Solids (TSS)**

About 100 ml of the water sample was filtered through pre-weighed filter paper and placed in the Hot air oven at a specified temperature as per the protocol for 1 hour. The filter paper was allowed to cool in a desiccator to obtain a constant weight by repeating the drying and desiccation steps.

#### **Total Dissolved Solids (TDS)**

The water samples were subjected for gravimetric procedure for confirmation of the readings obtained from the hand-held meter. About 100 ml of the water sample was taken in a beaker and filtered which was then dried totally in a Hot Air Oven (105°C). The TDS values were calculated using the difference in the initial and final weight of the container.

### **Turbidity**

The sample tube (Nephelometric cuvette) was filled with distilled water and placed in the sample holder. The lid of the sample compartment was closed. By adjusting the 'SET ZERO' knob, the meter reading was adjusted to read zero. The sample tube with distilled water was removed, the 40 NTU standard solutions were filled in the tube, and the meter reading was set to read 100. Other standards were also run. The turbidity of the marine water sample was then found by filling the sample tube with the sample, and the reading was noted.

### **Dissolved Oxygen (DO)**

DO was determined by Winkler's method (Strickland and Parsons, 1972).

### **Phosphate**

Acidified Molybdate reagent was added to the sample to yield a phosphomolybdate complex that is reduced with Ascorbic acid to a highly coloured blue compound, which is measured at the wavelength of 690 nm in a Spectrophotometer (Shimadzu UV 5040).

### **Total phosphorus**

Phosphorus compounds in the sample were oxidized to phosphate with alkaline Potassium persulphate at high temperature and pressure. The resulting phosphate was analyzed and described as total phosphorous.

### **Nitrite**

Nitrite in the water sample was allowed to react with Sulphanilamide in acid solution. The resulting diazo compound was reacted with N-1-Naphthyl ethylenediamine dihydrochloride to form a highly coloured azo-dye. The light absorbance was measured at the wavelength of 543 nm in Spectrophotometer (Shimadzu UV 5040).

### **Nitrate**

The Nitrate content was determined as nitrite (as mentioned above) after its reduction by passing the sample through a column packed with amalgamated Cadmium.

### **Petroleum Hydrocarbon (PHs)**

The water sample (1liter) was extracted with hexane and the organic layer was separated, dried over anhydrous sulphate and reduced to 10 ml at 30°C under low pressure. Fluorescence of the extract was measured at 360 nm (excitation at 310 nm) with Saudi Arabian crude residue as a standard. The residue was obtained by evaporating lighter fractions of the crude oil at 120°C.

### **Sediment characteristics**

Sediment samples were collected from the prefixed stations by using a Van Veen grab having a mouth area of 0.04m<sup>2</sup> or by a non-metallic plastic spatula. Sediment analysis was carried out using standard methodologies. In each location (grid), sediment samples were collected from three different spots and pooled together to make a composite sample, representative of a particular site. The collected samples were air dried and used for further analysis.

### **Sediment Texture**

For texture analysis, specified unit of sediment sample was sieved through sieves of different mesh size as per Unified Soil Classification System (USCS). Cumulative weight retained in each sieve was calculated starting from the largest sieve size and adding subsequent sediment weights from the smaller size sieves (USDA,1951). The percentage of the various fractions was calculated from the weight retained and the total weight of the sample. The cumulative percentage was calculated by sequentially subtracting percent retained from the 100%.

### **Total Organic carbon**

Percentage of organic carbon in the dry sediment was determined by oxidizing the organic matter in the sample by Chromic acid and estimating the excess Chromic acid by titrating against Ferrous ammonium sulphate with Ferroin as an indicator (Walkley and Black, 1934).

## **2.3. Biological Characteristics of water and Sediment**

### **Primary productivity**

Phytoplankton possess the plant pigment chlorophyll 'a' which is responsible for synthesizing the energy for metabolic activities of phytoplankton through the process of photosynthesis in which CO<sub>2</sub> is used and O<sub>2</sub> is released. It is an essential component to understand the consequences of pollutants on the photosynthetic efficiency of phytoplankton in the system. To estimate this, a known volume of water (500 ml) was filtered through a 0.45 µm Millipore Glass filter paper and

the pigments retained on the filter paper were extracted in 90% Acetone. For the estimation of chlorophyll 'a' and pheophytin pigments the fluorescence of the Acetone extract was measured using Fluorometer before and after treatment with dilute acid (0.1N HCL) (Strickland and Parsons,1972).

### **Phytoplankton**

Phytoplankton samples were collected from prefixed 15 sampling sites from the coastal water in and around DPA location using standard plankton net with a mesh size of 25µm and a mouth area of 0.1256 m<sup>2</sup> (20 cm radius). The net fitted with a flow meter (Hydrobios) was towed from a motorized boat moving at a speed of 2 nautical miles/hr. Plankton adhering to the net was concentrated in the net bucket by splashing seawater transferred to a pre-cleaned and rinsed container and preserved with 5% neutralized formaldehyde and appropriately labelled indicating the details of the collection, and stored for further analysis. The Quantitative analysis of phytoplankton (cell count) was carried out using a Sedgewick-Rafter counting chamber. The density (No/l) was calculated using the formula:  $N = n \times v/V$  (Where, N is the total No/liter, n is the average number of cells in 1 ml, v is the volume of concentrate; V is the total volume of water filtered. The identification was done by following the standard literature of Desikachary, (1987), Santhanam et.al. (2019) and Kamboj et.al. (2018).

### **Zooplankton**

Zooplankton samples were collected using a standard zooplankton net made of bolting silk having 50µm with mouth area of 0.25 m<sup>2</sup> fitted with a flow meter. The net was towed from a boat for 5 minutes with a constant boat speed of 2 nautical miles/hr. The initial and final reading in the flow meter was noted down and the plankton concentrate collected in the bucket was transferred to appropriately labeled container and preserved with 5% neutralized formaldehyde. One ml of the zooplankton concentrate was added to a Sedgwick counting chamber and observed under a compound microscope and identified by following standard literature. The group/taxa were identified using standard identification keys and their number was recorded. Random cells in the counting chamber were taken for consideration and the number of zooplankton was noted down along with their binomial name. This process was repeated for five times with 1 ml sample and the average value was considered for the final calculation. For greater accuracy, the final density values were counter-checked and compared with the data collected by the settlement method.

Univariate measures such as Shannon-Wiener diversity index ( $H'$ ), Margalef's species richness ( $d$ ), and Pielou's evenness ( $J'$ ), Simpson's dominance ( $D$ ) was determined using PAST software.

### **Intertidal Fauna**

Intertidal faunal assemblages were studied for their density, abundance and frequency of occurrence during monsoon 2022 at the pre-fixed 15 sampling locations within the DPA jurisdiction. Sample collection and assessment of intertidal communities were done in the intertidal zone during the low tide period. At each site, 1 x1 m<sup>2</sup> quadrates were placed randomly and all visible macrofaunal organisms encountered inside the quadrate were identified, counted and recorded. At each site, along the transects which run perpendicular to the waterfront, three to six replicate quadrate samples were assessed for the variability in macro-faunal population structure and the density was averaged for the entire intertidal belt. Organisms, which could not be identified in the field, were preserved in 5% formaldehyde, brought to the laboratory and identified using standard identification keys (Abott, 1954; Vine, 1986; Oliver, 1992; Rao, 2003; 2017; Psomadakis *et al.*, 2015; Apte, 2012; 2014; Naderloo 2017; Ravinesh *et al.* 2021; Edward *et al.*, 2022). Average data at each site were used to calculate the mean density (No/m<sup>2</sup>).

### **Subtidal macro benthic Fauna**

The sampling methods and procedures were designed in such a way to obtain specimens in the best possible condition as to maximize the usefulness of the data obtained. For studying the benthic organisms, triplicate samples were collected at each station using Van Veen grab, which covered an area of 0.04m<sup>2</sup>. The wet sediment was passed through a sieve of mesh size 0.5 mm for segregating the organisms. The organisms retained in the sieve were fixed in 5-7% formalin and stained further with Rose Bengal dye for ease of spotting at the time of sorting. The number of organisms in each grab sample was expressed as No. /m<sup>2</sup>. All the species were sorted, enumerated and identified by following the available literature. The works of Day (1967), Hartman (1968, 1969), Rouse and Pleijel (2001), Robin *et al.*, (2003), Amr (2021), were referred for polychaetes; Crane (1975), Holthuis (1993), Naderloo (2017). Xavier *et al.*, (2020) for crustaceans; Subba Rao (1989, 2003, 2017), Apte (2012, 2014), Ramakrishna and Dey (2007), Ravinesh *et al.* (2021) and Edward *et al.*, (2022) for molluscs. Statistical analyses such as diversity indices and quadrat richness were calculated using Paleontological Statistics Software Package for Education and Data (PAST) version 3.2.1 (Hammer *et al.*, 2001).





**Plate 1: Estimation of intertidal fauna by the quadrat method**



**Plate 2: Collection of Plankton and macrobenthos in subtidal habitat**



## **2.4. Mudflats**

Mudflats are ecologically and socio-economically vital ecosystems that bring benefits to human populations around the globe. These soft-sediment intertidal habitats, with >10% silt and clay (Dyer 1979), sustain global fisheries through the establishment of food and habitat (including important nursery habitats), support resident and migratory populations of birds, provide coastal defenses, and have aesthetic value. Mudflats are intimately linked by physical processes and dependent on coastal habitats, and they commonly appear in the natural sequence of habitats between subtidal channels and vegetated salt marshes. In some coastal areas, which may be several kilometres wide and commonly form the largest part of the intertidal area. Mudflats are characterized by high biological productivity and abundance of organisms but low in species diversity with few rare species. The mudflat biota reflects the prevailing physical conditions of the region. Intertidal mudflats can be separated into three distinct zones such as the lower tidal, middle and upper mudflats. The lower mudflats lie between mean low water neap and mean low water spring tide levels, and are often subjected to strong tidal currents. The middle mudflats are located between mean low water neaps and mean high water springs. The upper mudflats lie between the mean high-water neap and mean high water springs. The upper mudflats are the least inundated part and are only submerged at high water by spring tides (Klein, 1985). Salt marsh vegetation may colonize as far seaward as mean high water neaps. Mudflats will often continue below the level of low water spring tides and form sub-tidal mudflats (McCann, 1980). The upper parts of mudflats are generally characterized by coarse clays, the middle parts by silts, and the lower region by sandy mud (Dyer *et al.*, 2000). The intertidal mudflats are prominent sub-environments that occurred on the margin of the estuaries and low relief sheltered coastal environments. The fine-grained sediments of intertidal mudflats (70%-90%) are derived from terrestrial and marine regions (Lesuere *et.al.*, 2003). Estuarine mudflats are potential sites for deposition of organic matter derived from terrigenous, marine, atmospheric and anthropogenic sources and are mainly associated with fine grained particles (Wang *et.al.*, 2006).

### **Sampling locations**

The Sediment samples were collected from 15 sampling locations by using sediment corer. From each site triplicate samples were collected from up to 100 cm depth with four intervals (0-25cm, 25-50cm, 50-75cm & 75-100cm) and made into composite sample for analysis. The samples were packed in zip lock bags, stored in icebox and shifted to the laboratory for subsequent analysis.



**Plate 3: Sediment sample collection at mangrove and mudflat areas**

### **Total Organic Carbon**

The organic carbon content of the mudflats was estimated to assess the biological productivity of the sediment. Soil Organic Carbon (SOC) was estimated following the method of Walkley and Black (1934). In this method, organic matter (humus) in the soil gets oxidized by Chromic acid (Potassium dichromate plus concentrated H<sub>2</sub>SO<sub>4</sub>) by utilizing the heat evolved with the addition of H<sub>2</sub>SO<sub>4</sub>. The unreacted dichromate is determined by back titration with Ferrous ammonium sulphate (redox titration). Organic carbon was determined by following the below given formula:

$$\text{Oxidizable organic carbon (\%)} = \frac{10 (B - T)}{B} \times 0.003 \times \frac{100}{\text{wt. of soil}}$$

Where B = volume (mL) of Ferrous ammonium sulfate required for blank titration. T = volume of Ferrous ammonium sulfate needed for soil sample. Wt. = weight of soil (g).

### **Estimation of Bulk Density (BD)**

The soil under field condition exists as a three-phase system viz. solid (soil particles), liquid (water) and gas (mostly air). The soil organic matter contained in a unit volume of the soil sample is called its bulk density. The amount of bulk density depends on the texture, structure and organic matter status of the soil. High organic matter content lowers the bulk density, whereas compaction increases the bulk density. To determine the bulk density of the sediment samples collected during the present study, the oven-dry weight of a known sediment volume was considered, and mass per unit volume was calculated (Maiti, 2012).

### **2.5. Mangrove assessment**

Mangroves are widely distributed on the Deendayal Port Authority jurisdiction along the Kandla coast. The 15 mangrove sites selected at the different creeks belong to Deendayal Port Authority jurisdiction and all these stations are supposed to be sufficient to represent the mangroves status in Kandla. The mangrove stations in this study were named Tuna, Jangi, Kandla, Phan and Navlakhi based on the nearest location to the respective creek system. The Point Centered Quadrature Method (PCQM) was used for the collection of data of mangrove vegetation structure. The data included measurements of density of plants, height variations, canopy and basal area of mangrove trees as per the method of Cintron and Novelli (1984). For this method, a transect of a maximum of 200 m was applied mostly perpendicular or occasionally parallel to the creek. The sampling points considered at an interval of every 10 m and the vegetation structure of the that area were recorded. As the orientation of the transect line was already fixed, it was easy for movements within the station area for data recording. The distance between trees from the center of the sampling point for nearest 4 trees of four different directions, height of trees from the ground level, canopy length and canopy width were measured to determine the canopy cover in this study. The equipments utilized in the field were handy, and easy to use such as ranging rods, pipes and for measurement of girth at root collar above the ground (GRC), a measuring tape was used. The plants with a height <50 cm was considered as regeneration class and >50 cm but <100 cm was considered as recruitment class. Along the transects, sub-plots of 1×1 m<sup>2</sup> for regeneration and 2×2 m<sup>2</sup> were laid randomly for recruitment class of the mangrove sites.



**Plate 4: Assessment of mangrove density, height, canopy cover and girth**

## **2.6. Halophytes**

To quantify and document the halophytes at Deendayal Port Authority region, quadrature method was followed. At each sampling location quadrates of various sizes have been laid during every seasonal sampling. For recording the plant density at each transect, a quadrature 1 x 1m<sup>2</sup> has been laid within the site each tree quadrates were used randomly (Misra,1968; Bonham, 1989). Four quadrates each for shrubs and herbs were laid in side each tree quadrature to assess the halophytes and the percentage cover in the study area. To enrich the species inventory, areas falling outside the quadrates were also explored and the observed species were recorded and photographed and identified using standard keys. Specimens of the various species were collected to know more information on habitat and for the preparation of herbarium.





**Plate 5: Assessment and percentage cover of halophytes**

## **2.7. Marine Fishery**

Fishery resources and the diversity were assessed from the selected sampling sites. Finfish and shellfish samples were collected using a gill net with a 10 mm mesh size. The net was operated onto the water from a canoe or by a person standing in waist deep water during the high tide using a cast net. For effective sampling, points were fixed at distances within the 15 offshore sites for deploying fishing nets to calculate the Catch per Unit effort estimated per hour. The collected specimens were segregated into groups, weighed and preserved in 10% neutralized formalin solution. Finfishes were identified following Fischer and Bianchi (1984), Masuda *et al.* (1984), de Bruin *et al.* (1995) and Mohsin and Ambiak (1996). Relevant secondary information pertaining to fishery resources of Deendayal Port creek systems were gathered through technical reports, the District Fisheries department, Government gazette and other research publications.



**Plate 6: Collection of fisheries information from DPA environment**

## **2.8. Avifauna**

The Avifauna population was determined along DPA mangrove strands for which the area was demarcated into fifteen major stations. In each station, creeks of varying lengths from 2 to 5 km are available. These creeks were surveyed by using boat and adopting “line transect” method. A total of fifteen boat transect (one in each site) survey was conducted in the Monsoon season (June-September, 2022). Survey was done in both terrestrial habitats like Mangrove plantations adjoining the mudflats, waste land, and aquatic habitats, like creek area, rivers and wetland.

### **Boat Surveys**

Mangrove bird diversity was calculated by using Boat Survey method. Birds were observed from an observation post on board the boat which has given the greatest angle of clear view. Birds within a 100 meter transect on one side of the boat were counted in 10-minute blocks of time (Briggs *et al.* 1985; van Franeker, 1994). Detection of birds was done with a binocular (10 x 40) and counts were made: (1) continuously of all stationary birds (swimming, sitting on mangrove, or actively feeding) within the transect limits and (2) in a snap-shot fashion for all flying birds within the transect limits. The speed of the boat determines the forward limit of the snapshot area within a range of 100 meters. Longer or shorter forward distances were avoided by adapting the frequency of the snapshot counts. Birds that following and circling the boat were omitted from both snapshot and continuous counts. If birds arrive and then follow the boat, they were included in the count only if their first sighting falls within a normal snapshot or continuous count of the transect area. For each bird observation species, number of individuals and activity at the time of sighting, were recorded. Species richness and diversity index were calculated for different mangrove patches (i.e. fifteen station) of the study station in the Deendayal port Authority.

## **2.9. Data analysis**

Data collected in- situ and through laboratory analysis of samples were subjected to descriptive statistical analysis (PAST and Primer 7.0) for the mean, range and distribution of different variables from the selected 15 study stations.

### **3. Results**

#### **Water quality assessment**

The data on the mean water quality parameters measured at the time of sampling of the biological components from the 15 study sites are presented in Table1.

#### **Temperature (°C) and pH**

The water temperature at the sampling sites ranged from 23°C to 31°C. The maximum temperature of seawater was reported at S-5 and the minimum at S-6 in Kandla creek. The pH of seawater ranged from 7.1 to 8.3. The highest pH was reported at sites S-15 and S-10, however, the lowest pH 7.1 was noticed at S-14 in Kandla creek. The overall observation along the port environment revealed that the temperature fluctuation might be due to high degree of warmth in summer on the land but the pH range did not show major fluctuations among the sampling locations.

#### **Salinity (ppt)**

Salinity of the water strongly influences the abundance and distribution of marine biota in coastal and marine environments. The salinity ranged from 28 ppt to 40 ppt with the average value of 37 ppt. Minimum salinity was observed S-7 and maximum at S-9, S-13 & S-15. The poor rainfall induced aridity in the Gulf of Kachchh (GoK) region renders Gulf waters hypersaline round the year. In addition, GoK is known to be a negative water body where evaporation exceeds precipitation.

#### **Dissolved oxygen (DO)**

Dissolved oxygen is the amount of oxygen dissolved in water and is a fundamental requirement of all biota and chemical processes in the aquatic environment. The concentration varies mainly due to photosynthesis and respiration by plants and animals in water. Generally, the coastal waters are having high level of dissolved oxygen due to the dissolution from the atmosphere through diffusion process on the surface layer (CCME,1999). The dissolved oxygen in the coastal waters of Deendayal port authority area ranged from 4.5 mg/L to 6.9 mg. The highest DO concentration was observed at station S-7 and lowest was observed at station S-15.



### **Suspended Solids (TSS)**

The total suspended solids (TSS) concentration at the 15 sampling sites ranged from 127 mg/L to 403 mg/L with the average of 255 mg/L. The highest TSS values was reported at S-15 in the Phang creek followed by 354 mg/L in S-3 oil jetty. The minimum TSS value was recorded at S-7 which was 127 mg/L.

### **Total Dissolved solids (TDS)**

The total dissolved solids (TDS) in the water consist of inorganic salts and dissolved materials which mostly comprises of anions and cations. The TDS of the samples varied from 1967 mg/L to 11,288 mg/L with an average of 5,703 mg/L. The maximum value was reported at S-6.

### **Turbidity**

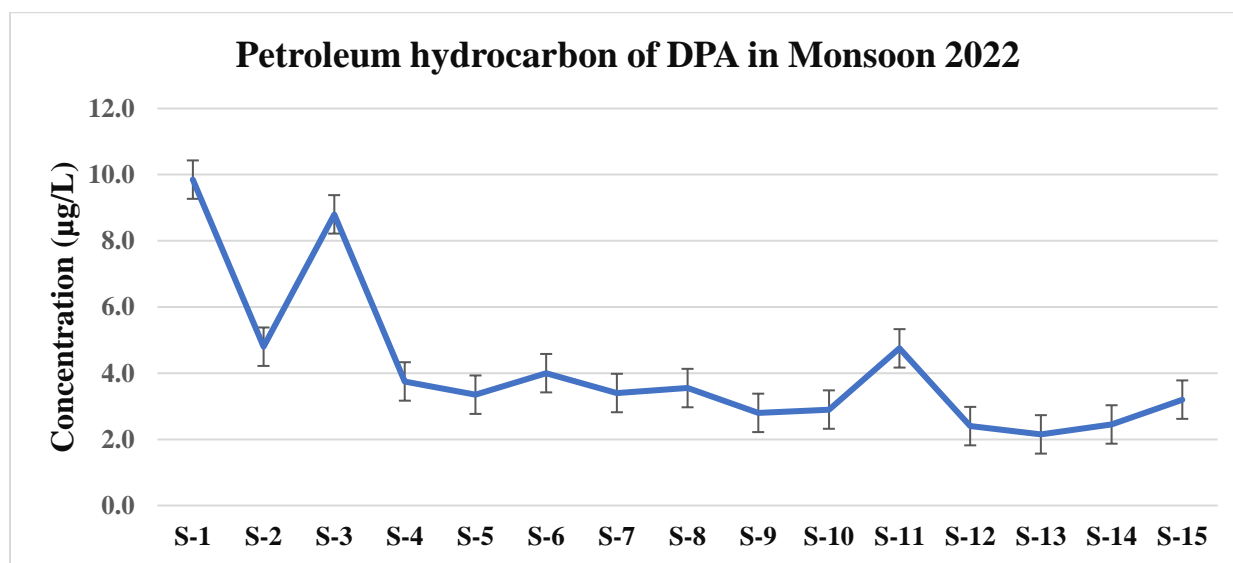
The turbidity of the water samples from the study sites ranged between 44 NTU and 147 NTU with the average of 76 NTU. The lowest value was reported at S-3 and a highest value at S-6 followed by S-6 (170 NTU).

### **Water nutrients (Nitrate, Nitrite and Total Phosphorus)**

The nutrients influence growth, metabolic activities and reproduction of biotic components in the aquatic environment. The distribution of nutrients mainly depends upon tidal conditions, season and fresh water influx from land. The nitrate concentration ranged from 0.01 mg/L to 0.02 mg/L with an average of 0.01 mg/L. The highest nitrate concentration was observed at station S-7 and the lowest at station S-11. There was no remarkable variation in concentration of nitrate among the study station. Similarly, nitrite values varied between 0.05 mg/L to 0.94 mg/L. The highest concentration was observed at station S-13 and lowest concentration was observed at station S-2. The highest concentration might be due to influx effluents from industries producing metals, dyes and celluloid in the periphery of port authority. The Total phosphorus values among the study station ranged from 0.02 mg/L to 0.96 mg/L with an average of 0.47 mg/L. The highest phosphorus concentration was observed at station S-13 near veera of Kandla creek and lowest concentration was observed at station S-11 in Jhangi creek. Highest concentration might be due to leaching of phosphatic fertilizer while handling of cargo port area.

### Petroleum Hydrocarbons (PHs)

Due to urbanization and modernization, petrochemical products are in heavy demand. Petroleum hydrocarbons (PHs) represent short-chain hydrocarbons like aromatic, paraffin, alicyclic complexes, and non-hydrocarbon mixtures such as thiol, and asphaltene, naphthenic acid, phenol, thiol, heterocyclic nitrogen, sulfuric amalgams and metalloporphyrin. Due to the hydrophobic nature of the PHs, they possess low solubility in water and a high persistence level in soil, water as well as sediments (Babu *et al.*, 2019). PHs are significant toxic compounds representing one of the major wide-scale environmental threats caused due to the coastal oil refining, production, leaks or accidental spilling, transport, shipping activities, offshore oil production and other anthropogenic activities. The release of such compounds into the environment irrespective of it being accidental or due to any anthropogenic activities leads to soil as well as water pollution. This in turn poses catastrophic health effects either directly or indirectly on all the forms of life thereby deteriorating the overall ecosystem. In the current study, the presence of PHs in water samples collected along all the 15 sampling sites were detected and estimated. The PHs ranged from 2.2 µg/L to 9.9 µg/L. The PHs detected from the individual sites have been represented in (Fig 2). The highest concentration of the PHs was detected at S-1 site (Tuna creek) while the lowest was noted for S-13 (Veera). A high level of the PHs content was noted down at site S-1 too followed by the rest of the sites.



**Figure 2: Petroleum hydrocarbons in water (µg/L) during Monsoon 2022**

**Table 2: Physico-chemical characteristics of coastal waters during Monsoon 2022**

Parameters	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15
Temp (°C) (Air)	27	28	31	33	36	26	31	29	30	32	26	34	29	29	34
Temp (°C) (Water)	25	25	29	30	31	23	29	26	27	30	23	30	27	26	29
pH	8	8.09	7.9	7.5	7.8	7.8	7.7	7.6	8.2	7.9	7.9	8.06	8.2	7.1	8.3
Salinity (ppt)	34.7	36.7	39.2	38.7	36.5	36.2	28.3	35.8	39.9	38.8	36.4	39	40.2	38.2	40.1
Dissolved oxygen (mg/L)	4.86	4.66	6.69	5.27	5.87	4.66	6.89	6.28	5.06	5.87	4.66	6.48	5.27	5.47	4.45
Total Suspended Solids (TSS) (mg/L)	200	236	354	132	347	234	127	172	342	232	334	190	272	252	403
Total Dissolved solids (TDS) (mg/L)	3970	4676	2985	3851	7885	1967	5988	4320	7549	11288	8983	3886	5676	4792	7733
Turbidity (NTU)	48	58	147	95	93	44	45	93	119	108	57	58	58	52	63
Nitrate (NO <sub>3</sub> ) (mg/L)	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.07	0.02	0.01
Nitrite (NO <sub>2</sub> ) (mg/L)	0.39	0.05	0.36	0.39	0.41	0.74	0.38	0.53	0.58	0.27	0.73	0.39	0.94	0.63	0.55
Total Phosphorus (mg/L)	0.35	0.64	0.46	0.41	0.39	0.90	0.76	0.30	0.04	0.06	0.02	0.35	0.96	0.85	0.63
PHs (µg/L)	9.85	4.8	8.8	3.75	3.35	4	3.4	3.55	2.8	2.9	4.75	2.4	2.15	2.45	3.2
Chlorophyll a (mg/L)	0.19	0.20	0.21	0.18	0.13	0.15	0.19	0.15	0.16	0.14	0.19	0.21	0.15	0.16	0.22

### 3.2. Sediment

#### Sediment texture

The percentage composition of the soil particles in the sediment analyzed from the 15 sampling sites are presented in Fig.3. There were noticeable variations in the soil fractions, sand, silt and clay, among the stations. In the present study the highest percentage of clay was reported at S-7 followed by S-9. The highest percentage of sand was observed at S-1 followed by S-14 station. As per the observations, the percentage of silt content was less compared to clay and sand in many sampling sites except S-1 and S-14. The nature of soil texture was characterized by the proportion of clay, sand and silt fractions. The Soil texture revealed the dominance of silty-clay type in all the stations with less variations among them. This consistently high clay-loam value may be attributed to the winnowing activity of sediment transport system. The absence of perennial flow of freshwater into the coast along with lack of wave induced sand transport from open sea are the possible reasons for this uniform pattern of soil texture.

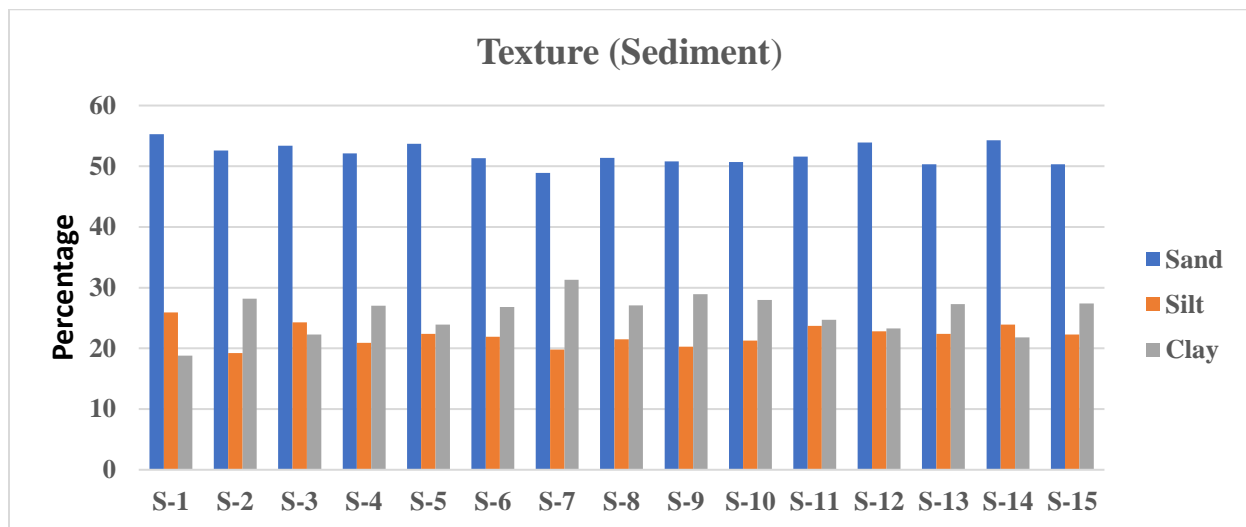
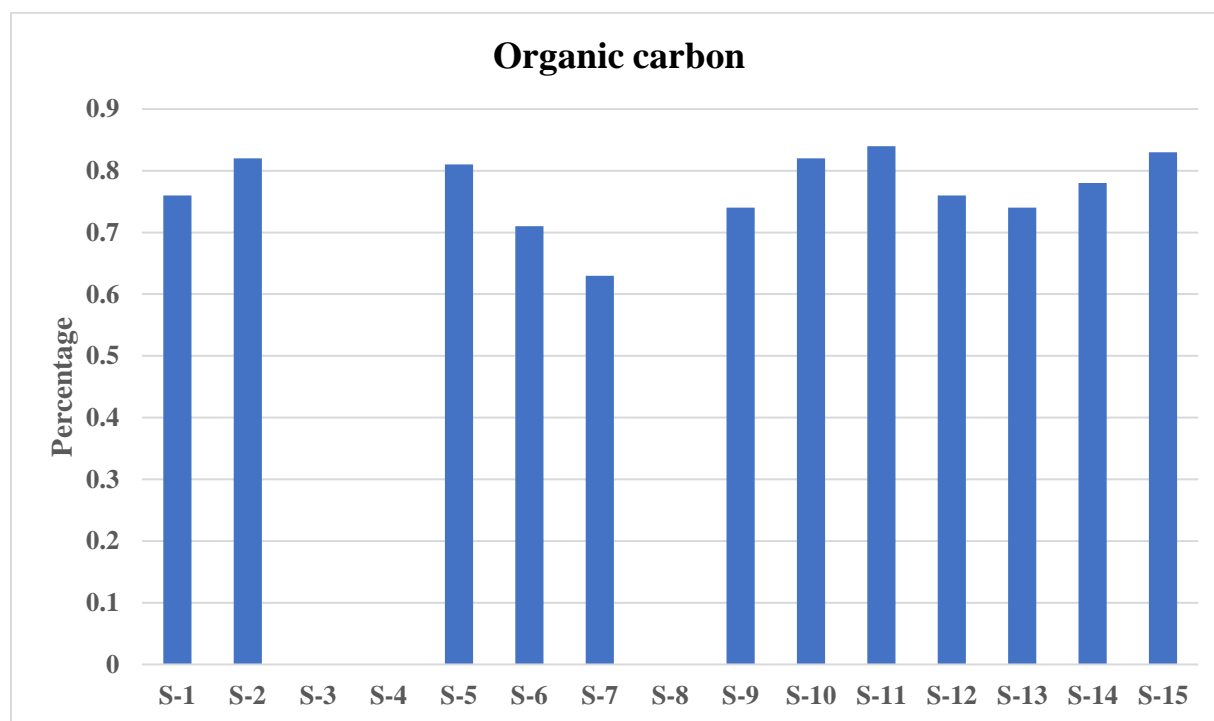


Figure 3: Characteristics of sediment at the study stations in Monsoon 2022

### **Total Organic Carbon (TOC)**

In the present study, the total organic carbon content varied from 0.63% to 0.84% (Fig.4). The highest values of TOC were reported at S-11 followed by S-15. The lowest TOC value was recorded at the S-7. The distribution of total organic carbon closely followed the distribution of sediment type i.e., sediment low in clay content contained relatively low organic carbon.



**Figure 4: Total Organic Carbon content (%) in the sediment during Monsoon 2022**

### 3.3. Biological characteristics of water and sediment

#### Primary productivity

Chlorophyll 'a' the photosynthetic pigment which can be used as a proxy for phytoplankton productivity and thus is an essential water quality parameter. Generally, the primary production of the water column is assessed from Chlorophyll 'a' concentration. It is well known that half of the global primary production being mediated by the activity of microscopic phytoplankton.

In the present study, Chlorophyll 'a' concentration ranged from 0.13 mg/L to 0.22 mg/L. The highest concentration 0.22 mg/L was reported at S-15 (Fig.5) followed by S-12 (0.21) and S-3 (0.20mg/L). The photosynthetic pigment chlorophyll a which is a measure of the population density of phytoplankton during the monsoon period showed narrow range of variations among the sites. The Chlorophyll 'a' content was very low at S-5.

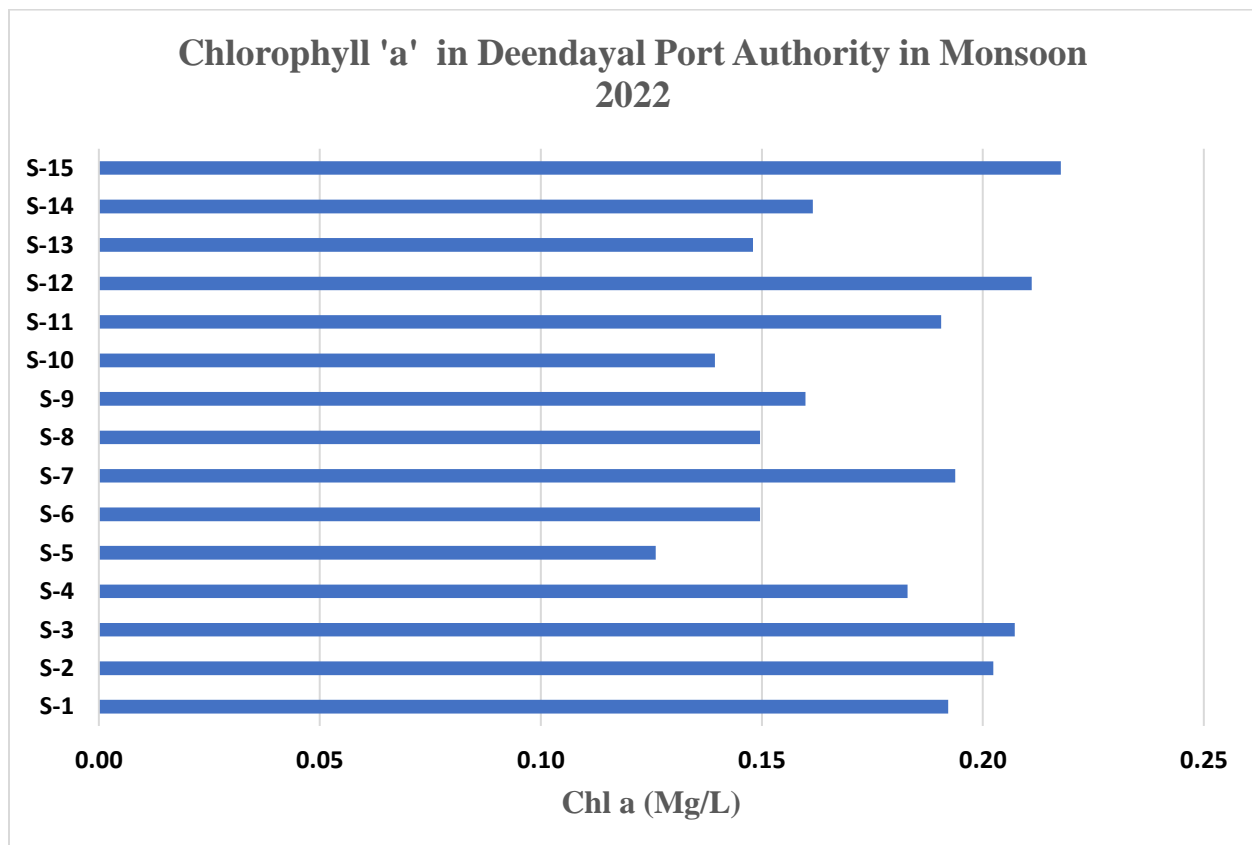


Figure 5: Chlorophyll 'a' concentration at the study stations in Monsoon 2022

### 3.4. Phytoplankton

Phytoplankton are free-floating, photosynthetic, aquatic microorganisms, which are distributed either actively by their locomotory organs (flagella) or passively by water currents. Most of the phytoplankton survive on the open surface waters of lakes, rivers and oceans. The phytoplankton community is mainly represented by algal representatives including both prokaryotes and eukaryotic genera. Plankton populations are mostly represented by members of Cyanobacteria, Chlorophyta, Dinophyta, Euglenophyta, Haptophyta, Chrysophyta, Cryptophyta, and Bacillariophyta. Planktonic representative taxa are absent in other algal divisions like Phaeophyta and Rhodophyta.

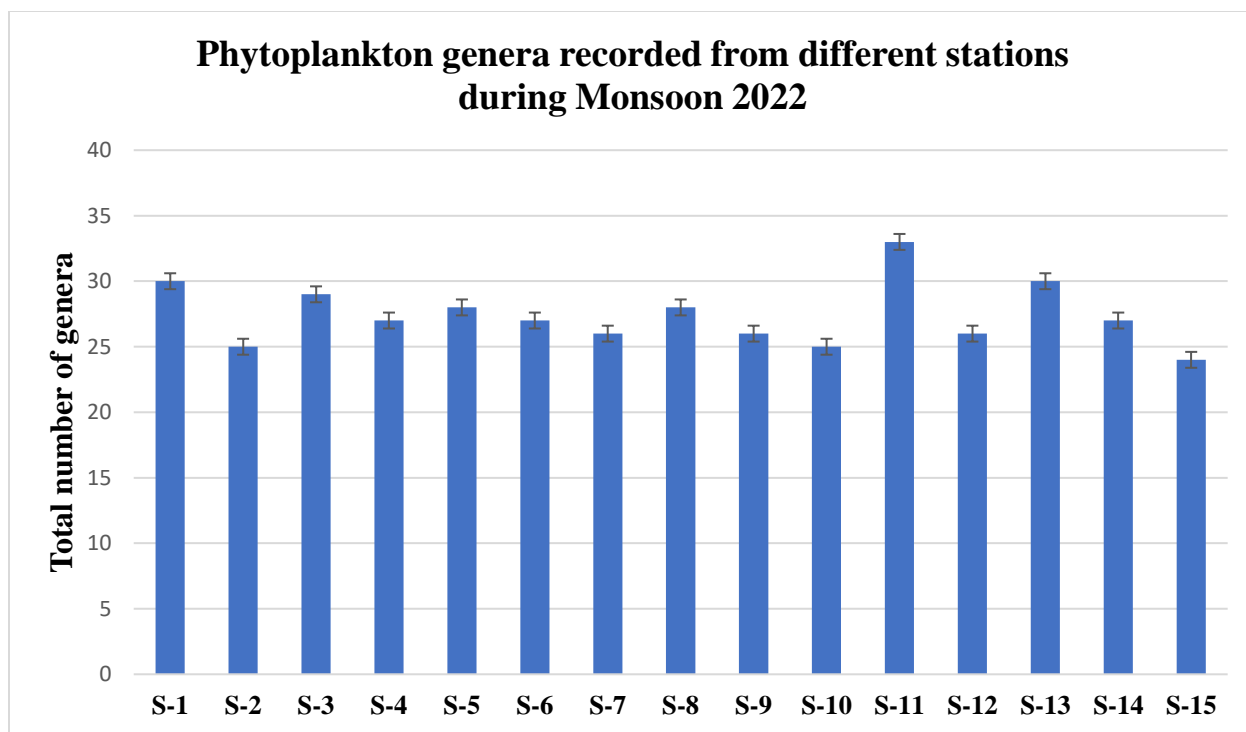
#### Generic Status

There were four groups of phytoplankton occurred during monsoon along the DPA, Kandla coast and its peripheral creek system which include Diatom (Pennales, Centrales), Dinophyceae and Cyanophyceae. The number of genera recorded during the monsoon period was 24 to 33 at the sampling stations with remarkable variations with respect to the composition. The maximum number (33) genera were observed at S-11 and the minimum from S-15 representing 24 genera. As far as generic status is concerned the centrales diatom contributed a greater number of genera (16) followed by Pennales (10) (Fig.6 & Table 3). Among the 4 groups of phytoplankton, the genera *Pseudonitzschia*, *Rhizosolenia*, *Coscinodiscus*, *Eucampia*, *Melosira* and *Planktoniella* occurred at all the sites.

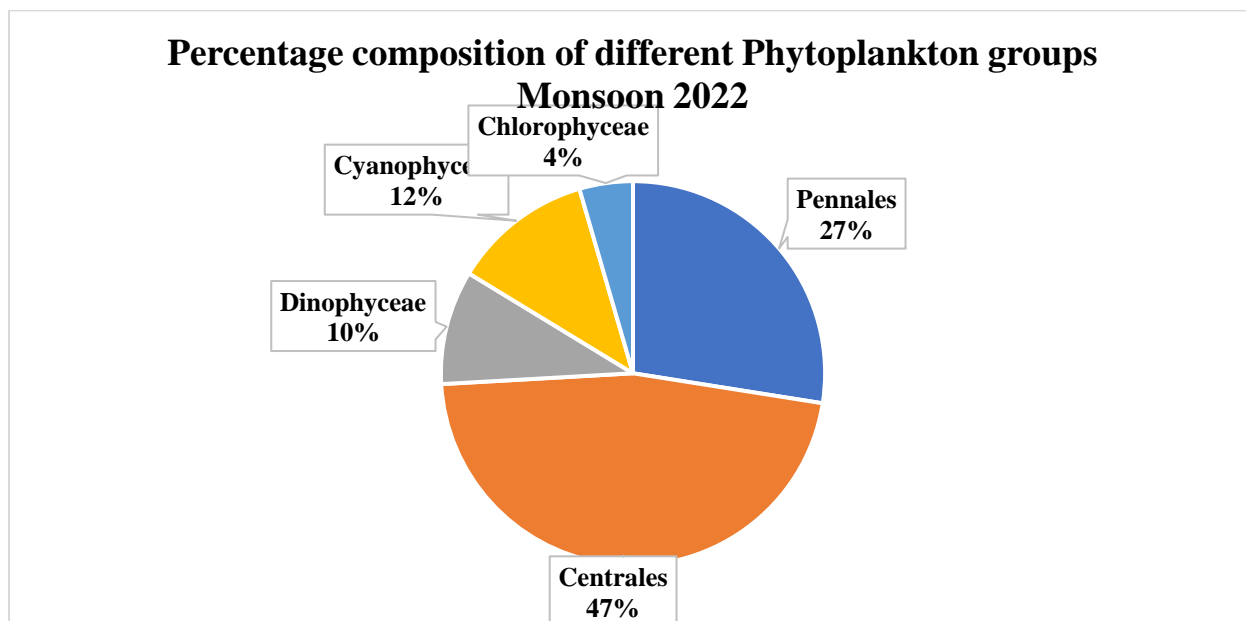
#### Percentage composition of phytoplankton

The cumulative percentage composition of the five groups of phytoplankton from all the study sites is presented in Fig.7. The percentage composition varied from 5 % to 47 % of which the centrales and pennales are the dominant constituting 47% and 27% respectively. The diatoms pennales and centrales together formed 74% of the phytoplankton population by number of genera as well as number of individuals while the rest is constituted by Dinophyceae (10%) and Cyanophyceae (12%) and Chlorophyceae (4%) during the monsoon 2022.





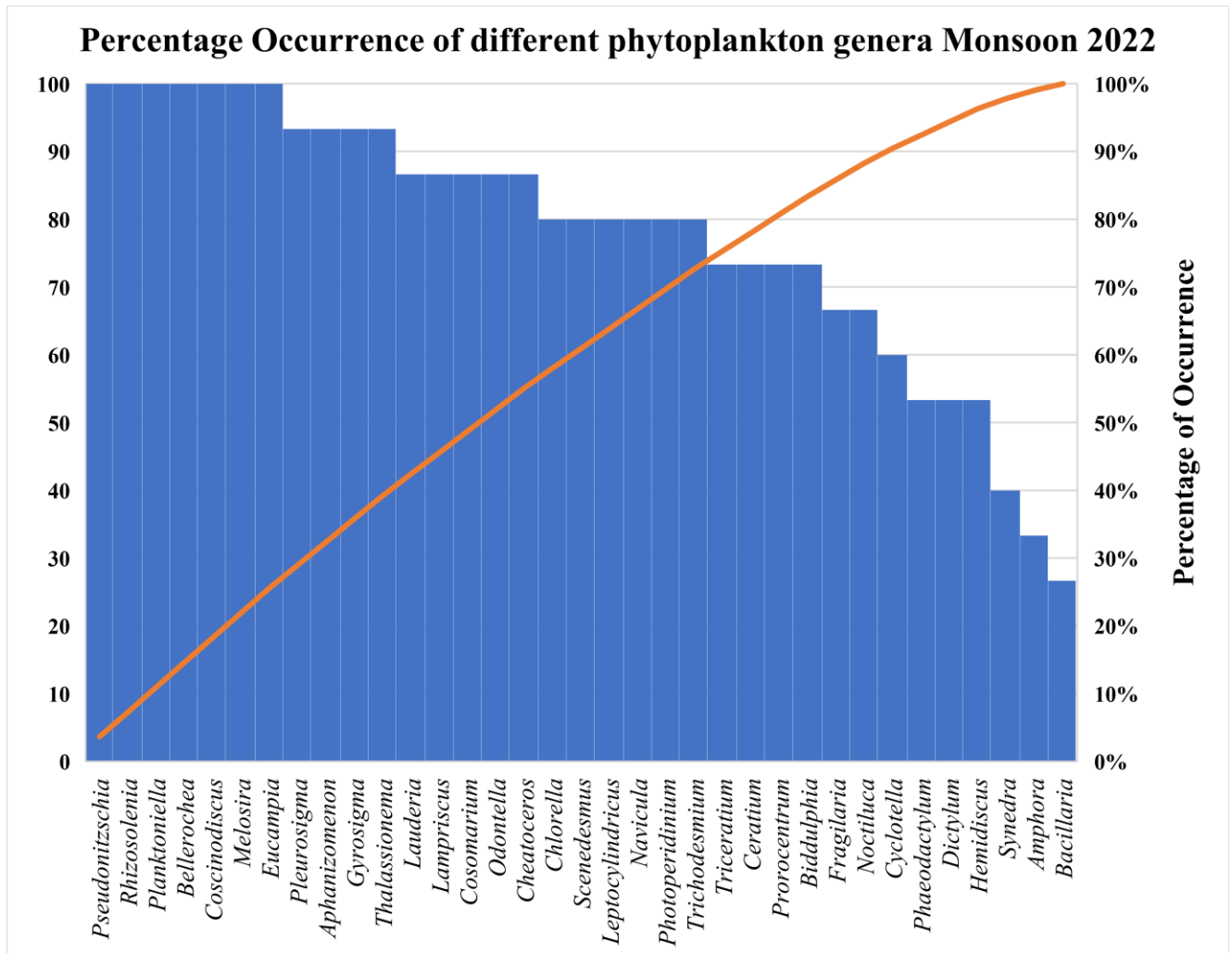
**Figure 6: Number of Phytoplankton genera in Monsoon 2022**



**Figure 7: Percentage composition of phytoplankton groups in Monsoon 2022**

### Percentage of occurrence

The percentage occurrence denotes the number of representations by a genus among the sites sampled. The percentage occurrence of different phytoplankton genera varied from 27% to 100% with an average of 78%. Seven phytoplankton genera have the highest percentage of occurrence (100%) (fig 8) followed by *Pleurosigma*, *Gyrosigma*, *Thalassionema* and *Aphanizomenon* (93%) occurrence during the monsoon season



**Figure 8: Percentage occurrence of phytoplankton genera in Monsoon 2022**

### Phytoplankton density and diversity

The density signifies the abundance of plankton which is measured as cell/ individual/L. The phytoplankton density varied from 1,760 No/L to 16,960 No/L with the average 13,483 No/L. The highest phytoplankton density was observed at station S-4 (16,960 No/L) followed by S-12 (16,480 No/L), whereas the lowest 1,760 No/L at S-11(fig.9). Diversity indices have become part of standard methodology in the ecological studies particularly, impact analysis and biodiversity monitoring of the environments (PEET,1974). Biodiversity indices reflects the biological variability which can be used for comparison with space and time. Various species diversity indices respond differently to different environmental and behavioral factors of biotic communities. Among the different stations, the phytoplankton taxa varied from 24 to 33 (Table-4). During monsoon the Margalef and Menhinik richness indices were maximum at stations S-11 (4.28& 0.79). The Shannon diversity index was maximum 3.31 (S-11) and minimum 2.93 at S-15. The Simpson index clearly reflexes the species dominance (genera) at S-11 (0.96) and the low value (0.94) was noticed at S-12.

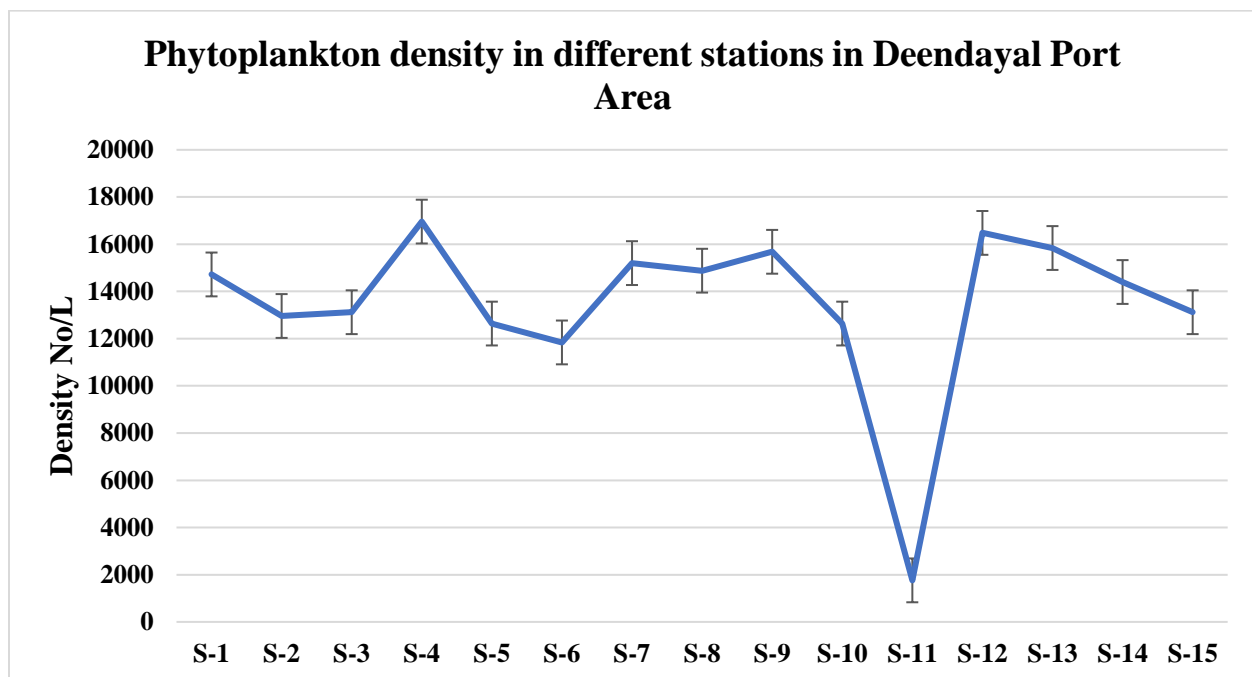
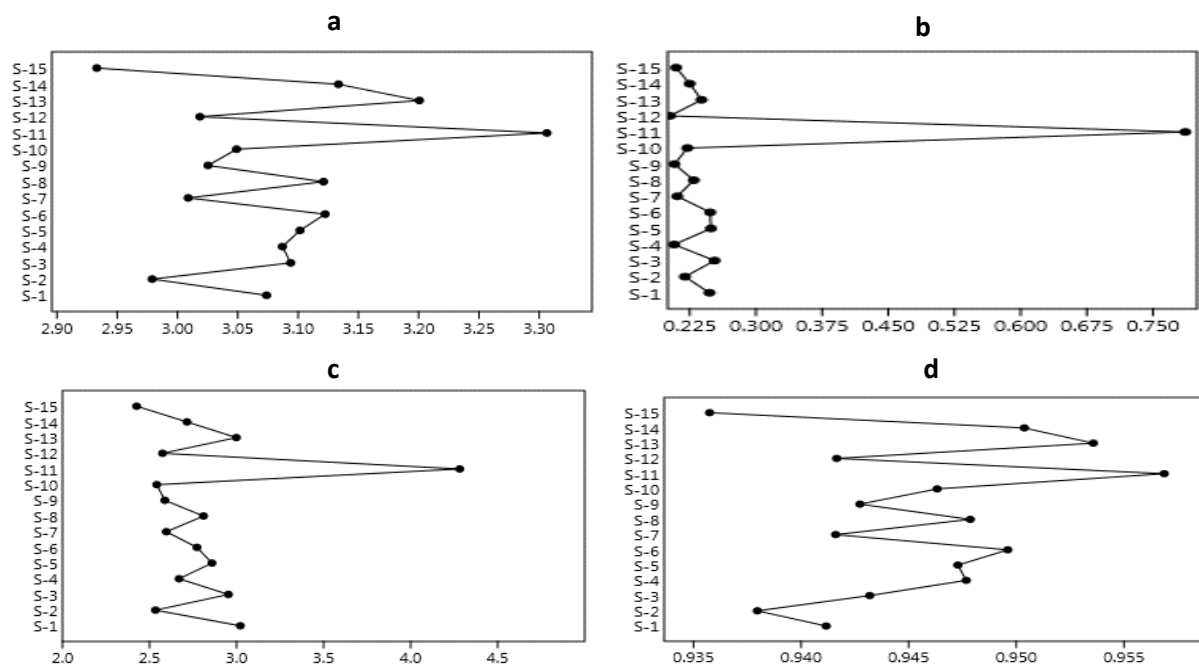


Figure 9: Phytoplankton density in Monsoon 2022

As per Shannon Wiener's rules for the aquatic environment i.e., both soil and water are classified as very good when  $H'$  value is greater than four ( $>4$ ), whereas the good quality represents the  $H'$  value with a range of 4-3, similarly moderate-quality ( $H'$  value 3-2), poor quality ( $H'$  value 2-1) and very poor-quality  $H'$  value significantly less than one ( $<1$ ). Presently Deendayal Port Authority and its periphery environment has been influenced by contaminants deposited from industries and the cargo movements. Accordingly, species diversity decreases at sites with poor water quality. As deduced from the Shannon diversity index values between 2.93 to 3.31 representing the moderate quality of environmental status dominated by the few genera such as *Pleurosigma*, *Gyrosigma*, *Thalassionema* and *Aphanizomenon*. A community dominated by relatively few species indicates environmental stress (Plafkin *et al.*, 1989). According to Staub *et al.* (1970) species diversity index value between 3.0 to 4.5 represents slightly polluted and the lightly polluted environment, the index value characterizes 2.0-3.0, similarly, moderately polluted environment shows index value of 1.0-2.0 and finally, the heavily polluted environment index value is 0.0-1.0. While considering the overall index values it is inferred that the study sites can be included under the category of lightly polluted.



**Figure 10: Different diversity indices a. Shannon Index b. Menhinick Index c. Margalef Index d. Simpson Index**

Table 3: Phytoplankton density, percentage composition and occurrence during Monsoon 2022

Group	Genera	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15	PO	PC
Pennales	<i>Amphora</i>	0	0	0	0	160	0	160	0	0	0	20	0	160	0	160	33	0.3
	<i>Bacillaria</i>	0	0	160	0	160	0	0	0	0	0	20	0	160	0	0	27	0.2
	<i>Ditylum</i>	160	0	0	960	480	0	0	640	0	320	100	640	480	0	0	53	1.9
	<i>Pseudonitzschia</i>	1760	320	480	640	960	640	1280	800	320	480	100	1600	960	640	1280	100	6.1
	<i>Pleurosigma</i>	160	320	640	1120	320	960	640	320	0	320	20	480	320	960	640	93	3.6
	<i>Rhizosolenia</i>	160	160	320	480	160	800	960	320	1120	160	40	640	160	800	960	100	3.6
	<i>Synedra</i>	320	0	320	160	0	0	0	160	0	0	20	320	0	0	0	40	0.6
	<i>Fragilaria</i>	480	320	480	0	0	160	0	1600	800	320	80	160	0	160	0	67	2.3
	<i>Gyrosigma</i>	160	320	160	640	800	320	480	1120	320	0	20	480	800	320	480	93	3.2
	<i>Thalassionema</i>	320	480	960	1600	1280	1120	800	480	800	640	60	0	1280	1120	800	93	5.8
Centrales	<i>Bellerochea</i>	800	480	1120	960	800	640	1760	960	1280	640	40	160	800	640	1760	100	6.3
	<i>Biddulphia</i>	160	0	320	160	160	480	0	160	0	640	40	320	160	480	0	73	1.5
	<i>Cheatoceros</i>	160	0	0	160	160	320	160	480	320	640	40	160	160	320	160	87	1.6
	<i>Coscinodiscus</i>	1440	640	320	480	640	800	160	320	1120	960	60	640	640	800	160	100	4.5
	<i>Cyclotella</i>	320	160	160	0	160	0	640	0	320	0	60	0	160	0	640	60	1.3
	<i>Eucampia</i>	800	960	320	1120	160	320	640	640	160	160	40	480	160	320	640	100	3.4
	<i>Hemidiscus</i>	0	0	160	0	0	160	320	0	320	0	40	160	0	160	320	53	0.8
	<i>Lauderia</i>	160	0	1600	800	320	640	160	320	480	320	60	0	320	640	160	87	3.0
	<i>Leptocylindricus</i>	320	480	1120	320	0	160	480	0	160	320	20	640	0	160	480	80	2.3
	<i>Lampriscus</i>	1120	800	480	800	640	480	0	160	320	480	120	1600	640	480	0	87	4.0
	<i>Melosira</i>	640	1760	960	1280	640	320	160	480	800	480	140	960	640	320	160	100	4.8
	<i>Navicula</i>	480	0	160	0	640	320	320	320	160	0	40	160	640	320	320	80	1.9
	<i>Odontella</i>	320	160	480	320	640	320	160	320	160	0	0	160	640	320	160	87	2.1
	<i>Planktoniella</i>	800	160	320	1120	960	480	640	800	1440	640	40	480	960	480	640	100	4.9
	<i>Phaeodactylum</i>	0	640	0	320	0	480	0	160	320	160	20	0	0	480	0	53	1.3
	<i>Triceratium</i>	160	160	160	1120	480	0	0	160	800	960	40	1120	480	0	0	73	2.8

Dinophyceae	<i>Ceratium</i>	160	0	160	160	160	160	1120	480	0	0	20	800	960	320	1120	73	2.8
	<i>Prorocentrum</i>	160	800	480	160	480	480	480	0	0	160	40	0	320	0	320	73	1.9
	<i>Photoperidinium</i>	640	1280	0	640	0	0	960	320	480	160	100	960	320	1120	160	80	3.5
	<i>Noctiluca</i>	160	800	160	480	160	160	160	320	160	0	0	0	160	0	0	67	1.3
Cyanophyceae	<i>Aphanizomenon</i>	160	160	160	160	160	160	320	160	640	800	40	480	1120	320	0	93	2.4
	<i>Cosomarium</i>	0	640	640	480	640	640	0	960	1600	1280	140	800	480	800	640	87	4.8
	<i>Trichodesmium</i>	160	160	0	320	0	0	1120	1120	960	800	80	1760	960	1280	640	80	4.6
Chlorophyceae	<i>Chlorella</i>	800	320	160	0	160	160	960	0	0	160	40	320	640	160	320	80	2.1
	<i>Scenedesmus</i>	1280	480	160	0	160	160	160	800	320	640	20	0	160	480	0	80	2.4
<b>Total genera</b>		<b>30</b>	<b>25</b>	<b>29</b>	<b>27</b>	<b>28</b>	<b>27</b>	<b>26</b>	<b>28</b>	<b>26</b>	<b>25</b>	<b>33</b>	<b>26</b>	<b>30</b>	<b>27</b>	<b>24</b>		
<b>Density No/L</b>		<b>14720</b>	<b>12960</b>	<b>13120</b>	<b>16960</b>	<b>12640</b>	<b>11840</b>	<b>15200</b>	<b>14880</b>	<b>15680</b>	<b>12640</b>	<b>1760</b>	<b>16480</b>	<b>15840</b>	<b>14400</b>	<b>13120</b>		

**Table 4: Diversity indices of Phytoplankton during Monsoon 2022**

Diversity Indices	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15
Shannon_H	3.07	2.98	3.09	3.09	3.10	3.12	3.01	3.12	3.03	3.05	3.31	3.02	3.20	3.13	2.93
Simpson_1-D	0.94	0.94	0.94	0.95	0.95	0.95	0.94	0.95	0.94	0.95	0.96	0.94	0.95	0.95	0.94
Margalef	3.02	2.53	2.95	2.67	2.86	2.77	2.60	2.81	2.59	2.54	4.28	2.58	3.00	2.72	2.43
Menhinick	0.25	0.22	0.25	0.21	0.25	0.25	0.21	0.23	0.21	0.22	0.79	0.20	0.24	0.23	0.21
Dominance_D	0.06	0.06	0.06	0.05	0.05	0.05	0.06	0.05	0.06	0.05	0.04	0.06	0.05	0.05	0.06

### 3.5. Zooplankton

Zooplankton are highly sensitive to changes caused by physical and chemical factors in aquatic ecosystems and their distribution deliver information regarding the productivity and pollution of the particular area (Gajbhiye and Desai, 1981). Zooplankton are distributed in a wide range of habitats extending from the neuston to benthos and play vital roles influencing fisheries, oceanography and climate (Terdalkar and Pai, 2001). It has various significant roles in the estuarine ecosystem and connecting link between nutrient cycling and phytoplankton, primary production and many commercial fisheries in estuaries and coastal waters and form a chief food for a variety of pelagic consumers including coelenterates, ctenophores, fish larva forage fish and some benthic organisms such as sponges and molluscs (Day *et al.*, 1989).

#### Phylum, group and generic status

The zooplankton identified from the 15 stations falls under 10 phyla and 41 genera belonging to the 16 groups (Table 5). The phylum Arthropoda was the predominant, represented with 25 genera including copepods, crabs, shrimps and their larva. The phylum Arthropoda dominated in the samples with major groups Calanoida, Harpacticoida, Cyclopoida, (Copepoda) Decapoda, and the larval forms of crustaceans. There were 14 genera of copepods in the samples. Among copepods, the Calanoida ranked first in terms of generic representation particularly *Acartia* sp, *Acrocalanus* sp, *Aetideus* sp. and *Calanus* sp. (figure-11).

#### Percentage composition

The overall percentage of the various groups of zooplankton varied from 0.3% to 36.9%. The highest percentage was due to the calanoid copepods (36.9%) followed by Decapoda (13.2%) and Gastropoda (8.2%). The group which contributed the least was *Chaetognatha* (0.3%) followed by Nematoda (0.4%) (Fig.12). Among the zooplankton groups calanoid group was observed predominantly at all sites.



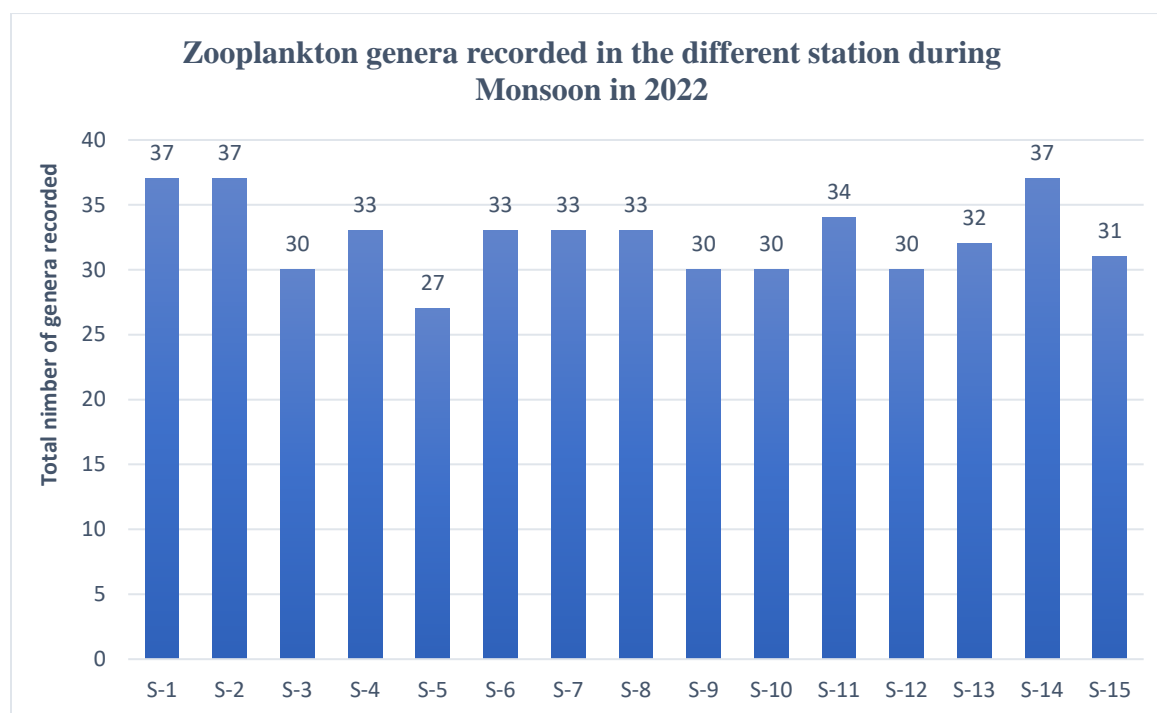


Figure 11: Phylum and generic status of zooplankton during Monsoon 2022

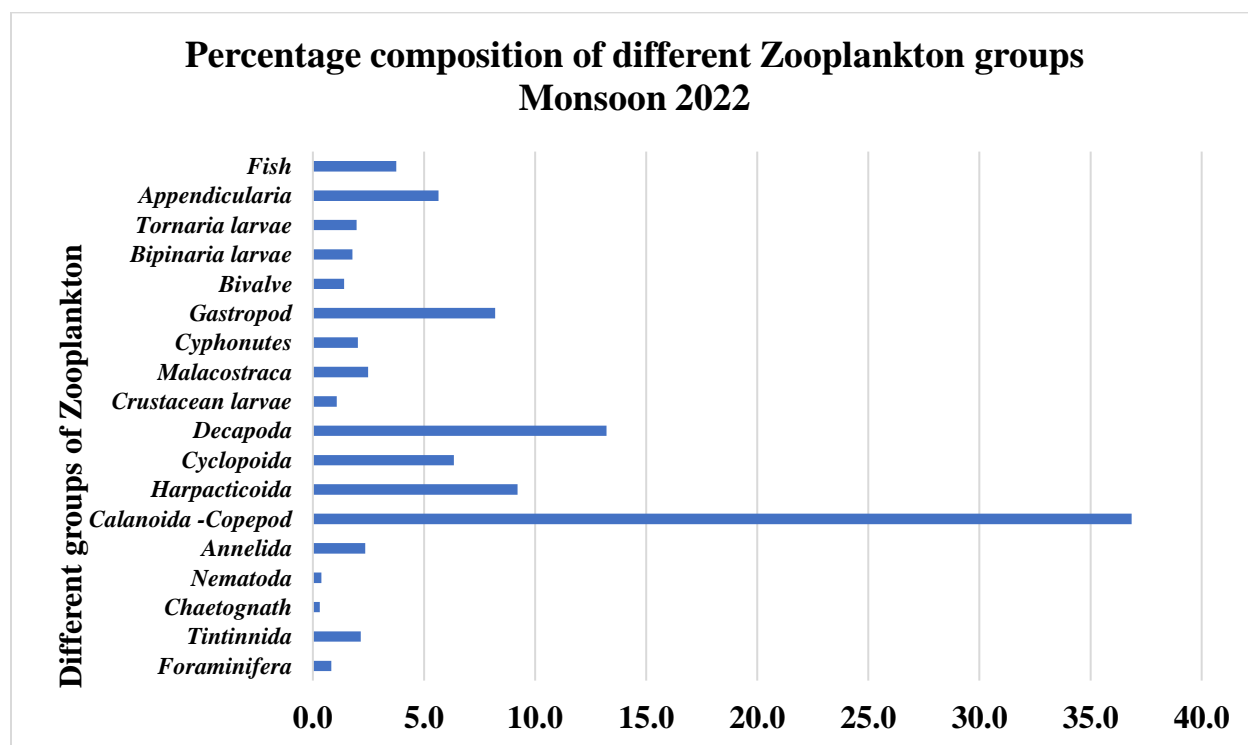
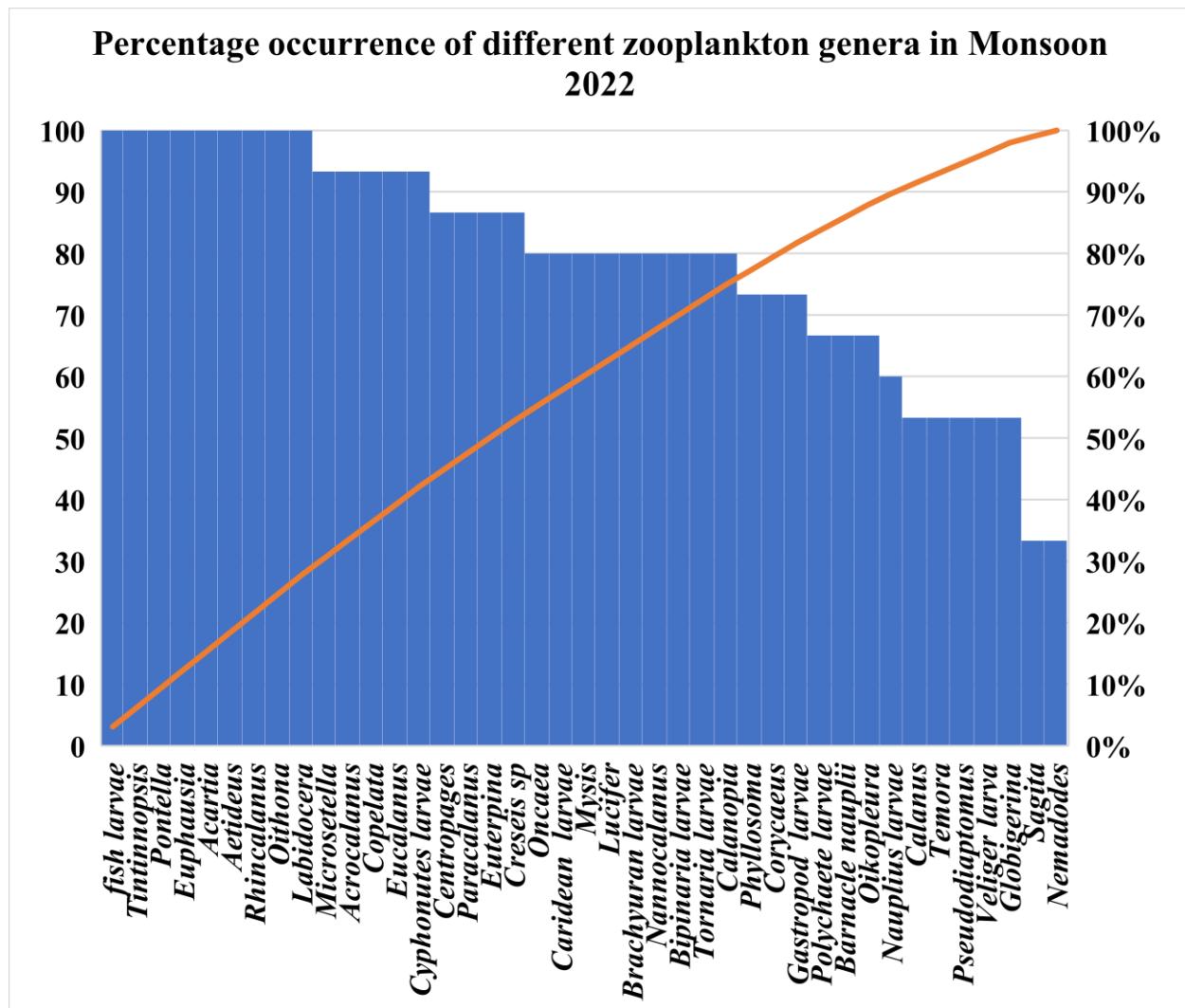


Figure 12: Percentage composition of zooplankton groups during Monsoon 2022

### Percentage occurrence of zooplankton

The percentage occurrence of zooplankton communities varied from 33% to 100 %. There were 9 zooplankton genera that exhibited 100% of occurrence (Fig.12) followed by the copepods *Microsetella*, *Aerocalanus*, *Copelata*, *Eucalanus* and the Cyphonautes larva ( 93%) from the study sites (Table5).



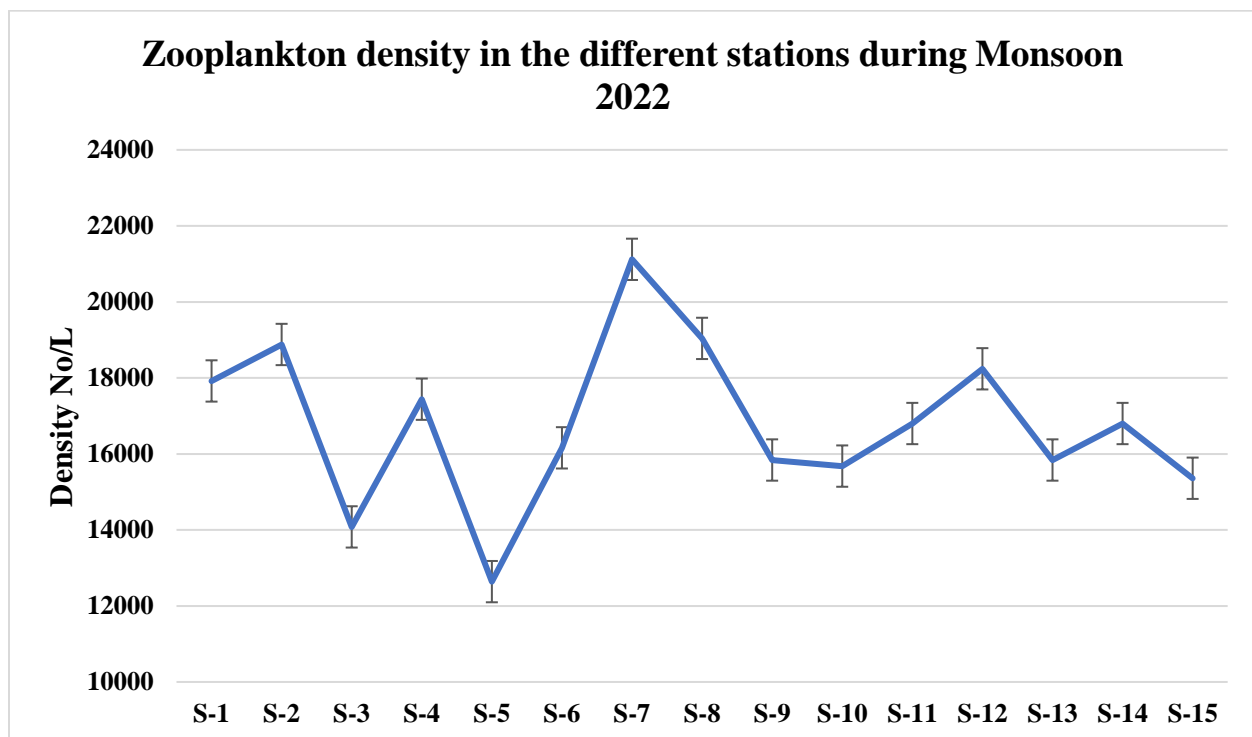
**Figure 13: Percentage occurrence of Zooplankton groups during Monsoon 2022**

### Density of zooplankton

Zooplankton population density values during the Monsoon 2022 at the 15 sampling sites ranged from 12,640 No/L to 21,120 No/L with an overall average of 16,789 No/ L (Table 5). Station-wise, the highest density of 21,120 No/ L was recorded in S-7 followed by S-2 (18,880 No/ L) and lowest density was reported at S-5 (12,640 No/ L) (Figure 14).

### Diversity Index

The Shannon diversity index of the zooplankton ranged between 3.05 to 3.41. Similarly, Margalef and Menhinick species richness index also varied from 2.75 to 3.70, and 0.22 to 0.29 respectively representing the moderate quality of the environment. (Table 6).



**Figure 14: Zooplankton Density in the different stations during Monsoon 2022**

Table 5: Zooplankton generic status during Monsoon 2022 in Deendayal Port Authority area

Phylum	Group	Genera	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15	PO	PC
<b>Protozoa</b>	Foraminifera	<i>Globigerina</i>	160	160	0	0	0	160	320	0	0	0	320	160	0	480	320	53	0.8
<b>Ciliophora</b>	Tintinnida	<i>Tintinnopsis</i>	480	320	320	160	480	160	320	640	320	480	640	320	160	320	320	100	2.2
<b>Chaetognath</b>		<i>Sagitta</i>	160	160	0	0	0	0	0	160	0	160	0	0	0	160	0	33	0.3
<b>Nematoda</b>		<i>Nemadodes</i>	320	160	0	0	0	160	0	160	0	0	0	0	0	160	0	33	0.4
<b>Annelida</b>		<i>Polychaete larva</i>	1120	480	320	160	0	0	960	480	0	0	640	0	320	800	640	67	2.4
<b>Arthropoda</b>	Calanoida	<i>Acartia</i>	480	1280	800	1760	320	480	640	960	640	1280	800	320	480	800	1600	100	5.0
		<i>Acrocalanus</i>	640	320	480	160	320	640	1120	320	960	640	320	0	320	160	480	93	2.7
		<i>Aetideus</i>	320	800	640	160	160	320	480	160	800	960	320	1120	160	320	640	100	2.9
		<i>Calanus</i>	480	320	0	320	0	320	160	0	0	0	160	0	0	160	320	53	0.9
		<i>Calanopia</i>	1120	800	320	480	320	480	0	0	160	0	1600	800	320	640	160	80	2.9
		<i>Centropages</i>	320	480	0	160	320	160	640	800	320	480	1120	320	0	160	480	87	2.3
		<i>Eucalanus</i>	640	480	160	320	480	960	1600	1280	1120	800	480	800	640	480	0	93	4.1
		<i>Labidocera</i>	320	160	480	800	480	1120	960	800	640	1760	960	1280	640	320	160	100	4.3
		<i>Nannocalanus</i>	160	320	320	160	0	320	160	160	480	0	160	0	640	320	320	80	1.4
		<i>Paracalanus</i>	320	160	320	160	0	0	160	160	320	160	480	320	640	320	160	87	1.5
		<i>Pontella</i>	1760	480	800	1440	640	320	480	640	800	160	320	1120	960	480	640	100	4.4
		<i>Pseudodiaptomus</i>	0	0	160	320	160	160	0	160	0	640	0	320	0	480	0	53	1.0
		<i>Rhincalanus</i>	320	480	160	800	960	320	1120	160	320	640	640	160	160	320	480	100	2.8
		<i>Temora</i>	320	160	0	0	0	160	0	0	160	320	0	320	0	320	160	53	0.8
	Harpacticoida	<i>Corycaeus</i>	480	0	0	160	0	1600	800	320	640	160	320	480	320	480	0	73	2.3
		<i>Euterpina</i>	160	640	800	320	480	1120	320	0	160	480	0	160	320	160	640	87	2.3

**Deendayal Port Authority 2<sup>nd</sup> Year Monsoon (June-September 2022)**

		<i>Microsetella</i>	960	160 0	128 0	112 0	800	480	800	640	480	0	160	320	480	960	1600	93	4.6
	Cyclopoida	<i>Oithona</i>	112 0	960	800	640	176 0	960	128 0	640	320	160	480	800	480	112 0	960	100	5.0
		<i>Oncaea</i>	320	160	160	480	0	160	0	640	320	320	320	160	0	320	160	80	1.4
	Decapoda	<i>Caridean larva</i>	0	160	160	320	160	480	320	640	320	160	320	160	0	0	160	80	1.3
		<i>Euphausia</i>	320	480	640	800	160	320	112 0	960	480	640	800	144 0	640	320	480	100	3.8
		<i>Nauplius larva</i>	160	0	160	0	640	0	320	0	480	0	160	320	160	160	0	60	1.0
		<i>Mysis</i>	160	0	160	160	160	160	112 0	480	0	0	160	800	960	320	1120	80	2.3
		<i>Phyllosoma</i>	160	800	480	160	480	480	480	0	0	160	320	0	320	0	320	73	1.7
		<i>Lucifer</i>	640	128 0	0	640	0	0	960	320	480	160	800	960	320	112 0	160	80	3.1
	Crustacean larva	<i>Barnacle nauplius</i>	160	800	160	480	160	160	160	320	160	0	0	0	160	0	0	67	1.1
	Malacostraca	<i>Brachyuran larva</i>	320	160	320	960	320	320	480	480	0	0	160	0	160 0	800	320	80	2.5
<b>Bryozoan</b>		<i>Cyphonautes larva</i>	160	160	160	160	160	160	320	160	640	800	320	480	112 0	320	0	93	2.0
<b>Mollusca</b>	<b>Gastropod</b>	<i>Creseis sp</i>	0	640	640	480	640	640	0	960	160 0	128 0	112 0	800	480	800	640	87	4.3
		<i>Gastropod larva</i>	160	160	0	320	0	0	112 0	112 0	960	800	640	176 0	960	128 0	640	73	3.9
	<b>Bivalve</b>	<i>Veliger larva</i>	0	320	0	0	0	0	480	112 0	160	320	640	0	160	320	0	53	1.4
<b>Echinoder mata</b>		<i>Bipinnaria larva</i>	800	320	160	0	160	160	960	0	0	160	320	320	640	160	320	80	1.8
<b>Hemichord ata</b>		<i>Tornaria larva</i>	128 0	480	160	0	160	160	160	800	320	640	160	0	160	480	0	80	2.0
<b>Chordata</b>	<b>Appendicula ria</b>	<i>Oikopleura</i>	800	160	0	800	0	0	480	320	0	160	480	640	480	0	160	67	1.8
		<i>Copelata</i>	160	960	160 0	128 0	112 0	800	320	800	640	480	0	640	320	160	480	93	3.9
	Fish	<i>Fish larva</i>	160	112 0	960	800	640	176 0	0	128 0	640	320	160	640	320	320	320	100	3.7
		<b>Total genera</b>	<b>37</b>	<b>37</b>	<b>30</b>	<b>33</b>	<b>27</b>	<b>33</b>	<b>33</b>	<b>33</b>	<b>30</b>	<b>30</b>	<b>34</b>	<b>30</b>	<b>32</b>	<b>37</b>	<b>31</b>		
		<b>Density No/L</b>	<b>179 20</b>	<b>188 80</b>	<b>140 80</b>	<b>174 40</b>	<b>126 40</b>	<b>161 60</b>	<b>211 20</b>	<b>190 40</b>	<b>158 40</b>	<b>156 80</b>	<b>168 00</b>	<b>182 40</b>	<b>158 40</b>	<b>168 00</b>	<b>1536 0</b>		

**Table 6. Diversity indices of Zooplankton along Deendayal Port Authority area during Monsoon 2022**

	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15
Taxa_S	37	37	30	33	27	33	33	33	30	30	34	30	32	37	31
Shannon_H	3.34	3.36	3.14	3.22	3.05	3.20	3.31	3.31	3.23	3.15	3.32	3.19	3.27	3.41	3.20
Simpson_1-D	0.96	0.96	0.95	0.95	0.94	0.95	0.96	0.96	0.95	0.95	0.96	0.95	0.96	0.96	0.95
Margalef	3.68	3.66	3.04	3.28	2.75	3.30	3.21	3.25	3.00	3.00	3.39	2.96	3.21	3.70	3.11
Menhinick	0.28	0.27	0.25	0.25	0.24	0.26	0.23	0.24	0.24	0.24	0.26	0.22	0.25	0.29	0.25



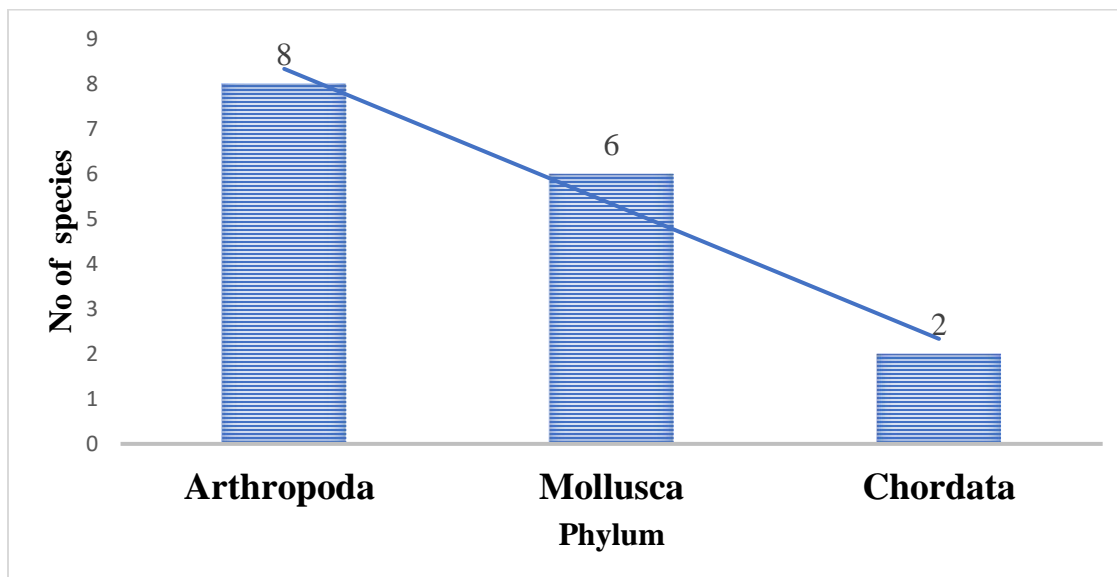
### **3.6. Intertidal Fauna**

The intertidal zone is the area above the water level at low tide and submerged at high tide. Intertidal habitats are found along the margins of the sea and include rocky shores, mudflats, salt marshes, and estuaries. The intertidal diversity was documented during monsoon at the prefixed 15 sampling locations within the DPA jurisdiction. All the macroinvertebrates and vertebrate samples were collected from the sampling stations during the low tide. At each site, 1x 1 m<sup>2</sup> quadrat was placed randomly, and all visible macro-faunal organisms encountered inside the quadrat were identified, counted and recorded. At each site along the transects that run perpendicular to the waterfront, three to six replicate quadrat samples were assessed for the variability in macro-faunal population structure (Davidson *et al.*, 2004; Ravinesh and Biju Kumar, 2013). The density of the different faunal groups was averaged for the entire intertidal belt. Organisms, which could not be identified in the field, were preserved in 5% formaldehyde, brought to the laboratory and identified using standard identification keys (Abott, 1954; Vine, 1986; Oliver, 1992; Rao, 2003; 2017; Psomadakis *et al.*, 2015; Apte, 2012; 2014; Naderloo 2017; Ravinesh *et al.*, 2021; Edward *et al.*, 2022). The invertebrates' taxonomic composition, relative abundance, species richness and diversity were determined (Zar, 1984) to describe the mangrove environment's overall biodiversity at DPA premises. Statistical analyses such as diversity indices and richness were calculated using Paleontological Statistics Software Package for Education and Data (PAST) version 3.2.1 (Hammer *et al.*, 2001).

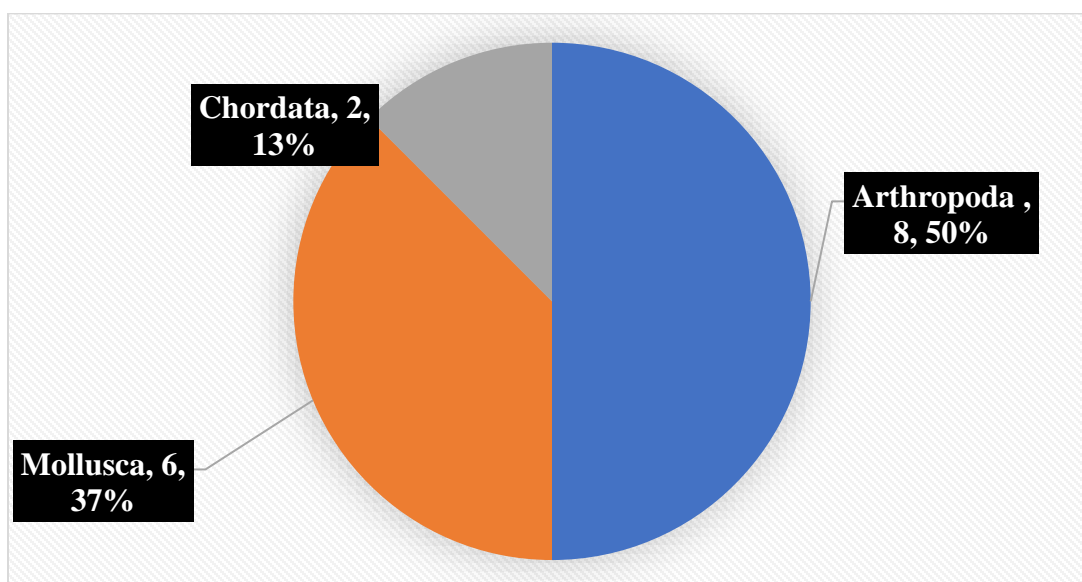
#### **Faunal composition of intertidal macrobenthos**

The intertidal ecological survey has been conducted at the prefixed 15 locations within the vicinity of the Deendayal port Authority. The species diversity of the invertebrate phyla showed the maximum for phylum Arthropoda (8 species), which is followed by Mollusca (6 species). The phylum Chordata was represented by two species (Table 7 & Fig.15).





**Figure 15: Number of genera of intertidal fauna (Phylum) during in Monsoon 2022**



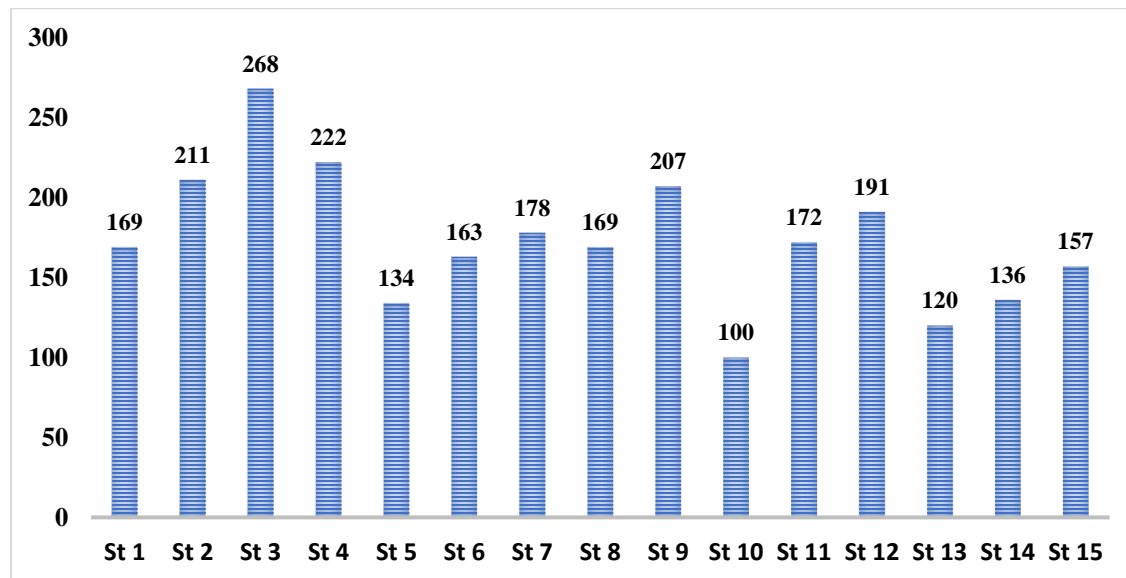
**Figure 16: Percentage composition of intertidal fauna during Monsoon 2022**

### Cumulative percentage composition of Fauna

The overall percentage composition of the three groups of intertidal fauna at the 15 sites was followed, ie Arthropoda (50%), Mollusca (37%), and Chordata (13%), as shown in figure 16.

### Intertidal Fauna density (No/m<sup>2</sup>) variation between the stations

The number of individuals of the Fauna collected from the intertidal zone of the mangroves are presented in Fig 17. It was observed that the faunal density was the highest in stations S- 3 and S-4 while the least from S-10.



**Figure 17: Density of intertidal fauna during Monsoon 2022**

The Intertidal faunal diversity documented during the monsoon period of 2022 has shown that the highest number of animals were collected from S-3, and the lowest was from S-10. The most common species were the crustaceans such as *Parasesarma plicatum* and *Austruca iranica*. The lowest density noticed was that of *Littoraria pallescens* (Table.7)

### **Diversity indices**

Table.8 presents the various diversity indices calculated for the different fauna recorded from the 15 sites adjoining the DPA port area, Kandla. Diversity indices were calculated for the subtidal fauna in which the Dominance diversity (D) values varied from 0.12 (S-5, S-15) to 0.27 (S -3). Shannon diversity (H') values varied from 1.50 (S-10) to 2.31 (S-5). The Simpson\_1-D varied from 0.73 (S -3) to 0.88 (S-5, S-15). The Evenness values varied from 0.42 to 0.83, with the maximum in S-3 and the minimum at S-12. The Margalef index ranged from 1.04 to 2.15, the maximum at S-13 and the minimum at S-3.



**Table 7: Intertidal faunal distribution along Deendayal Port Authority area during Monsoon 2022**

<b>Intertidal Fauna</b>	<b>S-1</b>	<b>S-2</b>	<b>S-3</b>	<b>S-4</b>	<b>S-5</b>	<b>S-6</b>	<b>S-7</b>	<b>S-8</b>	<b>S-9</b>	<b>S-10</b>	<b>S-11</b>	<b>S-12</b>	<b>S-13</b>	<b>S-14</b>	<b>S-15</b>
<b>Arthropoda</b>															
<i>Scylla serrata</i>	0	3	0	0	5	0	6	0	0	0	5	0	0	3	4
<i>Austruca sindensis</i>	0	17	6	8	11	0	18	23	12	15	19	17	0	4	9
<i>Austruca iranica</i>	12	19	16	31	21	24	28	26	31	39	41	52	11	26	19
<i>Parasesarma plicatum</i>	56	72	32	52	23	42	26	53	85	19	36	42	38	52	28
<i>Dotilla blanfordi</i>	0	1	2	0	2	0	1	0	0	0	0	0	0	2	3
<i>Eurycarcinus orientalis</i>	2	0	0	1	2	5	1	0	0	0	0	0	0	0	2
<i>Amphibalanus amphitrite</i>	0	23	0	56	11	0	0	38	0	0	0	21	0	0	14
<i>Tubuca dussumieri</i>	3	2	1	6	9	1	2	1	8	2	1	6	0	0	5
<b>Mollusca</b>															
<i>Pirenella cingulata</i>	2	8	123	19	0	11	35	0	12	0	8	0	31	6	0
<i>Telescopium telescopium</i>	0	0	2	3	0	0	6	0	2	0	5	0	2	0	1
<i>Bakawan rotundata</i>	8	0	5	0	2	0	15	0	0	0	12	0	0	2	8
<i>Littoraria pallescens</i>	0	1	2	0	2	0	0	0	0	0	0	0	0	0	0
<i>Platevindex martensi</i>	0	0	1	0	2	0	0	0	0	0	5	0	0	2	1
<i>Optedicerus breviculum</i>	35	42	52	12	7	42	0	0	34	0	15	25	0	0	19
<b>Chordata</b>															
<i>Periophthalmus waltoni</i>	25	11	15	21	12	7	8	9	11	4	2	9	11	8	26
<i>Scartelaos histophorus</i>	26	12	11	13	25	31	32	19	12	21	23	19	27	31	18
Total	169	211	268	222	134	163	178	169	207	100	172	191	120	136	157

**Table 8: Diversity indices of Intertidal Fauna during Monsoon 2022**

Indices	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15
<b>Dominance_D</b>	0.21	0.19	0.27	0.16	0.12	0.20	0.14	0.21	0.23	0.26	0.15	0.17	0.23	0.24	0.12
<b>Shannon_H</b>	1.77	1.95	1.70	2.02	2.31	1.75	2.12	1.69	1.77	1.50	2.11	1.89	1.56	1.70	2.30
<b>Simpson_1-D</b>	0.79	0.81	0.73	0.84	0.88	0.80	0.86	0.79	0.77	0.74	0.85	0.83	0.77	0.76	0.88
<b>Evenness_e^H/S</b>	0.65	0.58	0.42	0.69	0.72	0.72	0.69	0.77	0.65	0.75	0.69	0.83	0.79	0.55	0.71
<b>Margalef</b>	1.56	2.06	2.15	1.85	2.65	1.37	2.12	1.17	1.50	1.09	2.14	1.33	1.04	1.83	2.57



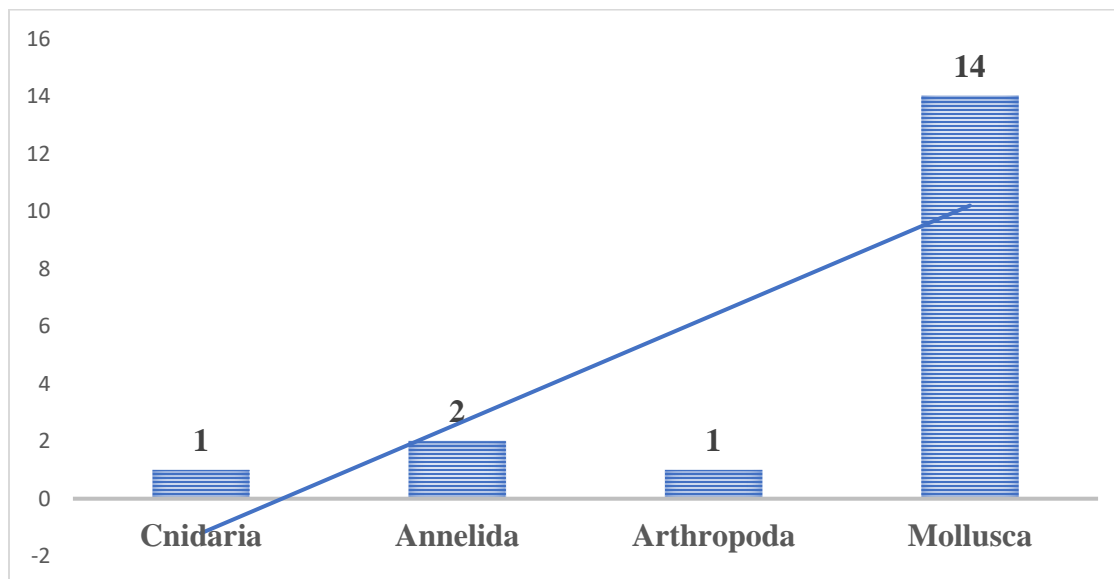
### 3.7. Subtidal Fauna (Macrobenthos)

Subtidal ecosystems are permanently submerged due to tidal influence, whereas intertidal ecosystems are found between the high tide and low tide, experiencing fluctuating influences of land and sea. Macrobenthos are an important component of estuarine and marine ecosystems. At large scales, food may be the prime limiting factor for benthic biomass. Depending on the system's characteristics, grazing by benthic suspension feeders may be the most important factor determining system dynamics. The sampling methods and procedures were designed in such a way as to obtain specimens in the best possible condition to maximize the usefulness of the data obtained. For studying the benthic organisms, triplicate samples were collected at each station using Van Veen grab, which covered an area of 0.04m<sup>2</sup>. The wet sediment was passed through a sieve of mesh size 0.5 mm for segregating the organisms. The organisms retained in the sieve were fixed in 5-7% formalin and stained further with Rose Bengal dye for the ease of spotting at the time of sorting (Ravinesh and Biju Kumar, 2022). The number of organisms in each grab sample was expressed as No /m<sup>2</sup>. All the species were sorted, enumerated and identified by following available literature. The works of Day (1967), Hartman (1968, 1969), Rouse and Pleijel (2001), Robin et al., (2003), Amr (2021), were referred for polychaetes; Crane (1975), Holthuis (1993), Naderloo (2017). Xavier *et al.*, (2020) for crustaceans; Subba Rao (1989, 2003, 2017), Apte (2012,2014), Ramakrishna and Dey (2007), Ravinesh *et al.* (2021) and Edward *et al.*, (2022). for molluscs. Statistical analyses such as diversity indices and quadrat richness were calculated using Paleontological Statistics Software Package for Education and Data (PAST) version 3.2.1 (Hammer *et al.*, 2001).

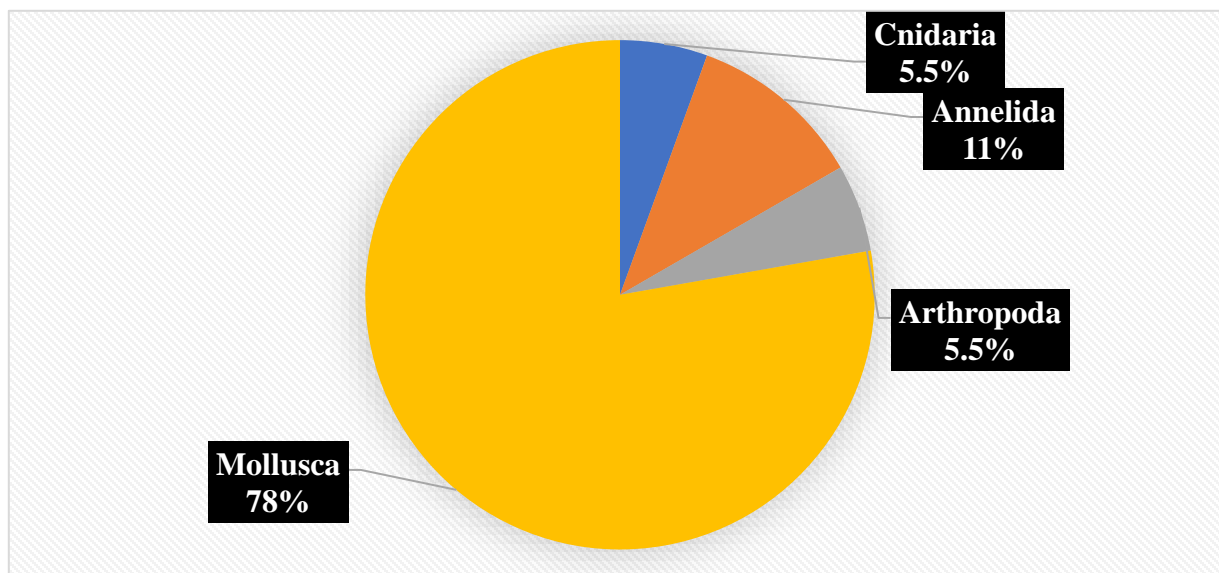
#### Faunal composition of subtidal macrobenthos

The number of macrobenthic species of the various groups recorded (Fig.18) from the DPA port environment revealed that Mollusca (14 species) and Annelida (2 species) were the major constituents, while the Arthropoda (1 species) and Cnidaria (1 species) were comparatively low in the species composition.

The percentage composition of the four phyla that occurred during the monsoon is shown in (Fig 19) The phylum Mollusca is represented by maximum (78%) share of the subtidal Fauna, followed by Annelida (11%), Arthropoda (5.5%) and Cnidaria (5.5%) in the total benthic samples collected.



**Figure 18. Number of genera of macrobenthos during Monsoon 2022**

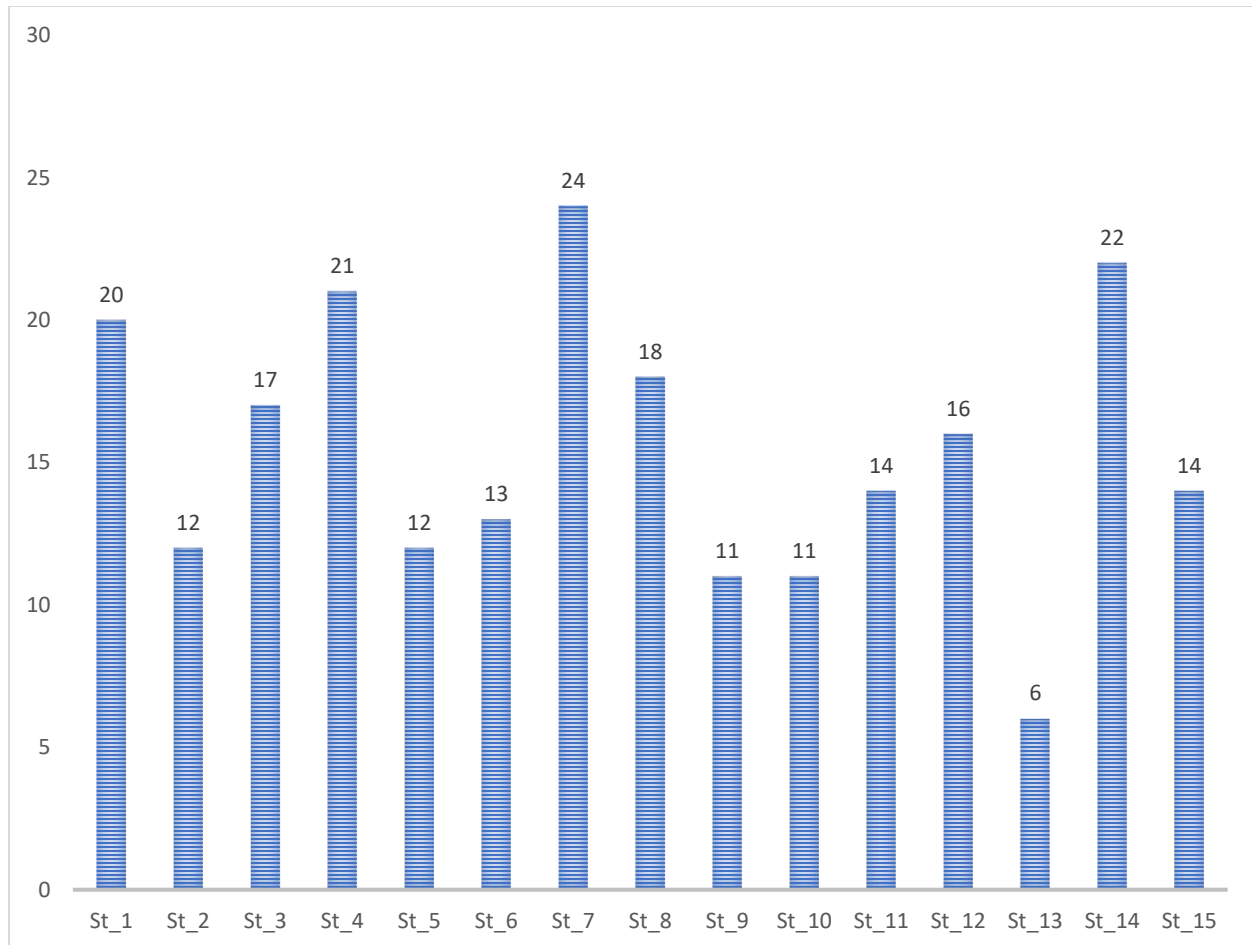


**Figure 19: Percentage composition of macrobenthos during Monsoon 2022**



**Subtidal Faunal density (No/m<sup>2</sup>) variation between the stations**

The number of individuals of the animals collected from the different sites are shown in Fig 20. The density of the Fauna was high at S-7 (24No/m<sup>2</sup>), and the lowest number (6/m<sup>2</sup>) was noticed at S-13 during the monsoon season 2022.



**Figure 20: Subtidal fauna density during Monsoon 2022**

**Subtidal fauna distribution at the selected sites in the Deendayal Port area during monsoon**

The table.9 depicts the subtidal microbenthic faunal diversity documented in the monsoon 2022. The highest diversity was documented from stations S-7, S-14, S-4 and S-1 and the lowest from stations S-9,10 and S- 6. The most common species are *Optedicerus breviculum*, *Glaucanome angulata* and *Pirenella cingulata*. The least diversity was documented for *Turritella* sp, *Stephensonactis* sp and *Natica* sp were found significantly less diversity. The Table.10 presents the various diversity indices calculated for the different Fauna recorded from the 15 sites adjoining

the DPA port area, Kandla. Diversity indices were calculated for the subtidal fauna in which the Dominance diversity (D) values varied from 0.12 (S- 4) to 0.24 (S -9). Shannon diversity (H') values varied from 1.52 (S-9) to 2.27 (S-4). The Simpson\_1-D varied from 0.76 (S -9) 0.87 (S-3, S-15). The Evenness values varied from 0.72 to 0.96, with the maximum in S-3 and the minimum at S-14. The Margalef index ranged from 1.67 to 3.03, the maximum at S-3 and the minimum at S-15.



**Table 9: Macro-benthic faunal distribution during Monsoon 2022 in Deendayal Port Area**

	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15	% of Occurrence
<b>Cnidaria</b>																
<i>Stephensonactis</i> sp.	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0.9
<b>Annelida</b>																
<i>Lumbrineria</i> sp.	0	2	0	0	0	2	0	0	2	0	0	0	0	0	0	2.6
<i>Nereis</i> sp.	0	0	3	0	0	0	0	0	0	1	0	0	1	0	1	2.6
<b>Arthropoda</b>																
<i>Ampithoe</i> sp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1.3
<b>Mollusca</b>																
<i>Umbonium vestiarius</i>	0	0	0	3	0	1	2	1	0	0	0	0	0	1	0	3.5
<i>Mitrella blanda</i>	0	0	0	2	0	1	0	2	2	0	3	0	0	5	0	6.5
<i>Clypeomorus bifasciata</i>	1	0	2	0	1	0	0	1	0	0	0	3	0	0	2	4.3
<i>Natica</i> sp.	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0.9
<i>Optedicerus breviculum</i>	5	1	2	1	2	2	4	5	4	1	1	3	1	2	1	15.2
<i>Pirenella cingulata</i>	5	2	3	1	2	1	1	2	2	1	1	2	1	1	2	11.7
<i>Turritella</i> sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0.4
<i>Macra</i> sp.	0	1	0	3	0	0	2	1	0	0	0	2	0	2	3	6.1
<i>Glaucanome angulata</i>	4	1	2	1	2	3	5	0	0	2	3	2	0	1	0	11.3
<i>Pelecypora</i> sp.	0	0	1	2	0	1	3	0	0	2	1	1	0	0	1	5.2
<i>Gafrarium divaricatum</i>	2	0	0	2	1	0	0	0	0	0	0	2	1	1	0	3.9
<i>Meretrix</i> sp.	0	2	0	4	3	0	1	2	0	3	0	0	0	0	1	6.9
<i>Solen</i> sp.	1	0	2	0	0	0	4	0	1	0	2	0	0	7	1	7.8
<i>Protapes cor</i>	1	3	2	1	1	2	1	2	0	1	3	1	2	1	0	9.1
Total	20	12	17	21	12	13	24	18	11	11	14	16	6	22	14	100
Total No/m <sup>2</sup>	500	300	425	525	300	325	350	450	275	275	350	400	150	550	350	

**Table10: Diversity indices of the benthic fauna during Monsoon 2022**

Indices	St_1	St_2	St_3	St_4	St_5	St_6	St_7	St_8	St_9	St_10	St_11	St_12	St_13	St_14	St_15
<b>Dominance_D</b>	0.19	0.17	0.13	0.12	0.17	0.15	0.14	0.15	0.24	0.17	0.17	0.14	0.22	0.18	0.13
<b>Shannon_H</b>	1.84	1.86	2.04	2.27	1.86	1.99	2.13	2.06	1.52	1.85	1.83	2.01	1.56	1.98	2.11
<b>Simpson_1-D</b>	0.82	0.83	0.87	0.88	0.83	0.85	0.86	0.85	0.76	0.83	0.83	0.86	0.78	0.82	0.87
<b>Evenness_e^H/S</b>	0.79	0.92	0.96	0.88	0.92	0.92	0.84	0.87	0.91	0.91	0.89	0.94	0.95	0.72	0.91
<b>Margalef</b>	2.34	2.42	2.47	3.29	2.42	2.73	2.83	2.77	1.67	2.50	2.27	2.53	2.23	2.91	3.03



### 3.8. Seaweeds

Along the Gujarat coast which is represented by 1600 km coastline, harbors 198 species of which 109 species from 62 genera belonging to Rhodophyta, 54 species of 23 genera to Chlorophyta, and 35 species from 16 genera to Ochrophyta (Jha *et.al.*, 2009). According to Mantri *et.al.* (2020) there are 13 potential sites for the occurrence of seaweed density and diversity. The survey conducted by CSIR-CSMCRI (Jha *et.al.*, 2009) confirmed the presence of industrially important taxa, namely, *Gelidiella acerosa*, *Gelidium micropterum*, *G. pusillum*, *Ahnfeltia plicata*, *Gracilaria dura*, *G. debilis*, *Gracilariopsis longissima* (formerly *G. verrucosa*), *Hypnea musciformis*, *Meristotheca papulosa*, *Porphyra sp*, *Asparagopsis taxiformis* (Rhodophyta), *Sargassum tenerrimum*, *S. plagiophyllum*, *S. swartzii*, *Turbinaria ornata* (Ochrophyta), *Ulva prolifera* (formerly *Enteromorpha prolifera*), *Ulva compressa* (formerly *Enteromorpha compressa*), and *Ulva flexuosa* (formerly *Enteromorpha tubulosa*) (Chlorophyta) from the coastal waters of Gujarat. In the present study, an attempt was made to describe the occurrence, diversity and other ecological features of seaweeds within Deendayal Port jurisdiction. It was found that except for some drifted species *Enteromorpha* and *Chaetomorpha* at S-13 and S-14 of Vira coast (Plate-6) no natural seaweed beds are seen in the different locations within DPA environment.

Seaweeds grow in the rocky intertidal and sub tidal habitats that offer a hard substratum for attachment. Low turbidity level in the water column with high nutrient content is a major habitat requirement that enables photosynthesis. Total dissolved solids (TDS) load in the Deendayal Port area creek waters ranged from 32088 to 42086 mg/L and suspended solids value between 88-223 mg/L restricts the photosynthetic activity of seaweeds which are highly sensitive to light. Hence, seaweed formations are absent in the creek systems of the Deendayal Port coastal environment.

### 3.9. Seagrass

Similar to seaweeds, sea grasses were also absent in the creek systems of Deendayal Port area and in the adjacent coastal stretches of Kachchh due to inherent habitat conditions. Sea grasses generally thrive in shallow coastal waters and are adapted to live in submerged conditions from mid intertidal to depth as much as 50 m when light penetration is sufficient; conditions contrary to the one prevailing in Deendayal Port and the nearby creek systems explain the total absence of sea grasses.



### 3.10. Halophytes

The halophytes are the plants that are adopted in coastal estuaries and salt marshes. It is common in arid and desert milieu which often have substantial salt accumulation. Technically it is the plant which has tolerance to moderate to high salt concentration in its growth substrate. Halophytes, that survive to reproduce in environments where the salt concentrations around 200 mM NaCl or more, constitute about 1% of the world's flora. (Timothy *et al.*, 2008). Halophytes are classified based on their growth conditions as obligate halophytes, facultative halophytes, and habitat-indifferent halophytes. In the present study, four major halophytes recorded along the selected Deendayal Port Authority sites during the Monsoon sampling, were *Salicornia brachiata*, *Aeluropus lagopoides*, *Salvadora persica* and *Sesuvium portulacastrum*. Among the halophyte species recorded, *Salicornia brachiata* alone was found in the 3 sampling locations. (Table-11 and Plate-12). The percentage of *Salicornia brachiata* was found to be the highest at station S-8 (78%) and the lowest in S-11.

**Table 11: Percentage of Halophytes cover in the DPA during Monsoon 2022**

	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15
<i>Aeluropus lagopoides</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Salicornia brachiata</i>	0	0	0	0	0	0	0	78%	63%	0	57%	0	0	0	0
<i>Salvadora persica</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sesuvium portulacastrum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0







**a. *Salicornia brachiata* b. *Aeluropus lagopoides* c. *Salvadora persica* d. *Sesuvium portulacastrum***

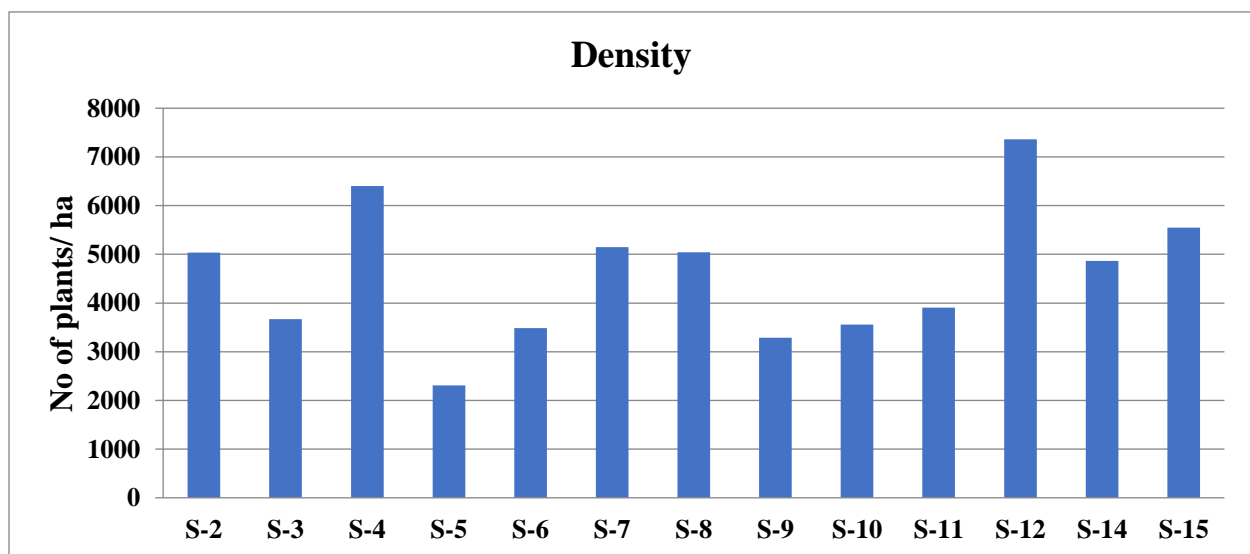
**Plate 7: Halophyte species on the intertidal zone of Deendayal Port Authority area**

### 3.11. Mangroves

In India, the second largest mangrove cover is located in the Gujarat state which accounts for 1175 km<sup>2</sup> (23.66%) cover of mangroves. However, it is also the fact that, this mangrove cover is predominance of *Avicennia marina*. In Gujarat, the Gulf of Kachchh shows major part of mangrove abundance, particularly of *A. marina*. The arid and hot environment of this area make it mono-species formation of *A. marina* within DPA area of Kandla.

#### Tree Density

In this study, totally 13 sites were surveyed for recoding the mangrove growth parameters and the density of plants. The overall average density of mangrove was 4602 plants per hectore. Among all sampling stations, the mean plant density was maximum at Tuna creek (6199/ha), followed by Kandla creek (5205/ha). Considering the sampling sites individually the highest tree density was reported at S-12 station in the Tuna creek area (7359/ha). The lowest average tree density (2935 trees/ha) was reported in Phang creek, however, the lowest density (individual site) was recorded in the site S-5 at Phang creek. Form this study, it is clear that geomorphology and environmental characteristics of the Kandla coastal regions play an important role in the formation of variability in mangrove (Fig.21 & Table 12).

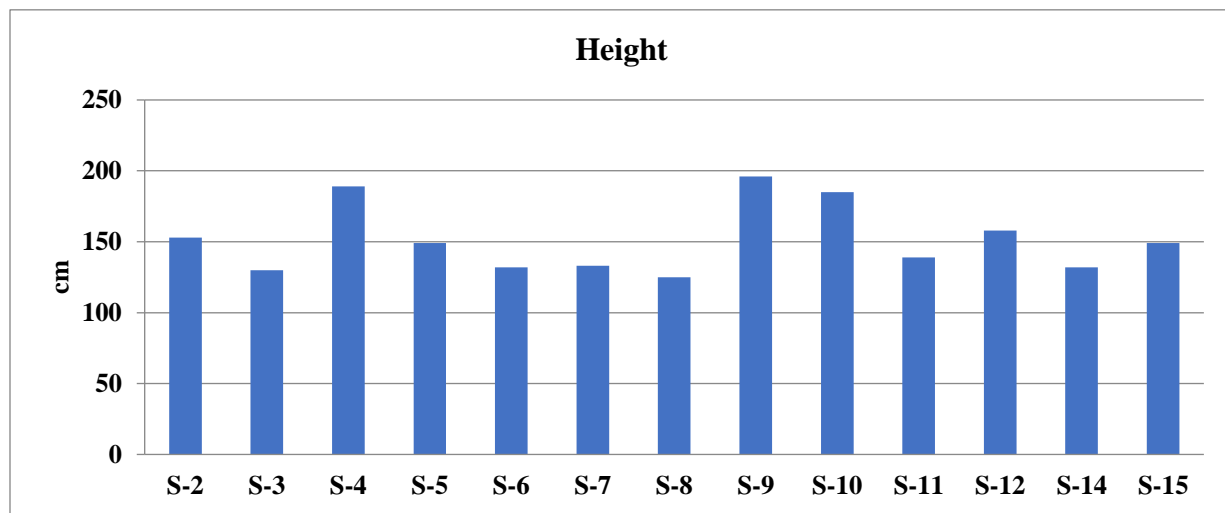


**Figure 21. Mangrove Plant density during Monsoon 2022**



## Height

The overall mean height of the mangroves from the study sites along the DPA port environment was 105 cm. The highest average tree height was found at Phang creek area (167 cm) followed by Navlakhi creek (160 cm). The highest tree height was recorded in station S-9 of Navlakhi creek, followed by S-4 of Kandla creek (Fig. 22).



**Figure 22. Plant height during Monsoon 2022**

## Canopy Crown Cover

The canopy cover of sampling stations exhibited wide variation and the average was 2.54 m<sup>2</sup>. The sites S-5, S-9 and S-10 showed relatively large canopy cover. However, the lowest canopy cover was reported at S-2 and S-7 stations located at Tuna creek and Kharo creek respectively (Fig.23).

## Basal area

The overall average basal area (GBH) of the mangroves of the DPA environment was 14.64 cm. Station wise the maximum mean basal area (21 cm) was at S-4 located in the Kandla creek followed by S-5 and S-11 in Phang creek and Jangi creek respectively. The minimum basal area reported to all sites was 7 cm (Fig.24). The highest value of DBH indicates the mangrove plants have multiple stems or main branches arising close to the ground from a single buttress or base. This type of growth pattern is characteristics of mangroves particularly *Avicennia marina* and *Aegiceros corniculatum*

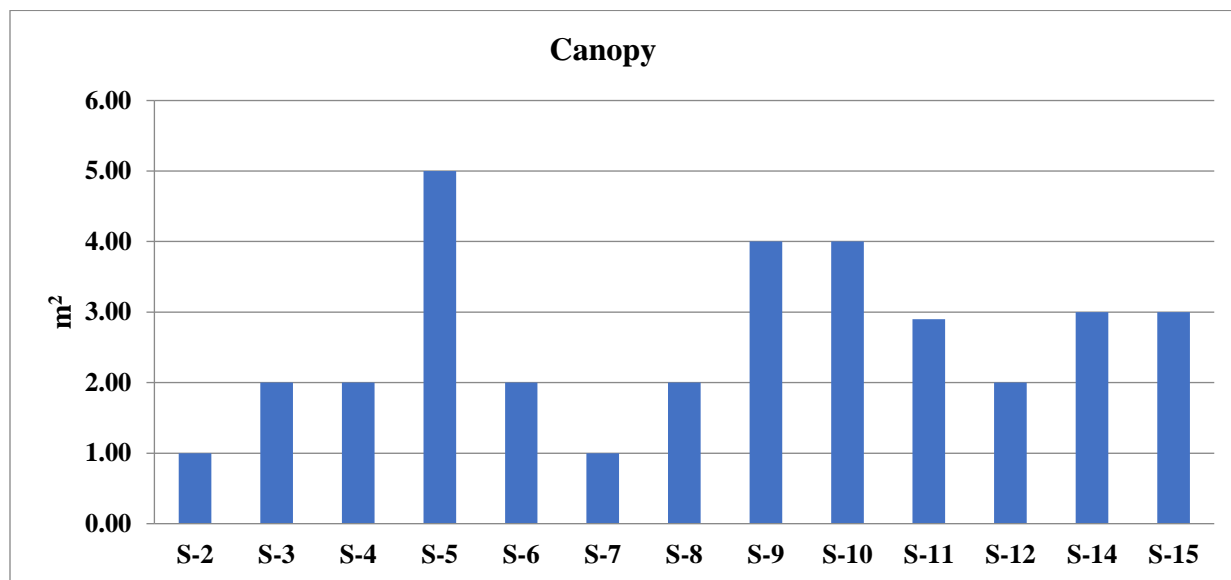


Figure 23. Mangrove canopy cover during Monsoon 2022

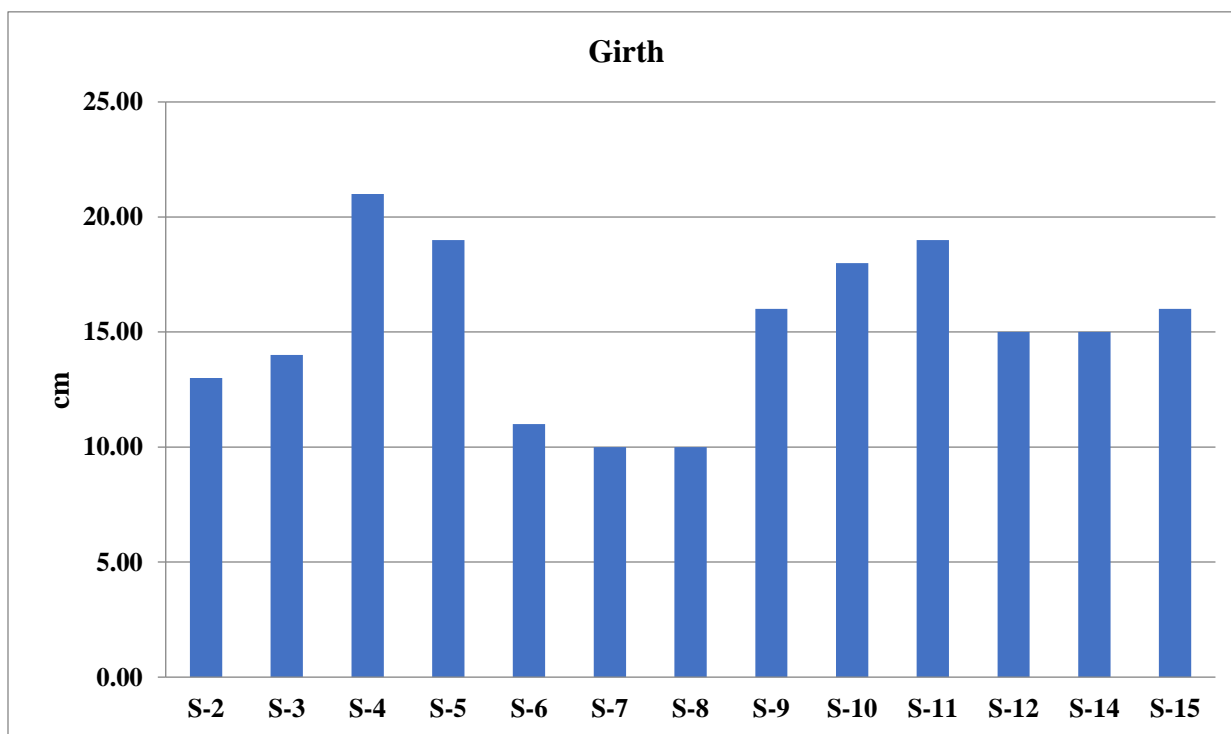


Figure 24. Mangrove basal area during Monsoon 2022

### **Regeneration and Recruitment class**

During the monsoon, generally higher values of regeneration class of mangroves is expected, but the average density was 60167 plants/ha and that of recruitment class 15434 plants/ha. The highest regeneration (140000 plants/ha) at S-9 of Navlakhi creek and recruitment (31500 plants/ha) class density were recorded at Kharo creek (S-7). The lowest regeneration class and recruitment plant density were found at S-14 station of Vira coast site. The highest density of recruitment class after the S-7 site was observed at S-8 and S-9 sites of Navlakhi creek.



**Plate 8: Mangrove species recorded along the Deendayal Port area**

*a. Avicennia marina b. Aegiceras corniculatum c. Ceriops tagal d. Rhizophora mucronata*

Table 12: Density of mangroves in the DPA vicinity during monsoon 2022

Sampling stations	Density (Tree/Ha)	Tree height (m)			Canopy cover (m)			Basal Area (cm)		
		Min	Max	Avg.	Min	Max	Avg.	Min	Max	Avg.
Tuna creek										
S-2	5038	110.00	230.00	153.00	0.24	6.48	1.00	7.00	36.00	13.00
S-12	7359	100.00	300.00	158.00	0.42	11.55	2.00	7.00	43.00	15.00
Mean	6198.64	105.00	265.00	155.50	0.33	9.02	1.50	7.00	39.50	14.00
Phang creek										
S-5	2311	110.00	220.00	149.00	0.88	11.20	5.00	7.00	50.00	19.00
S-10	3558	100.00	310.00	185.00	0.63	10.50	4.00	9.00	43.00	18.00
Mean	2934.70	105.00	265.00	167.00	0.76	10.85	4.50	8.00	46.50	18.50
Kandla creek										
S-3	3669	100.00	160.00	130.00	0.05	5.04	2.00	7.00	32.00	14.00
S-4	6400	110.00	310.00	189.00	0.16	6.48	2.00	8.00	50.00	21.00
S-15	5545	110.00	220.00	149.00	0.77	7.20	3.00	7.00	30.00	16.00
Mean	5204.96	106.67	230.00	156.00	0.33	6.24	2.33	7.33	37.33	17.00
Kharo creek										
S-7	5144	100.00	300.00	133.00	0.30	6.25	1.00	7.00	43.00	10.00
Jangi creek										
S-6	3483	100.00	190.00	132.00	0.17	3.99	2.00	8.00	14.00	11.00
S-11	3906	110.00	185.00	139.00	2.24	3.42	2.90	9.00	30.00	19.00
Mean	3694.59	105.00	187.50	135.50	1.21	3.71	2.45	8.50	22.00	15.00
Navlakhi creek										
S-8	5045	100.00	210.00	125.00	0.35	8.00	2.00	7.00	25.00	10.00
S-9	3290	110.00	420.00	196.00	0.30	42.25	4.00	7.00	85.00	16.00
Mean	4167.65	105.00	315.00	160.50	0.33	25.13	3.00	7.00	55.00	13.00
Vira coast										
S-14	4867.50	110.00	210.00	132.00	0.48	8.00	3.00	7.00	35.00	15.00
Overall average	4601.71	105.24	253.21	148.50	0.53	9.88	2.54	7.40	39.76	14.64

Table 13: Regeneration and Recruitment class plants during Monsoon 2022

Station	Tree density- No/ha (1)	Regeneration density- No/ha (2)	Recruitment density- No/ha (3)	Ratio of 1:3	Ratio of 2:3
<b>Tuna creek</b>				1 to	to 1
S-2	5038	68000	13250	2.63	5.13
S-12	7359	70000	16500	2.24	4.24
Mean	6198.64	69000	14875	2.40	4.64
<b>Phang creek</b>					
S-5	2311	24000	3750	1.62	6.40
S-10	3558	75000	17500	4.92	4.29
Mean	2934.70	49500	10625	3.62	4.66
<b>Kandla creek</b>					
S-3	3669	79000	17000	4.63	4.65
S-4	6400	56000	8250	1.29	6.79
S-15	5545	23000	3750	0.68	6.13
Mean	5204.96	52667	9667	1.86	5.45
<b>Kharo creek</b>					
S-7	5144	77000	31500	6.12	2.44
<b>Jangi creek</b>					
S-6	3483	49000	13250	3.80	3.70
S-11	3906	79000	18000	4.61	4.39
Mean	3694.59	64000	15625	4.23	4.10
<b>Navlakhi creek</b>					
S-8	5045	52000	26500	5.25	1.96
S-9	3290	140000	19500	5.93	7.18
Mean	4167.65	96000	23000	5.52	4.17
<b>Vira coast</b>					
S-14	4867.50	13000	2750	0.56	4.73
Overall average	4601.71	60166.67	15434.52	3.35	3.90



### **3.12. Marine Reptiles**

During the field surveys, one reptilian species, the saw-scaled viper *Echis carinatus sochureki* was recorded at site S-3 located in the northern part of Sat Saida bet opposite to oil jetty during monsoon season. This species was spotted on the ground among the mangrove trees. The literature describes the species as aggressive and strikes at a lightning speed, the observed specimen was active. In monsoon, the maximum number of this snake was recorded in S-10 located on the northern part of Sat Saida bet.



**Plate 9: Marine reptiles recorded along the Deendayal Port Authority area**



### **3.13. Marine Fishery**

Marine fish production of India during the financial year 2019-2020 was 37.27 lakhs tons (Fisheries statistics 2021). The production varied from 0.2 to 7.01 lakh tons and Gujarat state contributed the highest production (Fisheries statistics 2021). The Ichthyofauna diversity of the Gulf of Kachchh includes a total of 20 orders, 47 families and 96 species (Katira & Kardani 2017). Along the Sikka coast of Jamnagar where 112 ichthyofauna species belonging to 50 families, 12 orders, and 84 genera has been reported. Similarly, the locality of Jamnagar Marine National Park, Gulf of Kachchh reported 109 ichthyofauna species belonging to 58 families, 19 orders, and 93 genera (Brahmane et al. 2014). Apart from this, a recent study conducted by Sidat *et al.*, (2021) reported 96 species which include 20 order and 47 families. During the field observation, in the gill net catches *Mugil cephalus*, *Planiliza klunzingeri*, *Planiliza planiceps*, *Planiliza macrolepis* (Plate 9) were observed of which *Mugil cephalus* catch was the maximum during monsoon season of (20 kg) followed by mud crab (30 kg).



**Plate 10: Fish and Crab catch along the Deendayal Port Authority in monsoon 2022**

### **3.14. Marine Mammals**

*Sousa plumbea* (Cuvier, 1829) is commonly referred to as the Indian Ocean humpback dolphin. During the field surveys, the Indian Ocean humpback dolphin (*Sousa plumbea*) was recorded at the site between the S-3 and S-4 opposite the oil jetty during monsoon season. The length of the humpback dolphin is approximately 1.7 to 2m. Humpback dolphins feed mostly on small fishes, sometimes shrimps; occur mostly in small groups (mostly 12 or less); have limited nearshore movements and in most parts of their range, exhibit a fission/fusion type of social organization. The evaluation of the conservation status of a species and its subsequent listing as a Threatened species is a function of its risk of extinction, which is influenced primarily by population dynamics (population size and trends, population structure) and the key biological and environmental factors influencing those dynamics (distribution, behaviour, life history, habitat use and the effects of human activities).



**Plate 11. Indian Ocean humpback dolphin *Sousa plumbea***



#### **4. Mud flat**

Mudflats and mangroves establish a major ecosystem of the DPA coastal region and the significance of ecosystem services rendered by mudflat is endorsed in Coastal Regulation Zone (CRZ, 2011) as it accords special status to highly productive zone. Mudflat has an assemblage of plant-animal-geomorphological entities. DPA has been surrounded by two major ecosystems such as mangroves and mudflats which support a number of ecosystem services like nursery grounds for fish and shellfishes and breeding/feeding grounds for the birds (Spencer and Harvey, 2012). The TOC concentration is direct indicator of mudflat productivity and blue carbon sequestration.

##### **Bulk density of the sediment samples**

The data on the bulk density of the sediment samples are presented in (Fig.25). The bulk density of mangrove soil at Deendayal Port Authority coastal region ranged from 1.26 g/cm<sup>3</sup> to 1.34 g/cm<sup>3</sup>. The highest bulk density was recorded at S-4 and S-12 sites followed by S-15. The lowest bulk density was recorded at site S-8 located at Tuna creek and S-1.

##### **Total Organic Carbon (TOC)**

The highest TOC value (0.83%) was recorded at station S-4 followed by S-2 site. Lowest TOC value was reported at site S-12 (Fig.26). It is observed that TOC values varied significantly among the sampling stations which means that organic carbon is dependent on the living life forms and variations in the life forms in the mudflats. The TOC concentration is a direct indicator of mudflat productivity and blue carbon sequestration. The data on monsoon samplings revealed that the different sampling sites of Deendayal Port Authority jurisdiction have considerable variations with respect to organic carbon.

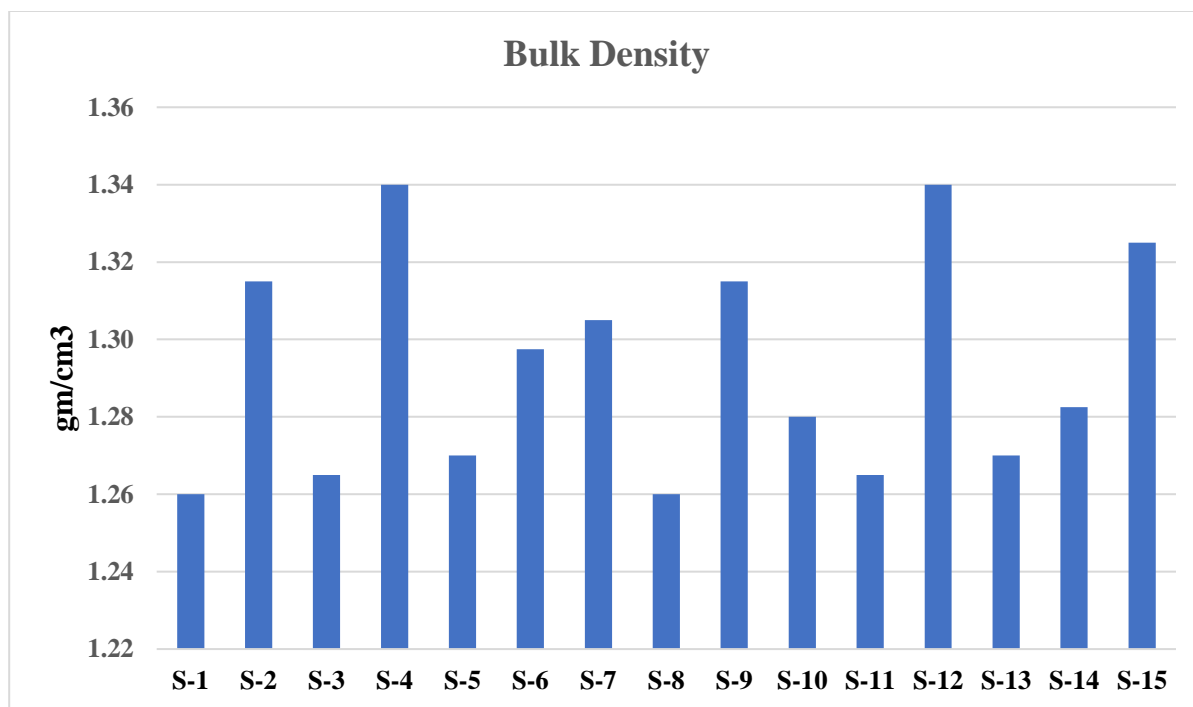


Figure 25: Bulk density of mudflat sediment during Monsoon 2022

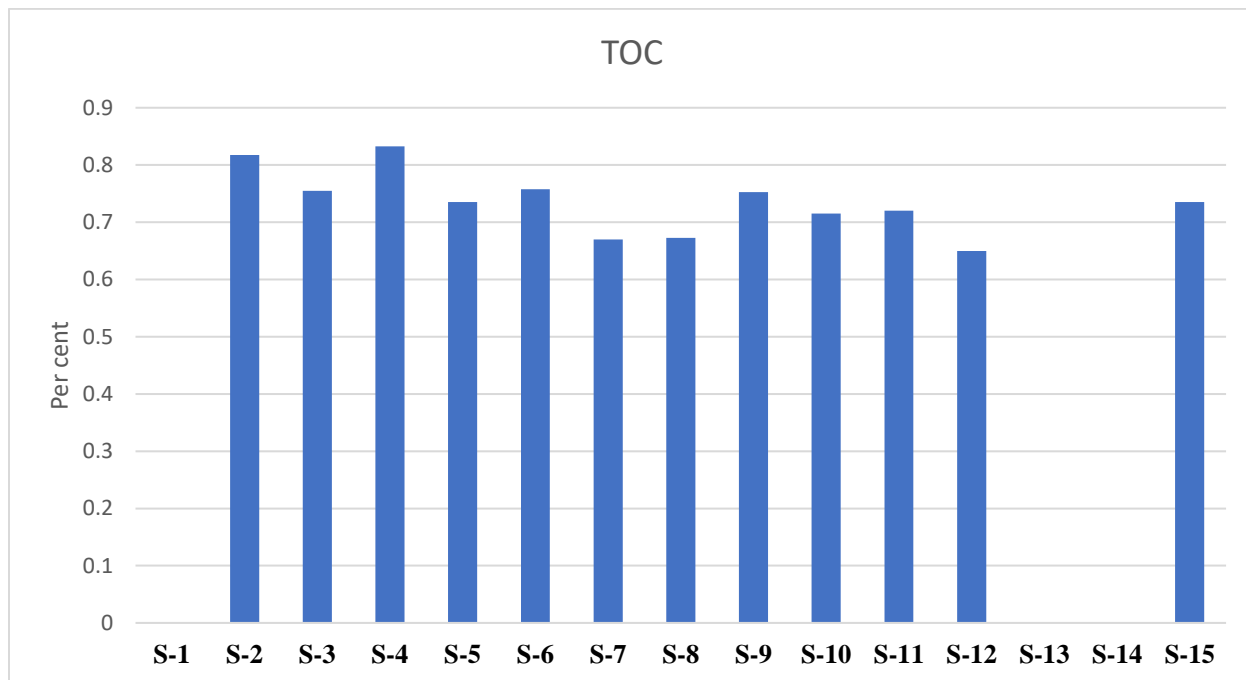


Figure 26: Percentage of Total Organic Carbon in the mudflat in Monsoon 2022

## 5. Avifauna

A large amount of research on bird diversity emphasizes the general negative effects of land conversion to human dominated habitats (Brooks *et al.* 1997; Castelletta *et al.* 2000). But human dominated and coastal habitats vary a lot and therefore the effect on birds can be very different. Birds depend on the habitats where they occurred, so the response of the species in particular habitat may always differ according to the habitat changes (Tworek, 2002, Winter & Faaborg, 1999; Cornelius *et al.* 2000; Zhanette 2000; Zhanette *et al.* 2000; Johnson & Igl, 2001; Beier *et al.* 2002; Herkert *et al.* 2003; Kurosawa & Askins, 2003). A total of 49 species belonging to six orders, 25 families and 38 genera were recorded from the coastal area of Deendayal Port during this study (Annexure 1). Among these, 26 species were aquatic and 23 species were terrestrial, which included three species listed as Near Threatened in the IUCN (2022), Red List.

Order Charadriiformes i.e. aquatic birds (including raptors and most water birds) constituted the predominant groups representing 58% of all species recorded from the study area followed by order Passeriformes (31%), i.e., perching birds (including babblers, drongos, mynas, sunbirds, doves, warblers, larks, chats, wagtails, robins). The families with a greater number of species were Ardeidae (eight spp.), Scolopacidae (seven spp.), Charadriidae (three spp.), Columbidae (three spp.), Laridae (two spp.), and Passeridae (one spp.). Among the recorded species, four were migrants, 10 were local migrants or resident migrants, 35 were breeding resident. During the present investigation, birds with diverse food habits viz., Aquatic (20 spp.), Insectivores (12 spp.), Granivores (eight spp.), Piscivores (six spp.), Omnivores (one spp.) Frugivores (one spp.), and Nectarivores (one spp.) were observed. The overall Shannon diversity ( $H'$ ) was 3.6 with species richness index for study area 1.2. The overall species evenness index value for study area was 0.77 and Equitability 0.93 (Table 13).

### **Status, distribution and diversity of avifauna in different stations:**

A Total of fifteen sites were surveyed, of which the maximum number of species was found in Site 1 & 2 (33 spp.) followed by Site 9 (27 spp.) and Site 10 & 15 (26 spp.). Site 5 recorded the least richness (16 spp.) (Fig. 27).

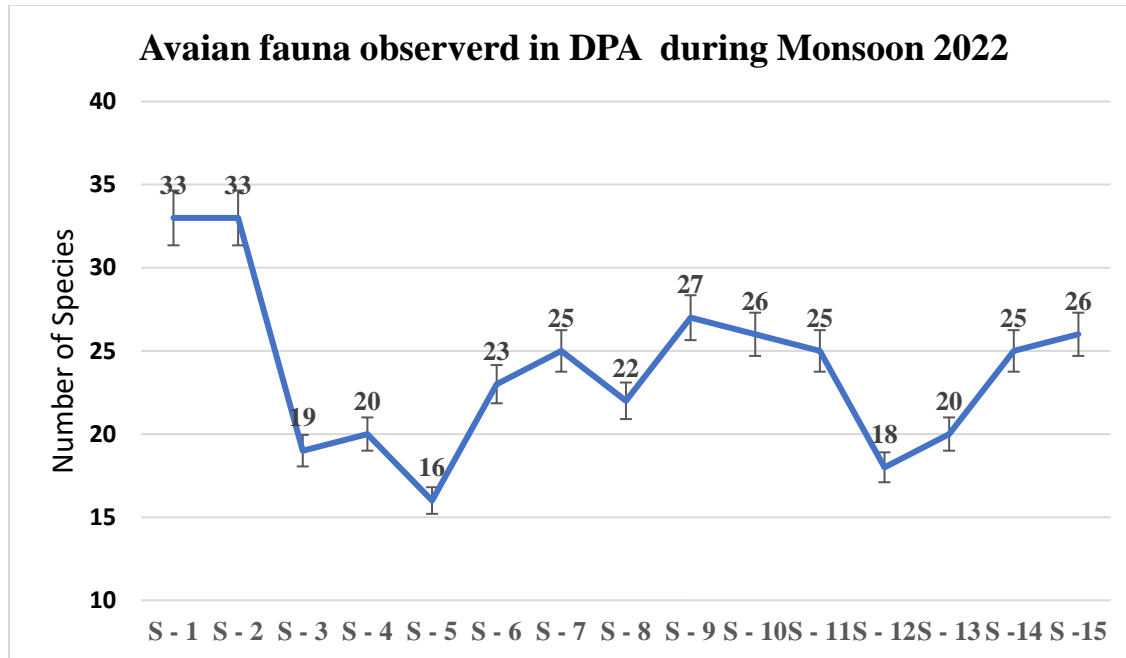


Figure 27. Number of Avian species recorded from the Deendayal Port Area

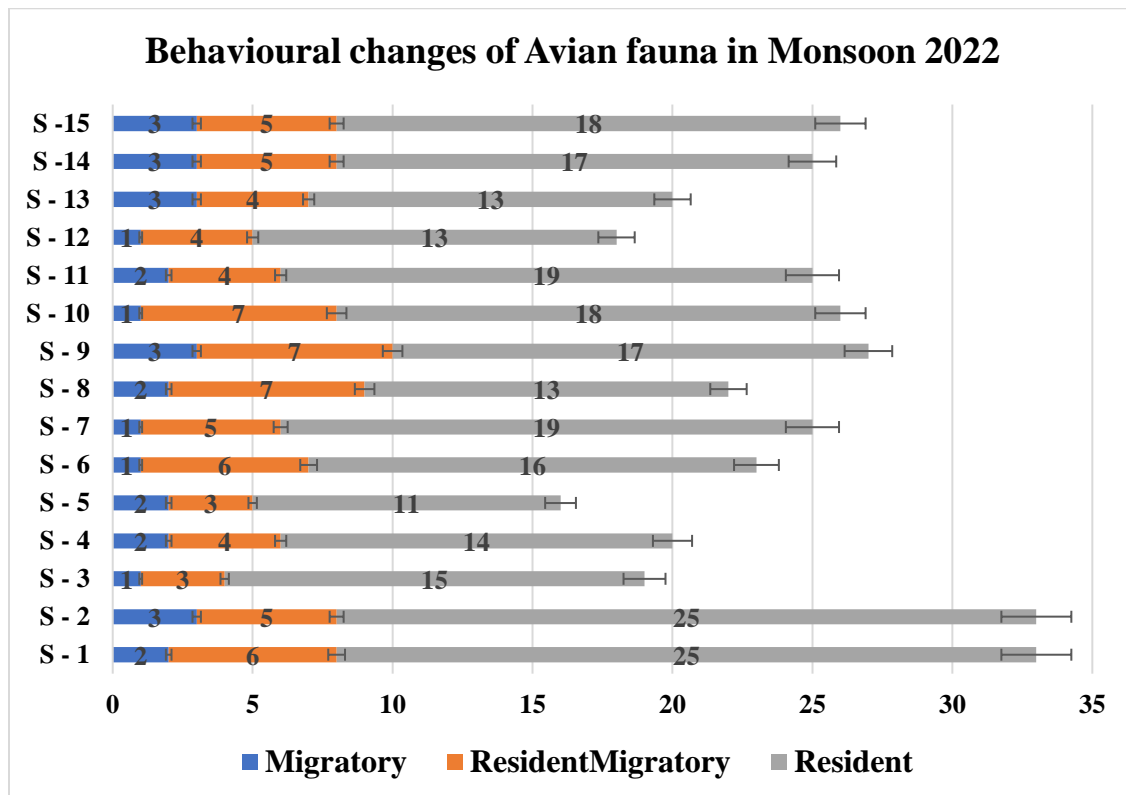
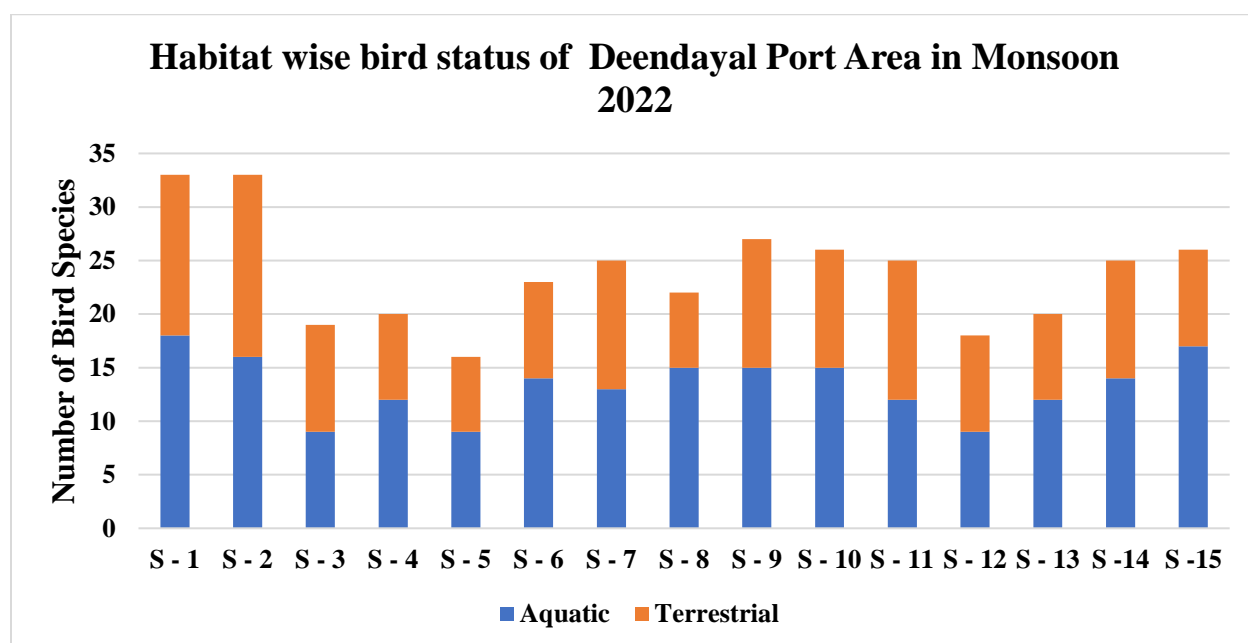


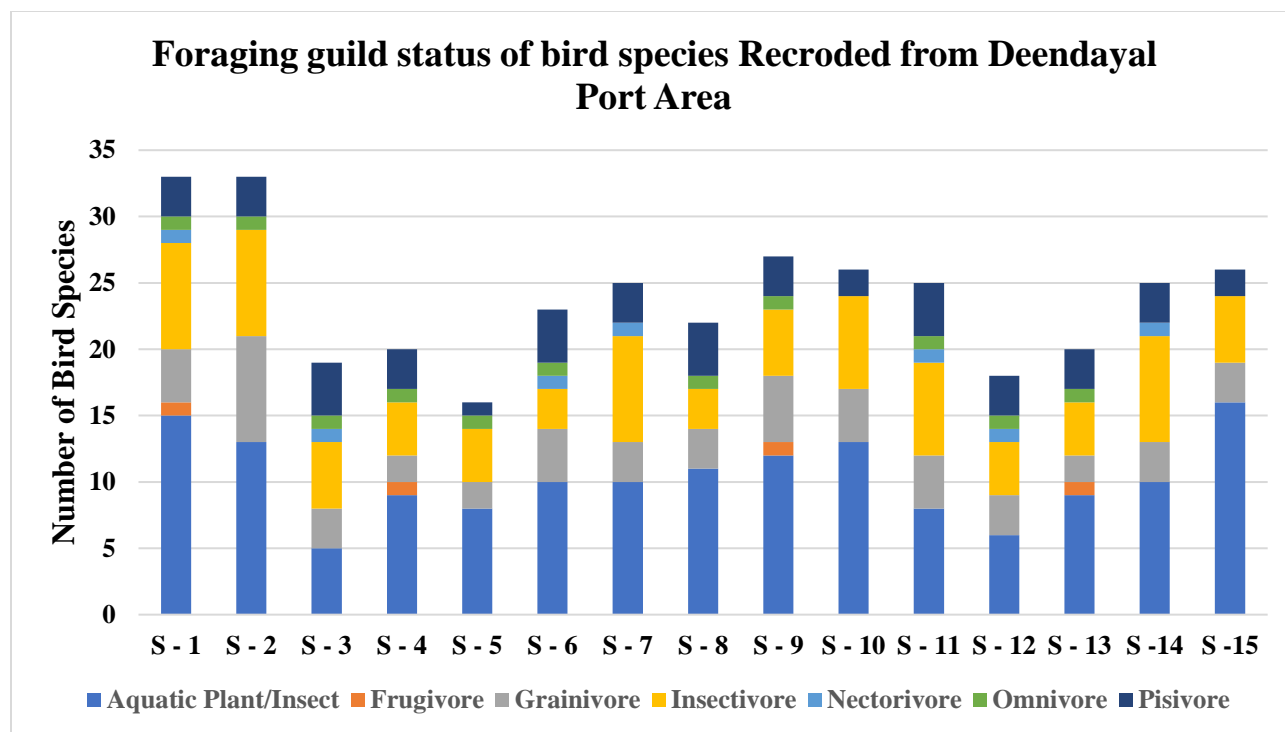
Figure 28. Behavioral status of Avian species from the DPA in Monsoon 2022

Site wise migratory status showed that maximum migratory species were found in S- 2, S-9,S-13,S-14 & S-15 (three spp.) followed by S- 1,S-4,S-5,S-8 & S-11 (two spp.) (Fig. 28). From the study area all the species were categorized into two habitats i.e. terrestrial and aquatic. Survey for terrestrial and aquatic avifauna showed that maximum terrestrial avifaunal richness was recorded from S-2 (17 spp.) followed by site S-1 (15 spp.), S-11 (13 spp.) and site S-9 (12 spp.); while aquatic avifaunal species richness was more in site S-1 (18 spp.) followed by S- 15 (17 spp.), S-2 (16 spp.) and S- 8 (15 spp.) (Fig. 29).



**Figure 29. Habitat wise distribution of Bird species from the DPA in Monsoon 2022**

During the present investigation birds with diverse food habits were observed, viz., Aquatic, Insectivores, Granivores, Piscivores, Frugivores, Omnivores and Nectarivores. All the sites have found more number of aquatic birds species (maximum 16 species recorded from S- 15) followed by Insectivores (Maximum 8 species recorded from Site 1&2), granivore (maximum 8 species recorded from S-2) and piscivores (maximum 4 species recoded from S-3,S-6,S-8&S-11) and least species found of frugivores, omnivores and nectarivores (Fig.30)



**Figure 30. Station wise Foraging Guild status of species recorded during Monsoon 2022**

Data collected from point counts allows us to calculate species diversity, richness and species composition. The results showed that the maximum diversity was found from the S-1 ( $H'$  3.3) followed by S-2 ( $H'$  3.2) and the minimum diversity recorded from site 12 ( $H'$  2.6) and S- 5 ( $H'$  2.5). The maximum species richness was recorded from Site 1 (2.9 spp.) and the minimum from Site 12 (2.1 spp.). These changes in individual species abundance, whether they occur independently of one another (Wiens, 1989) or are influenced by interactions with other bird species are governed by the degree of anthropogenic pressure including disturbance to habitat of species (Block & Brennan, 1993). The distribution and abundance of many bird species are mainly determined by the configuration and composition of the vegetation that comprises a major element of their habitat (Cody, 1985; Block & Brennan, 1993). As vegetation changes along complex geographical and environmental gradients, particular bird species may appear, increase in abundance, decrease, and disappear, when habitat becomes more or less suitable for its persistence. Totally 16% species were found rarely distributed in the study area while 36% species were very common. Aquatic and Insectivores species form the major groups while each of the frugivores, omnivores and nectarivores constitute about 2% of all species. Although more than 67% of the birds in the study area were Aquatic and insectivores, food competition was reduced by the

utilization of different habitat types and distinct feeding behaviour. Largely insectivorous birds like babblers (Sylviidae) and drongos (Corvidae) feed on fruits and seeds of plants particularly during winter season due to the shortage of insect food. Wetland birds were dominated largely by the aquatics followed by insectivore and grainivore species (Annexure 1). The present season study shows 49 different types of birds belonging to six orders and 25 families from the coastal area of Deendayal Port. The richness of avifauna is little low, indicator of ecological health of the coastal area of Deendayal Port. Proper and in-depth study, awareness, regarding the importance of birds and their role in ecosystem, to the local peoples through different massive programs will ultimately help the protection of birds of this region



**Great Egret *Ardea alba***



**Grey Heron *Ardea cinerea***



**Great Cormorant *Phalacrocorax carbo***



**Western Reef Egret *Egretta gularis***

**Plate 12: Some common Birds from the Deendayal Port Authority**

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# **Annexure -III**

## ENVIRONMENTAL MONITORING REPORT FOR DEENDAYAL PORT AUTHORITY



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

**Mont** : November 01

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



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## EXECUTIVE SUMMARY

## **ENVIRONMENTAL MONITORING PLAN FOR DEENDAYAL PORT ENVIRONMENTAL MONITORING REPORT- NOVEMBER, 2022**

### **1. EXECUTIVE SUMMARY**

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

#### **A) Ambient Air**

The monitoring of Ambient Air quality at 6-locations at Deendayal Port Authority Kandla and 2- location at Vadinar Port on 24 hourly basis for TSPM, PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub>, NO<sub>2</sub>, NH<sub>3</sub>, CO<sub>2</sub>, CO, C<sub>6</sub>H<sub>6</sub> and NMHC in twice a week 24 hourly at uniform intervals (as per NAAQS) at Gopalpuri, Tuna Port, Marine Bhavan Building, Coal storage area, Estate building, Oil jetty and at Vadinar port, Vadinar Jetty and Vadinar colony area using respirable dust sampler, Fine particulate sampler and gaseous sampler.

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

At Gopalpuri location the mean concentration of PM<sub>10</sub> was 127 µg/m<sup>3</sup> & PM<sub>2.5</sub> was 66 µg/m<sup>3</sup> which are slightly exceed the Standard limit (NAAQS).

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

The overall values of November for Gaseous SO<sub>2</sub>, NO<sub>2</sub>, NH<sub>3</sub>, CO<sub>2</sub>, CO, C<sub>6</sub>H<sub>6</sub> concentration were within the permissible limit at all location and NMHC were found BQL (Below Quantification Limit).

## **B) Weather**

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

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

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

## **D) Drinking Water Quality**

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

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

### **E) Monitoring Performance of Sewage Treatment Plant**

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

### **F) Noise**

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



# CHAPTER-1

## INTRODUCTION

### DEENDAYAL PORT AUTHORITY

## **1.0 Introduction**

### **About Deendayal Port**

The Deendayal Port is situated in the Kandla Creek and is 90 Kms. From the mouth of Gulf of Kachchh. Latitude: 23° 01" N Longitude: 70° 13"E. Deendayal Port's journey began in 1931 with construction of RCC Jetty by Maharao Khengarji. After partition, Deendayal Port's success story has continued and it rise to the No. 1 Port in India in the year 2007-08 and since then retained the position for the 15 consecutive year. On 31.03.2016, Deendayal Port created history by handling 100 MMT cargoes in a year, the first Major Port to achieve the milestone. Kandla, also known as the Deendayal Port Authority is a seaport in Kutch District of Gujarat state in western India, near the city of Gandhidham. Located on the Gulf of Kutch, it is one of major ports on west coast. Kandla was constructed in the 1950s as the chief seaport serving western India, after the partition of India from Pakistan left the port of Karachi in Pakistan. The Port of Deendayal is located on the Gulf of Kutch on the northwestern coast of India some 256 nautical miles North West of the Port of Karachi in Pakistan and over 430 nautical miles north-northwest of the Port of Mumbai (Bombay). It is the largest port of India by volume of cargo handled. Kandla history Deendayal Port Authority, India's busiest major port in recent years, is gearing to add substantial cargo handling capacity with private sector participation. Deendayal port Authority creates a new record by handling 127.10 million metric tons of cargo during the FY 2021-22, as against 117.566 million metric tons in FY 2020-21. Showing a growth of 8.11 %. Incidentally, DPA is the only major Indian port of handle more than 127 MMT cargo throughout and it has also registered the highest cargo throughput in its history. While the port has flagged off several projects related to infrastructure creation, DPA has successfully awarded the work of augmentation of liquid cargo handling capacity by revamping the existing pipeline network at the oil jetty area in Sept. 2021. Even as much of this growth has come from handling of crude oil imports, mainly for Essar Oil's Vadinar refinery in Gujarat, the port is also taking measures to boost non-POL cargo. Last fiscal, POL traffic accounted for 63 per cent of the total cargo handled at Deendayal Port, as against 59% in 2007-08. The Deendayal Port Authority had commissioned the Off-shore Oil Terminal facilities at Vadinar in the year 1978, for which M/s. Indian Oil Corporation Limited (IOCL) provided Single Bouy Mooring (SBM) system, having a capacity of 54 MMTPA, which was first of its kind in India. Further, significant. Quantum of infrastructural up-gradation has been affected & excellent maritime infrastructure been created at Vadinar for the 32 MMTPA Essar Oil Refinery in Jamnagar District. Monitoring of various environmental aspects of the Deendayal port by M/s Detox Corporation Pvt. Ltd. has been carried out through collection of samples, analysis of the same, comparing results with respect to the prescribed standards by GPCB/CPCB/MoEF& CC. The results shall address the identified impacts and suggest measures to minimize the environmental impact due to various operations at Deendayal Port. The environmental monitoring is carried out as per the Environment Management and Monitoring Plan submitted by Detox Corporation Pvt. Ltd.

## **CHAPTER-2**

### **AMBIENT AIR QUALITY MONITORING**



## 2. Introduction

Air pollutants are added in the atmosphere from variety of sources that change the composition of atmosphere and affect the biotic environment. The concentration of air pollutants depend not only on the quantities that are emitted from air pollution sources but also on the ability of the atmosphere to either absorb or disperse these emissions. The air pollution concentration vary spatially and temporarily causing the air pollution pattern to change with different locations and time due to changes in meteorological and topographical condition. Air pollution occurs when harmful substances including particulates and biological molecules are introduced into earth's atmosphere. It may cause diseases, allergies or death of humans; it may also cause harm to other living organisms such as animals and food crops, and may damage the natural or built environment. Human activity and natural processes can both generate air pollution. A physical, biological or chemical alteration to the air in the atmosphere can be termed as pollution. It occurs when any harmful gases, dust, smoke enters into the atmosphere and makes it difficult for plants, animals and humans to survive as the air becomes dirty. The consequences of industrialization and the demand for improved quality of life has been increased exposure to air pollution (Vallero, 2014). An air pollutant is a substance in the air that can have adverse effects on humans and the ecosystem. The substance can be solid particles, liquid droplets, or gases. A pollutant can be of natural origin or man-made. Pollutants are classified as primary or secondary. Any gas could qualify as pollution if it reached a high enough concentration to do harm. Theoretically, that means there are dozens of different pollution gases. In practice, about ten different substances cause most concern. Heavy metals represent a class of omnipresent pollutants, with toxic potential, in some cases even at low exposure levels. They concentrate in each tropic level because of their weak mobility, so the concentration in plants is higher than in soil, in herbivore animals higher than in plants, in carnivores' tissues higher than in herbivore, the highest concentration being reached at the end of the tropic chain, at big predacious and human bodies.

Globally, one of the main contributors to emissions of atmospheric pollutants and a significant user of energy is the industrial sector (Conti et al. 2015).

The concentration of air pollutants depends not only on the quantities that are emitted from the polluting sources, but also on the ability of the atmosphere to either absorb or disperse such emissions (USEPA, 2008).

Nowadays, the shipping sector provides low-cost and reliable delivery services in the economic field (Arunachalam et al. 2015). Nevertheless, shipping-related activities have a considerable impact on air pollution, especially in coastal areas but also globally (Buccolieri et al. 2016). The primary air pollutants are PM, VOCs, NO<sub>x</sub>, O<sub>3</sub>, SO<sub>2</sub>, and CO (Bailey and Solomon 2004). As a consequence, a wide range of options toward “greener” seaports is needed (Bailey and Solomon 2004). Some of these measures are easy to adopt such as the regulation of fuel quality (by using low-sulfur alternative fuels), the speed reduction (Lack et al. 2011), and the use of alternative transportation equipment (Lai et al. 2011).

Clean air is the basic requirement of all living organisms. In recent times, due to population growth, urban sprawl, industrial development, and vehicular boom, the quality of air is deteriorating and being polluted. Pollutants of major public health concerns include particulate matter, carbon monoxide, ozone, nitrogen dioxide, and sulfur dioxide, which pose serious threats to human health and hygiene. In the present study, prime particulate pollutants (PM<sub>10</sub>, PM<sub>2.5</sub>), and gaseous pollutants (SO<sub>2</sub>, and NO<sub>2</sub>) were estimated at seven stations in and around Dahej Port, Gujarat, India (Soni and Jagruti Patel, 2017).

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

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

## 2.1 Ambient Air Quality Monitoring

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

**Table: 1. Ambient Air Sampling Location**

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

### ● Air Quality Monitoring Methodology

Air quality is measured in all the stations, for 24 hour for Total Suspended Particulate Matter (TSPM), PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub>, NO<sub>2</sub>, NH<sub>3</sub> & Benzene and Grab-sampling for CO & CO<sub>2</sub> measurements. The Air samplers are operated for a period of 24 hours and after a continuous operation of 8 hours for gaseous parameters. The absorbing reagents for SO<sub>2</sub>:- Absorbing Reagent TCM (Potassium Tetrachloromercurate 0.04M): Mercuric Chloride, Potassium Chloride and EDTA used. For NO<sub>2</sub>:- Absorbing Reagent Sodium Hydroxide (NaOH): Sodium Hydroxide and Sodium Arsenite used. For NH<sub>3</sub> need Conc. Sulphuric Acid and Distilled water was used. By replacing 3 times the reagents per day for each parameter namely, SO<sub>2</sub>, NO<sub>2</sub>, NH<sub>3</sub>. The GFA filter paper and PTFE Membrane bound filter paper are used for a period of 24 hours to obtain one sample each of TSPM, PM<sub>10</sub> & PM<sub>2.5</sub>. The AAQ samples are collected two consecutive days a week as per CPCB guidelines, from all the eight locations as mentioned in the EMP.

## 2.2 Results

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

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

**Location 1: Marine Bhavan (AL1)**

**Table 2 : Results of Air Pollutant Concentration at Marine Bhavan**

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

**Table 2 : Results of Air Pollutant Concentration at Marine Bhavan**

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

\* NMHC- Non- Methane Hydrocarbons

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

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

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

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

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

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



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

\* NMHC- Non- Methane Hydrocarbons

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

Oil Jetty Area, the overall values of TSPM, PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub>, NO<sub>2</sub> and NH<sub>3</sub> was mainly by motor vehicle emission produced from various types of vehicles at Oil Jetty Area. The mean TSPM value at Oil Jetty was 256 µg/m<sup>3</sup>. The mean PM<sub>10</sub> value was 175 µg/m<sup>3</sup> and mean PM<sub>2.5</sub> value was 75 µg/m<sup>3</sup> which was above the permissible limit. The average values of SO<sub>2</sub>, NO<sub>2</sub> and NH<sub>3</sub> were within the permissible limit prescribed by NAAQS. The mean concentration of SO<sub>2</sub>, NO<sub>2</sub> and NH<sub>3</sub> were 3.97 µg/m<sup>3</sup>, 13.70 µg/m<sup>3</sup> and 3.47 µg/m<sup>3</sup> respectively.

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

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

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

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

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

Sampling Period	Date	C <sub>6</sub> H <sub>6</sub> [µg/m <sup>3</sup> ]	*NMHC	CO [mg/m <sup>3</sup> ]	CO <sub>2</sub> [ppm]
		8 hr		Grab Sampling	Grab Sampling
		5.0 µg/m <sup>3</sup>		4.0 mg/m <sup>3</sup>	-
NAAQMS limit					
AL3 -1	01.11.2022	1.06	BQL	1.27	508
AL3 -2	04.11.2022	1.1	BQL	1.19	508
AL3 -3	08.11.2022	1.1	BQL	1.65	502
AL3 -4	11.11.2022	1.09	BQL	1.83	429
AL3 - 5	15.11.2022	1.09	BQL	1.76	813
AL3 - 6	18.11.2022	1.2	BQL	1.14	559
AL3 - 7	22.11.2022	1.19	BQL	2.18	1022
AL3 - 8	25.11.2022	1.11	BQL	2	1026
	29.11.2022	1.06	BQL	1.22	537
Monthly Average		1.11	-	1.58	656.00
Standard Deviation		0.05	-	0.39	234.02

\* NMHC- Non- Methane Hydrocarbons

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

The overall values of TSPM, PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub>, NO<sub>2</sub> and NH<sub>3</sub> at Kandla Port Colony (Estate Office) was attributed by vehicle emission produced from trucks and heavy duty vehicles that pass through the road outside Kandla Port Colony. The mean TSPM values at Estate Office were 441 µg/m<sup>3</sup>, the mean PM<sub>10</sub> value was 329 µg/m<sup>3</sup>, and PM<sub>2.5</sub> value was 107 µg/m<sup>3</sup> which was above the permissible limit prescribed by NAAQS. The average values of SO<sub>2</sub>, NO<sub>2</sub> and NH<sub>3</sub> were 3.76 µg/m<sup>3</sup>, 13.77 µg/m<sup>3</sup> and 3.50 µg/m<sup>3</sup> respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Kandla Port Colony. The mean Benzene concentration was 1.11 µg/m<sup>3</sup>, well below the permissible limit of 5.0 µg/m<sup>3</sup>. NMHC's were below the detectable limit and Carbon Monoxide was 1.58 mg/m<sup>3</sup>, well below the permissible limit of 4.0 mg/m<sup>3</sup>.

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

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

Table 5 : Results of Air Pollutant Concentration at Gopalpuri Hospital										
	Date	TSPM [µg/m3]	PM10 [µg/m3]	PM2.5 [µg/m3]	SO2 [µg/m3]		NOx [µg/m3]		NH3 [µg/m3]	
Sampling Period		24hr	24hr	24hr	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)	8 hr	24hr (Avg.)
NAAQMS Limit			100 µg/m3	60 µg/m3		80 µg/m3		80 µg/m3		400 µg/m3
AL4 -1	01.11.2022	107	67	34	1.21	2.22	5.77	6.93	2.42	2.53
					3.02		10.39		4.14	
					2.42		4.62		1.04	
AL4 -2	04.11.2022	177	117	54	0.91	2.22	5.19	10.00	1.61	2.49
					4.53		8.66		2.42	
					1.21		16.16		3.45	
AL4 -3	08.11.2022	148	101	44	1.15	2.21	6.93	9.81	1.73	1.69
					2.88		17.31		2.42	
					2.59		5.19		0.92	
AL4 -4	11.11.2022	184	111	68	1.51	2.62	6.93	12.89	1.04	2.30
					3.63		14.43		2.42	
					2.72		17.31		3.45	
AL4 – 5	15.11.2022	202	125	72	2.12	2.42	12.12	12.70	2.42	2.49
					3.63		8.66		3.45	
					1.51		17.31		1.61	
AL4 – 6	18.11.2022	233	153	78	1.21	2.92	8.66	12.89	2.42	2.49
					4.84		17.89		1.61	
					2.72		12.12		3.45	
AL4 – 7	22.11.2022	268	168	94	0.60	2.22	5.77	12.70	1.73	2.88
					3.32		14.43		3.68	
					2.72		17.89		3.22	
AL4 – 8	25.11.2022	202	142	56	2.12	3.42	14.43	12.50	2.07	2.99
					5.14		17.89		4.03	
					3.02		5.19		2.88	
AL1 – 9	29.11.2022	249	157	91	3.02	4.03	8.66	11.54	1.38	2.49
					6.35		20.20		3.80	
					2.72		5.77		2.30	
Monthly Average		197	127	66		2.70		11.33		2.49
Standard Deviation		50	32	20		0.65		2.05		0.37

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

\* NMHC- Non- Methane Hydrocarbons

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

The overall values of TSPM, PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub>, NO<sub>2</sub> and NH<sub>3</sub> at Gopalpuri Hospital was attributed by vehicle emission produced from light motor vehicles of the colony residents. The mean TSPM values at Gopalpuri Hospital were 197 µg/m<sup>3</sup>, the mean PM<sub>10</sub> value was 127 µg/m<sup>3</sup> and PM<sub>2.5</sub> was 66 µg/m<sup>3</sup> which was exceed the standard limit. The average values of SO<sub>2</sub>, NO<sub>2</sub> and NH<sub>3</sub> were 2.70 µg/m<sup>3</sup>, 11.33 µg/m<sup>3</sup> and 2.49 µg/m<sup>3</sup> respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Gopalpuri Hospital. The mean Benzene concentration was 1.12 µg/m<sup>3</sup>, well below the permissible limit of 5.0 µg/m<sup>3</sup>. NMHC's were below the detectable limit and Carbon monoxide concentration was 1.49 mg/m<sup>3</sup> which is well below the permissible limit of 4.0 mg/m<sup>3</sup>.

**Location 5: Coal Storage Area (AL-5)**

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

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

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

Sampling Period	Date	C <sub>6</sub> H <sub>6</sub> [µg/m <sup>3</sup> ]	*NMHC	CO [mg/m <sup>3</sup> ]	CO <sub>2</sub> [ppm ]
		8 hr		Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m <sup>3</sup>		4.0 mg/m <sup>3</sup>	-
AL5 – 1	01.11.2022	1.1	BQL	1.12	483
AL5 – 2	04.11.2022	1.06	BQL	1.48	475
AL5 – 3	08.11.2022	1.08	BQL	1.66	421
AL5 – 4	11.11.2022	1.06	BQL	1.69	492
AL5 – 5	15.11.2022	1.06	BQL	1.06	702
AL5 – 6	18.11.2022	1.22	BQL	1.18	483
AL5 – 7	22.11.2022	1.11	BQL	1.86	564
AL5 – 8	25.11.2022	1.2	BQL	1.54	777
AL5 – 9	29.11.2022	1.22	BQL	1.89	895
Monthly Average		1.12	-	1.50	588.00
Standard Deviation		0.07	-	0.31	164.11

\* NMHC- Non- Methane Hydrocarbons

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

The overall values of TSPM, PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub>, NO<sub>2</sub> and NH<sub>3</sub> at Coal Storage Area was comparatively highest among all the locations of Air Quality monitoring in Kandla Port. High values of TSPM, PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub>, NO<sub>2</sub> at this location was due to lifting of coal with grab and other coal handling processes near Berth no. 6 & 7. Moreover, the traffic was also heavy around this place for transport of coal thus emissions produced from heavy vehicles. The mean TSPM values at Coal storage were 743 µg/m<sup>3</sup>, the mean PM<sub>10</sub> value was 574 µg/m<sup>3</sup>, and the PM<sub>2.5</sub> value was 164 µg/m<sup>3</sup> which was above the permissible limit prescribed by NAAQS. The average values of SO<sub>2</sub>, NO<sub>2</sub> and NH<sub>3</sub> were 5.20 µg/m<sup>3</sup>, 17.89 µg/m<sup>3</sup> and 4.72 µg/m<sup>3</sup> respectively and were all within the permissible limit.

The levels of Benzene, Hydrocarbons (HC) and CO were within the permissible limit at Coal Storage Area. The mean Benzene concentration was 1.12 µg/m<sup>3</sup>, well below the permissible limit of 5.0 µg/m<sup>3</sup>. NMHC's were below the detectable limit and Carbon Monoxide concentration was 1.50 mg/m<sup>3</sup>, well below the permissible limit of 4.0 mg/m<sup>3</sup>.



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

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

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

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

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

\* NMHC- Non- Methane Hydrocarbons

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

The mean TSPM values at Tuna Port was 219 µg/m<sup>3</sup>, the mean PM<sub>10</sub> value was 145 µg/m<sup>3</sup> and the mean PM<sub>2.5</sub> value was 71 µg/m<sup>3</sup> which was exceed the standard limit prescribed by NAAQS. The average values of SO<sub>2</sub>, NO<sub>2</sub> and NH<sub>3</sub> were 2.45 µg/m<sup>3</sup>, 10.69 µg/m<sup>3</sup> and 3.50 µg/m<sup>3</sup> respectively and were all within the standard limit prescribed by NAAQS.

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

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

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

**Table 8 : Results of Air Pollutant Concentration at Admin Building Vadinar**

Sampling Period	Date	C <sub>6</sub> H <sub>6</sub> [µg/m <sup>3</sup> ]	*NMHC	CO [mg/m <sup>3</sup> ]	CO <sub>2</sub> [ppm ]
		8 hr		Grab Sampling	Grab Sampling
		5.0 µg/m <sup>3</sup>		4.0 mg/m <sup>3</sup>	-
<b>NAAQMS limit</b>					
<b>AL7 -1</b>	01.11.2022	1.08	BQL	1.43	225
<b>AL7 -2</b>	04.11.2022	1.13	BQL	1.54	236
<b>AL7 -3</b>	08.11.2022	1.17	1.81	1.53	455
<b>AL7 -4</b>	11.10.2022	1.14	BQL	1.61	443
<b>AL7 -5</b>	15.10.2022	1.03	BQL	1.1	347
<b>AL7 -6</b>	18.10.2022	1.06	BQL	1.57	416
<b>AL7 -7</b>	22.10.2022	1.10	BQL	1.05	372
<b>AL7 -8</b>	25.10.2022	1.20	BQL	1.79	464
<b>AL7 -9</b>	28.10.2022	1.13	BQL	1.42	487
<b>Monthly Average</b>		<b>1.12</b>	<b>-</b>	<b>1.46</b>	<b>388</b>
<b>Standard Deviation</b>		<b>0.06</b>	<b>-</b>	<b>0.25</b>	<b>75</b>

\*NMHC- Non- Methane Hydrocarbons

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

At Admin Building, Vadinar the mean TSPM value was 191 µg/m<sup>3</sup>, the mean PM<sub>10</sub> value was 114 µg/m<sup>3</sup> and the mean PM<sub>2.5</sub> value was 74 µg/m<sup>3</sup> which was slightly exceed the standard limit. The average values of SO<sub>2</sub>, NO<sub>2</sub> and NH<sub>3</sub> concentrations were 4.85 µg/m<sup>3</sup>, 15.08 µg/m<sup>3</sup> and 6.68 µg/m<sup>3</sup> respectively and were all within the permissible limit.

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

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

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

**Table 9 : Results of Air Pollutant Concentration at Signal Building Vadinar**

		C <sub>6</sub> H <sub>6</sub> [µg/m <sup>3</sup> ]		CO [mg/m <sup>3</sup> ]	CO <sub>2</sub> [ppm]
Sampling Period	Date	8 hr	*NMHC	Grab Sampling	Grab Sampling
NAAQMS limit		5.0 µg/m <sup>3</sup>		4.0 mg/m <sup>3</sup>	-
AL8 -1	01.11.2022	1.06	BQL	1.5	467
AL8 -2	04.11.2022	1.05	BQL	1.46	501
AL8 -3	08.11.2022	1.14	1.81	1.31	489
AL8 -4	11.11.2022	1.16	BQL	1.38	439
AL8 -5	15.11.2022	1.17	BQL	1.29	231
AL8 -6	18.11.2022	1.10	BQL	1.31	244
AL8 -7	22.11.2022	1.00	BQL	1.34	227
AL8 -8	25.11.2022	1.05	BQL	1.37	261
AL8 -9	28.11.2022	1.02	BQL	1.29	234
Monthly Average		1.16	-	1.46	442
Standard Deviation		0.05	-	0.27	63

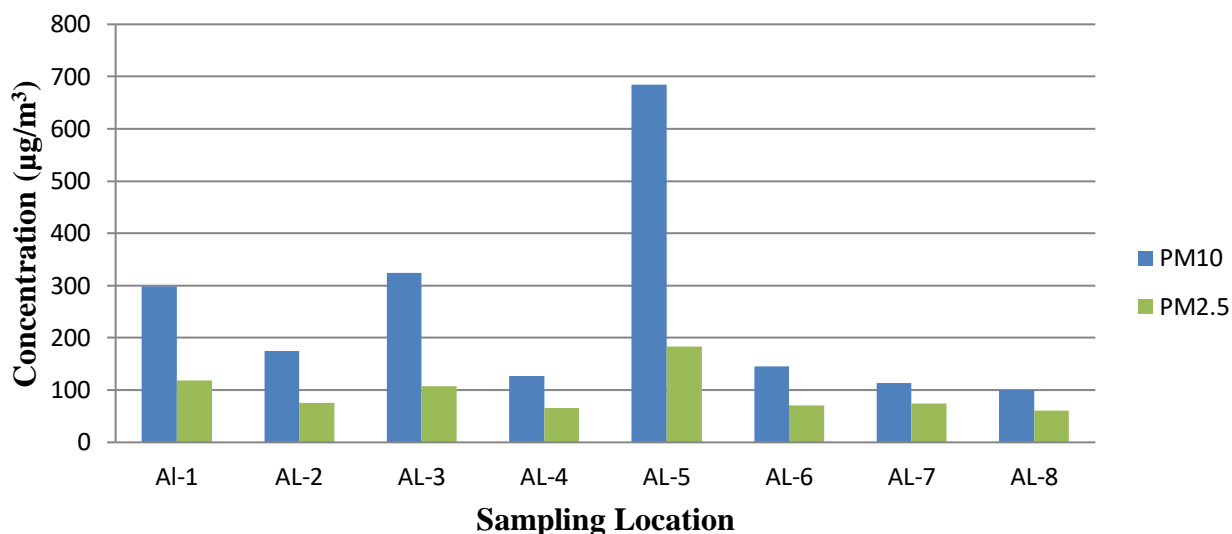
\* NMHC- Non- Methane Hydrocarbon

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

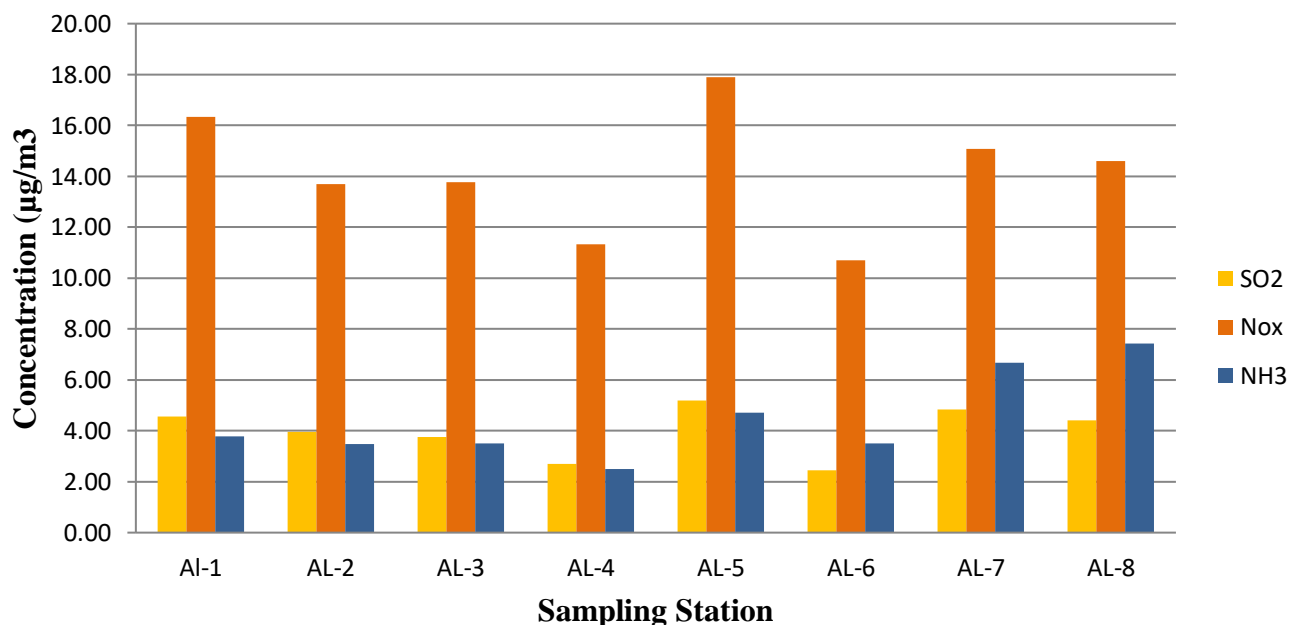
At Signal Building, Vadinar the mean TSPM value was 164 µg/m<sup>3</sup>, the mean PM<sub>10</sub> value was 100 µg/m<sup>3</sup> which was boundary line of the permissible limit, the mean PM<sub>2.5</sub> value was 61 µg/m<sup>3</sup> which was within the permissible limit. The average values of SO<sub>2</sub>, NO<sub>2</sub> and NH<sub>3</sub> concentrations were 4.40 µg/m<sup>3</sup>, 14.59 µg/m<sup>3</sup> and 7.44 µg/m<sup>3</sup> respectively and were all within the standard limit.

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

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

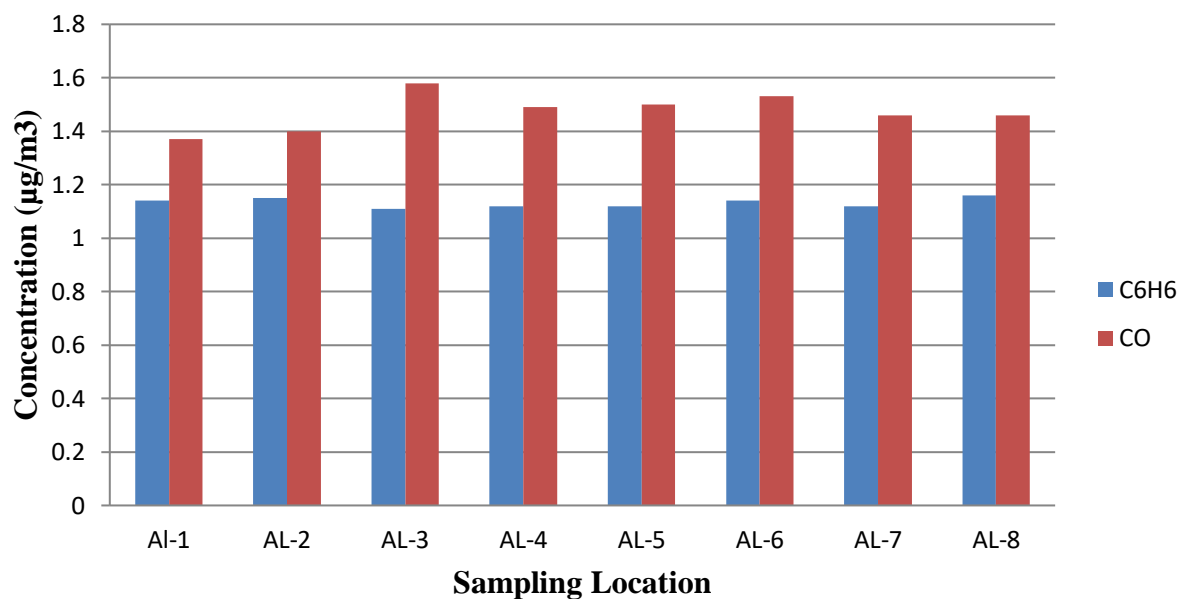


**Fig. No:-2. Average ambient air quality (Gaseous) month of November-2022 at DPA and Vadinar sampling location**

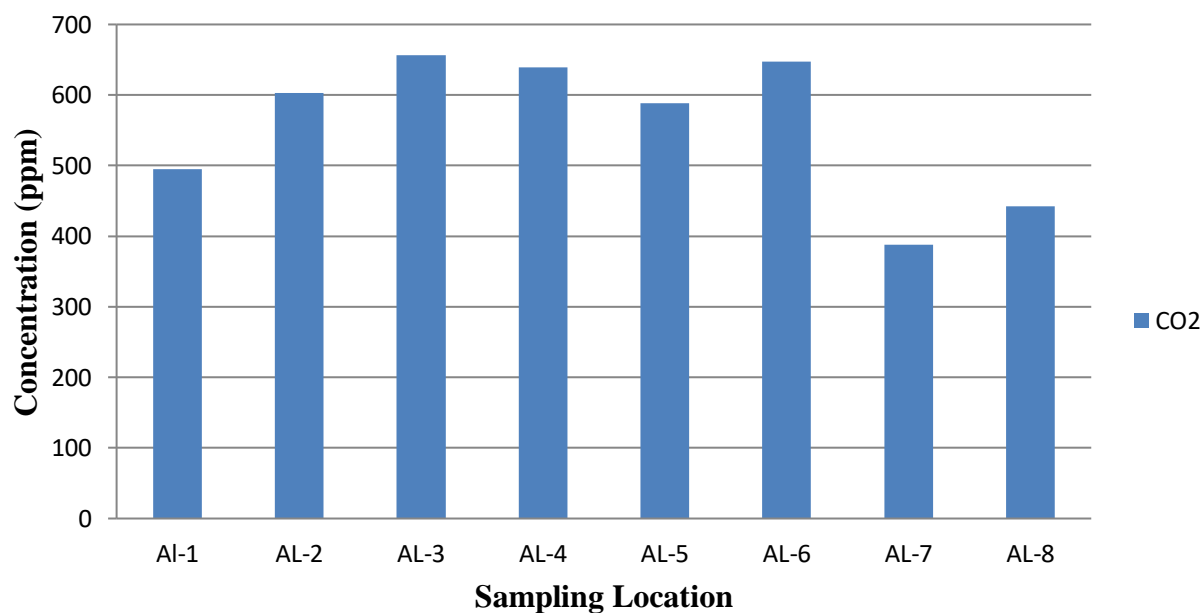




**Fig. No:-3. Average ambient air quality (Gaseous) month of November-2022 at DPA and Vadinar sampling location**



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



### 2.3 Observations and Conclusion

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

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

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

## **CHAPTER-3**

### **METEOROLOGICAL OBSERVATIONS**

#### **4.1 Meteorological Data**

Automatic Weather station (ID KAZPHOEN424) have been installed in Seva Sadan-3 at the Deendayal Port which records the data on Temperature (°C), Relative Humidity (%), Wind speed (m/s), Wind Direction (°), Solar radiation (w/m<sup>2</sup>) and Rainfall mm.

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

##### **Temperature**

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

##### **Solar Radiation**

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

##### **Rainfall**

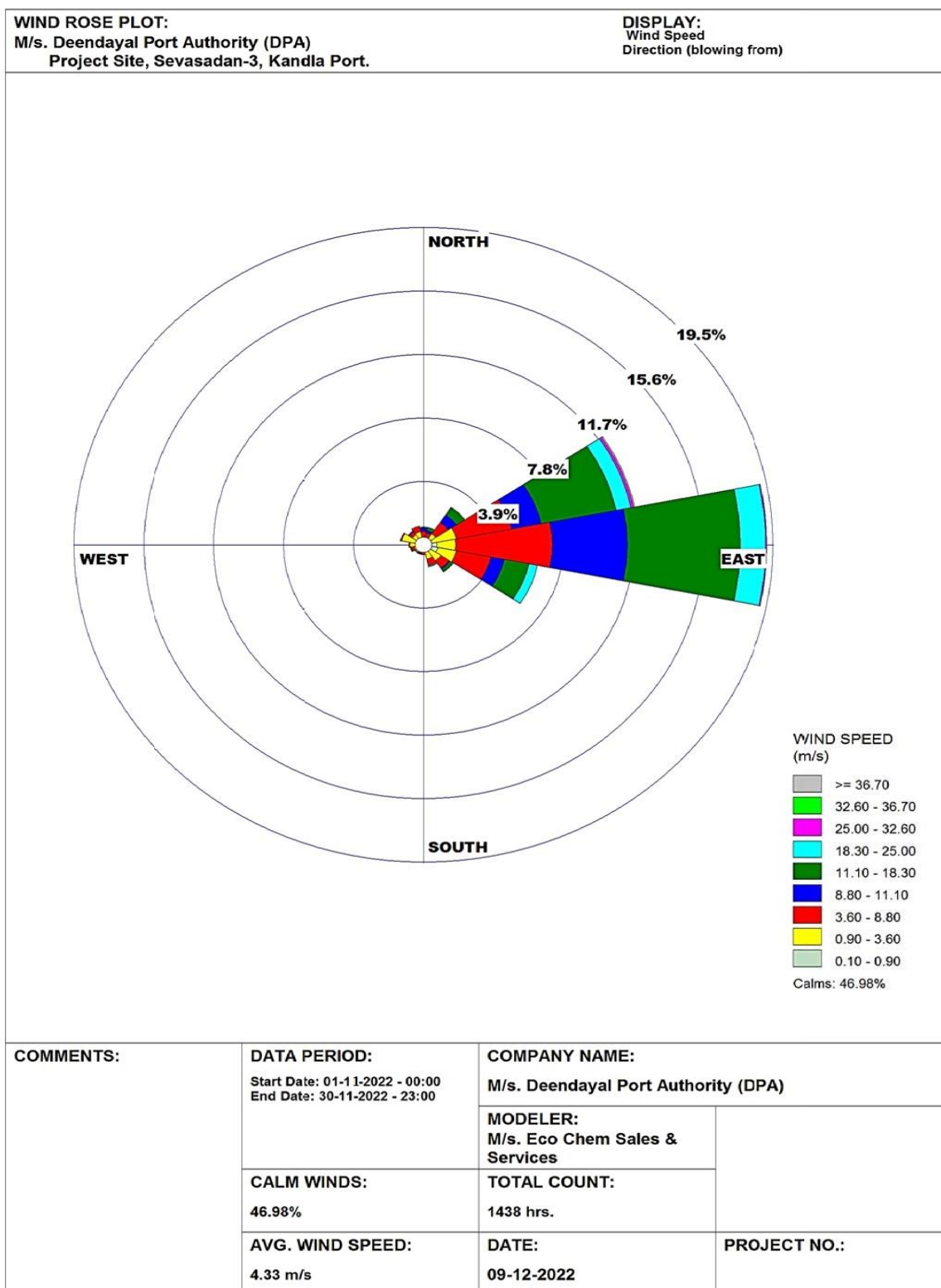
Rain fall of November month was recorded 0.00 mm.

##### **Relative Humidity**

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

##### **Wind Velocity and Wind Direction**

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



## CHAPTER-4

### DRINKING WATER QUALITY MONITORING

#### 4.0 Drinking Water Quality Monitoring

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

**Table No:-10. Drinking Water Sampling Location**

Sr. No.	Name of Location	Location Code	Latitude	Longitude
1.	Nirman Building	DL-1	23° 0' 27"N	70° 13' 21"E
2.	P & C Building	DL-2	23° 0' 33"N	70° 13' 20"E
3.	North Gate	DL-3	23° 0' 26.97"N	70° 13' 21.87"E
4.	KPT-Canteen	DL-4	23° 2' 17.2674"N	70° 13' 18.2814"E
5.	West Gate	DL-5	23° 59' 40.48"N	70° 12' 50.96"E
6.	Wharf Area	DL-6	22° 59' 52.2"N	70° 13' 22.95"E
7.	Sevasadan-3	DL-7	23° 0' 22.55"N	70° 13' 15.34"E
8.	Workshop	DL-8	23° 0' 33.74"N	70° 13' 20.05"E
9.	Custom Building	DL-9	23° 1' 8.70"N	70° 12' 52.0"E
10.	Kandla Colony	DL-10	23° 11' 14.9"N	70° 12' 48.4"E
11.	KPT Hospital	DL-11	23° 1' 5.02"N	70° 12' 44.38"E
12.	A.O. Building	DL-12	23° 3' 42.89"N	70° 8' 41.5"E
13.	Gopalpuri School	DL-13	23° 5' 1.03"N	70° 7' 55.42"E
14.	Gopalpuri Guest House	DL-14	23° 4' 43.14"N	70° 7' 51.92"E
15.	E-Type Quarters	DL-15	23° 4' 59.90"N	70° 7' 56.72"E
16.	F-Type Quarters	DL-16	23° 4' 38.45"N	70° 8' 8.63"E
17.	Gopalpuri Hospital	DL-17	23° 4' 54.09"N	70° 8' 7.5"E
18.	Tuna Port	DL-18	23° 58' 23.06"N	70° 5' 35.6"E
19.	Vadinar Jetty	DL-19	22° 25' 51.73"N	69° 41' 36.62"E
20.	Vadinar Colony	DL-20	22° 30' 26.25"N	69° 39' 45.03"E



#### **4.1 Drinking Water Monitoring Methodology**

Samples for physico-chemical analysis were collected in 2 Carboys and samples for microbiological parameters were collected in sterilized bottles. These samples were then analyzed in laboratory for various drinking water parameters at Kandla Lab/Surat.

The Sampling was done as per IS: 3025 Part-1, analysis was done as per IS: 3025/APHA standard methods and, the analysis results compare with IS 10500:2012. The water samples were analyzed for various parameters, viz. Color , Odor, Turbidity , Conductivity , pH , Chlorides , TDS, Total Hardness, Iron , Sulphate, Salinity , DO, BOD, Na, K, Ca, Mg, F, NO<sub>3</sub>, NO<sub>2</sub>, Mn, Cr-6, Cu, Cd, As, Hg, Pb, Zn, Bacterial Count (CFU) .

#### **4.2 Results**

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

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

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

\*NS: Not Specified

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

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

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

\*NS: Not Specified,

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

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

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

\*NS: Not Specified,

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

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

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

\*NS: Not Specified,

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

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

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

\*NS: Not Specified,

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

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

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

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



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

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

\*NS: Not Specified,

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

### **4.3 Results & Discussion**

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

#### **pH**

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

#### **Turbidity**

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

#### **Total Dissolved Solids (TDS)**

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

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

#### **Conductivity**

Electrical Conductivity is the ability of a solution to transfer (conduct) electric current. Conductivity is used to measure the concentration of dissolved solids which have been ionized in a polar solution such as water. The conductivity in the samples collected during the month of November DPA ranged from 1044.0  $\mu\text{S}/\text{cm}$  at Tuna Port to 1821.0  $\mu\text{S}/\text{cm}$  at A.O. Building and mean value was 1381.72  $\mu\text{S}/\text{cm}$  while at Vadinar ranged from 300-570  $\mu\text{S}/\text{cm}$  and mean was 435  $\mu\text{S}/\text{cm}$ .

## **BOD**

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

## **Chlorides**

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

## **Calcium**

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

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

## **Magnesium**

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

## **Total Hardness**

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

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

### **Iron**

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

### **Fluoride**

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

### **Sulphate**

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

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

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

### **Salinity**

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

### **Sodium and Potassium Salts**

Sodium values in the samples collected at DPA ranged from 180 - 204 mg/l and average was 195.74 mg/l while at Vadinar sodium ranged from 191.6- 192.0 mg/l and average was 191.8 mg/l . Potassium salts ranged at DPA ranged from 3.15 to 4.18 mg/l while average was 3.42 mg/l while at Vadinar sampling locations potassium were BQL (<2.0 mg/l). There are no prescribed limits of Sodium and Potassium in Indian standards for Drinking water.

### **Heavy Metals in Drinking Water**

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

### **Bacteriological Study**

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

## **4.4 Conclusions**

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

## CHAPTER-5

### NOISE MONITORING

## 5.0 Noise Level Monitoring

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

### 5.1 Method of Monitoring

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

### 5.2 Results

**Table 18: Noise Monitoring data for ten locations of Deendayal Port and three locations of Vadinar Port**

Sr. No.	Location	Day Time Average Noise Level (SPL) in dB(A)	Night Time Average Noise Level (SPL) in dB(A)
	Sampling Time	6:00 am to 10:00 PM	10:00PM to 6:00 AM
1	Marine Bhavan	60.8	51.9
2	Nirman Building 1	69.9	52.0
3	Tuna Port	53.2	45.4
4	Main Gate North	63.3	51.9
5	West Gate I	67.7	58.1
6	Canteen Area	68.2	51.2
7	Main Road	66.3	52.2
8	ATM Building	69.1	51.1
9	Wharf Area /Jetty Area	70.4	61.7
10	Port & Custom Office	54.7	50.2
<b>Vadinar Port</b>			
11	Entrance Gate of Vadinar Port	55.0	53.5
12	Nr. Port Colony, Vadinar	60.6	57.6
13	Nr. Vadinar Jetty	52.5	51.0



### 5.3 Conclusions

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

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

## CHAPTER-6

### SOIL MONITORING

## 6.0 Soil Monitoring

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

**Table No.:-19. Soil Sampling Location**

Sr. No.	Name of Location	Location Code	Latitude	Longitude	Remarks
1.	Tuna Port	SL-1	22° 58' 10.18"N	70° 6' 3.7"E	Near main gate of Port
2.	IFFCO Plant	SL-2	23° 26' 8.37"N	70° 13' 4.4"E	10 m away from main gate
3.	Khori creek	SL-3	22° 58' 10.18"N	70° 6' 3.7"E	Sand from creek after tide
4.	Nakti Creek	SL-4	23° 2' 1.10"N	70° 9' 33.6"E	
5.	DPA admin site	SL-5	22° 26' 30.9"N	69° 40' 37.03"E	Vadinar
6.	DPA colony	SL-6	22° 23' 57.09"N	69° 42' 49.42"E	

## 6.1 Methodology

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

## 6.2 Results

**Table-20: Chemical Characteristics of Soil in the Study Area for Tuna port, IFFCO, Khori Creek, Nakti Creek, DPA admin site, DPA colony.**

Sr. No.	Parameter	Unit	Station Name					
			SL1	SL2	SL3	SL4	SL5	SL6
			Tuna Port	IFFCO Plant	Khori Creek	Nakti Creek	DPA Admin Site	DPA Colony
			Near main gate of Port	10 m away from main	Sand from creek after tide		Vadinar	
1	Texture		Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	pH	-	7.79	7.80	7.54	7.58	8.14	7.54
3	Electrical Conductivity	µs/cm	35000.0	36100.0	26,820.00	12,700.0	155.0	594.0
4	Phosphorus	mg/kg	10.3	10.5	9.19	8.49	6.00	4.80
5	Moisture	%	15.9	20.3	20.90	3.50	7.20	10.10
6	Total Organic	%	4.04	1.7	3.64	7.80	2.30	2.00
7	Alkalinity	mg/kg	900.0	1000.0	800.0	500.0	800.0	600.0
8	Total Nitrogen	%	BQL	BQL	BQL	BQL	BQL	BQL
9	Sulphate	mg/kg	820.00	982.00	1,080.00	810.00	30.0	70.0
10	Chloride	mg/kg	15598.0	14275.0	12,600.00	2,950.00	140.00	525.00
11	Calcium	mg/kg	2,605.00	2,505.00	31,600.00	3,086.00	1,729.00	1,849.00
12	Sodium	mg/kg	5657	7136.0	7,649.00	4,675.00	33.02	116.90
13	Potassium	mg/kg	552	694	708.00	437.00	44.60	44.52
14	Copper as Cu	mg/kg	27.4	15.5	30.50	14.50	54.10	31.60
15	Lead as Pb	mg/kg	7.4	7.4	9.50	6.30	74.10	75.30
16	Nickel as Ni	mg/kg	39.40	32.70	44.40	27.20	30.30	32.00
17	Zinc as Zn	mg/kg	62.4	77.40	79.20	56.50	50.60	86.00
18	Cadmium as Cd	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL

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

### 6.3 Discussion

- DPA Kandla soil sampling data shows that value of pH ranges from 7.54 at Khori Creek to 7.80 at IFFCO Plant while the average value was 7.68. At Vadinar sampling location pH were 7.54 at DPA colony and 8.14 at DPA Admin Site.
- The Electrical Conductivity of DPA Kandla soil sample ranged from 12700.0  $\mu\text{S}/\text{cm}$  at Nakti Creek (Sand from creek after tide) to 36100  $\mu\text{S}/\text{cm}$  at IFFCO Plant and mean was 27655  $\mu\text{S}/\text{cm}$  while Vadinar soil sampling location conductivity were 155  $\mu\text{S}/\text{cm}$  at DPA Admin Site and 594  $\mu\text{S}/\text{cm}$  at DPA Colony site.
- Total organic Carbon of DPA Kandla soil sample ranged from 1.7 % at IFFCO Plant to 7.80 % at Nakti Creek (Sand from creek after tide) and mean was 4.30 % while Vadinar soil sample were 2.0 % at DPA Colony and 2.30 % at DPA admin Site.
- The concentration of Phosphorus in the soil samples of DPA Kandla varies from 8.49 mg/kg at Nakti Creek (Sand from creek after tide) and 10.5 mg/kg at IFFCO Plant and mean was 9.62 mg/kg while the Vadinar soil sample for Phosphorus were 4.80 mg/kg at DPA Colony and 6.00 mg/kg at DPA Admin Site.
- Chloride in soil sample of DPA ranged from 2950.00 mg/kg at Nakti Creek (Sand from creek after tide) to 15598 mg/kg at Tuna Port and mean was 11356 mg/kg while Vadinar soil sample were 140 mg/kg at DPA admin and 525 mg/kg at DPA Colony.
- The Concentration of Potassium in the soil samples of DPA Kandla ranged from 437 mg/kg at Nakti creek and 708 mg/kg at Khori Creek and mean was 597.75 mg/kg while the Vadinar soil sample for Potassium were 44.52 mg/kg at DPA Colony Site and 44.60 mg/kg at DPA Admin Site.
- The concentration of Sodium in the soil samples of DPA Kandla ranged from 4675.0 mg/kg at Nakti creek and 7649.0 mg/kg at Khori Creek and mean was 6279 mg/kg while the Vadinar soil sample for Sodium were 33.00 mg/kg at DPA Admin Site and 117 mg/kg at DPA Colony.

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

### Heavy Metals in the Soil

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

### 6.4 Conclusion

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

## **CHAPTER-7**

### **SEWAGE TREATMENT PLANT MONITORING**

## 7.0 Sewage Treatment Plant Monitoring

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

### 7.1 Methodology for STP Monitoring

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

A new STP with an improved capacity of 1 MLD is being constructed at Gopalpuri Colony.

**Table No. 21. Sewage Treatment Plant**

Sr. No.	Location of STP	Types of Treatment	STP Capacity	Treated water Utilization
1.	Gopalpuri Township	MBBR	450 KLD	Plantation and Gardening
2.	Deendayal Port, Kandla	MBBR	600 KLD	Discharge to marine through pipeline, Plantation, Gardening
3.	Vadinar Port Colony	MBBR	1.5 MLD	Plantation and Gardening



## 7.2 Results

**Table 22: Sewage Water Monitoring at Kandla STP (1<sup>st</sup> Week)**

<b>Date of Sampling</b>	03.11.2022
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Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.55	7.42	6.5 - 8.5
2	Total Suspended Solids	mg/l	100.6	46.8	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	80.8	30.3	100
5	BOD @ 27 °C	mg/l	22	11	30
<b>Aeration Tank</b>					
6	MLSS	mg/l	14.0		
7	MLVSS	%	99.73		

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

<b>Date of Sampling</b>	10.11.2022
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Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.41	7.36	6.5 - 8.5
2	Total Suspended Solids	mg/l	127	52.6	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	90.9	40.4	100
5	BOD @ 27 °C	mg/l	23	11	30
<b>Aeration Tank</b>					
6	MLSS	mg/l	18.0		
7	MLVSS	%	85.00		

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

<b>Date of Sampling</b>	17.11.2022
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Sr. No.	Parameters	Unit	Results		CPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.48	7.29	6.5 - 8.5
2	Total Suspended Solids	mg/l	86.4	22.9	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	101	50.5	100
5	BOD @ 27 °C	mg/l	26	14	30
<b>Aeration Tank</b>					
6	MLSS	mg/l	20.0		
7	MLVSS	%	98.0		

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

<b>Date of Sampling</b>	24.10.2022
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Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.41	7.29	6.5 - 8.5
2	Total Suspended Solids	mg/l	164.2	58.7	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	171.7	30.3	100
5	BOD @ 27 °C	mg/l	43	10	30
<b>Aeration Tank</b>					
6	MLSS	mg/l	20.0		
7	MLVSS	%	89.0		

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

<b>Date of Sampling</b>	03.11.2022
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Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.47	7.31	6.5 - 8.5
2	Total Suspended Solids	mg/l	121.2	61	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	111.1	60.6	100
5	BOD @ 27 °C	mg/l	32	13	30
<b>Aeration Tank</b>					
6	MLSS	mg/l	22.0		
7	MLVSS	%	97.16		

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

<b>Date of Sampling</b>	10.11.2022
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Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			DPA STP I/L	DPA STP O/L	
1	pH	-	7.35	7.27	6.5 - 8.5
2	Total Suspended Solids	mg/l	189	67.9	100
3	Residual Chlorine	mg/l			-
4	COD	mg/l	141.4	60.6	100
5	BOD @ 27 °C	mg/l	37	15	30
<b>Aeration Tank</b>					
6	MLSS	mg/l	16.0		
7	MLVSS	%	89.6		

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

<b>Date of Sampling</b>	17.11.2022
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Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Gopalpuri STP I/L	Gopalpuri STP O/L	
1	pH	-	7.41	7.36	6.5 - 8.5
2	Total Suspended Solids	mg/l	127	52.6	100
3	Residual Chlorine	mg/l			-
4	COD	mg/l	90.9	40.4	100
5	BOD @ 27 °C	mg/l	23	11	30
<b>Aeration Tank</b>					
6	MLSS	mg/l	08.0		
7	MLVSS	%	98.0		

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

<b>Date of Sampling</b>	24.11.2022
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Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Gopalpuri STP I/L	Gopalpuri STP O/L	
1	pH	-	7.48	7.28	6.5 - 8.5
2	Total Suspended Solids	mg/l	110.2	42.1	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	78	40	100
5	BOD @ 27 °C	mg/l	24.0	12.0	30
<b>Aeration Tank</b>					
6	MLSS	mg/l	18.0		
7	MLVSS	%	90.0		

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

<b>Date of Sampling</b>	03.11.2022
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Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar STP O/L	
1	pH	-	7.35	7.25	6.5 - 8.5
2	Total Suspended Solids	mg/l	74.9	39.5	100
3	Residual Chlorine	mg/	-	<0.5	-
4	COD	mg/l	101	40.4	100
5	BOD @ 27 °C	mg/l	26.0	10.0	30

**Table 31: Sewage Water Monitoring at Vadinar STP (2<sup>nd</sup> Week)**

<b>Date of Sampling</b>	10.11.2022
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Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar STP O/L	
1	pH	-	7.38	7.21	6.5 - 8.5
2	Total Suspended Solids	mg/l	69.6	40.3	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	131.3	50.5	100
5	BOD @ 27 °C	mg/l	32.0	7.0	30

**Table 32: Sewage Water Monitoring at Vadinar STP (3<sup>rd</sup> Week)**

<b>Date of Sampling</b>	17.11.2022
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Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar O/L	
1	pH	-	7.51	7.42	6.5 - 8.5
2	Total Suspended Solids	mg/l	38.6	16.9	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	80.8	20.2	100
5	BOD @ 27 °C	mg/l	24.0	12.0	30

**Table 33: Sewage Water Monitoring at Vadinar STP (4<sup>th</sup> Week)**

<b>Date of Sampling</b>	24.11.2022
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Sr. No.	Parameters	Unit	Results		GPCB Prescribed Limit
			Vadinar STP I/L	Vadinar STP O/L	
1	pH	-	7.61	7.42	6.5 - 8.5
2	Total Suspended Solids	mg/l	76.9	33.3	100
3	Residual Chlorine	mg/l	-	<0.5	-
4	COD	mg/l	131.3	20.2	100
5	BOD @ 27 °C	mg/l	20.0	8.0	30

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

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

**Sources:-CPCB****7.3 Results & Discussion**

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

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

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

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

#### **7.4 Conclusions:**

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



## CHAPTER-8

### MARINE WATER MONITORING

## **8.0 Marine Water Monitoring**

### **Marine Water Quality**

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

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

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

### **Sampling Stations**

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

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

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

### Sampling Locations

Offshore monitoring requirement	Number of locations
Offshore Installations	3 in Kandla creek 2 in Nakti creek 1 in Khorī creek 1 near Vadinar Jetty 1 near 1 <sup>st</sup> SBM
<b>Total Number of locations</b>	<b>8</b>

### 8.1 Marine Water Quality and Results

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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



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

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

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

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

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

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

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

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

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

## **8.2 Results & Discussion for Marine water samples**

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

### **pH**

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

### **Color and Odor**

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

### **Turbidity**

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

### **Total Dissolved Solids (TDS)**

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

### **Calcium**

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

### **Magnesium**

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

### **Nitrate**

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

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

### **Iron**

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

### **Sulphates**

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

### **Salinity**

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

### **Sodium and Potassium Salts**

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

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

## **DO**

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

## **BOD**

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

## **Heavy Metals in Marine Water**

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

## **9.3 Conclusion**

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

## CHAPTER-9

### MARINE SEDIMENT MONITORING

## 9.0 Marine Sediments

The deep-sea ocean floor is made up of sediment. This sediment is composed of tiny particles such as fine sand, silt, clay, or animal skeletons that have settled on the ocean bottom. Over long periods of time, some of these particles become compressed and form stratified layers. Scientists that study these layers look at particle size, particle composition, and origin to help them create historical records of the deep ocean floor. This process is called weathering. Weathering can be either mechanical or chemical. Mechanical weathering can occur as ice, wind, or water wears away the rock's surface. Chemical weathering can occur as rocks are dissolved by a chemical such as acid rain. The particles created as a result of weathering are called terrigenous sediments. These particles are transported to the ocean by wind and by rivers and streams. Once the particles enter the ocean, they are dispersed by waves, currents, and tides. The heaviest and largest particles that reach the oceans, such as sand, settle very quickly to the bottom as a result of gravity. Sand is deposited near the coast whereas the smaller silt and clay particles are transported farther distances offshore before they settle to the bottom. Sediments are an important component of aquatic ecosystems because they provide nutrients and habitat for aquatic organisms (Benhamed et al. 2016). However, human activities result in accumulation of toxic substances such as heavy metals in marine sediments. Heavy metals are well-known environmental pollutants due to their toxicity, persistence in the environment, and bioaccumulation. Metals affect the ecosystem because they are not removed from water by self-purification, but accumulate in sediments and enter the food chain (Astakhov et al. 2015).

Sediment samples were collected with Van Veen Grab from the six locations in Kandla Port Waters and two locations in Vadinar Port. Benthic surface grab samplers look like giant metal jaws. They dig into the bottom and take a bite of the sediment. These samplers are good for collecting softer, sandy or silty sediments that do not contain rocks. A box corer is a cross between a surface sampler and a sediment corer. It is a special device that is used to collect an undisturbed sample of the very top surface layers and the sediment underneath. Samples were collected and preserved in silver foil in ice box to prevent the contamination/decaying of the samples.



## 10.1 Results

The Sediment Quality results are given in below from table no. 43 & 44.

**Table 43: Results of Analysis of Sediment of Kandla & Vadinar Port (Neap Tide)**

Sr. No.	Parameters	Unit	DPA – 1	DPA - 2	DPA - 3	DPA - 4	DPA - 5	Jetty	SPM
1	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
2	Organic Matter	mg/kg	1.32	0.6	0.1	0.1	0.16	1.14	1.59
3	Organic Carbon	mg/kg	0.76	0.35	0.07	0.06	0.09	0.66	0.91
4	Inorganic Phosphate	mg/kg	89.00	90.00	101.00	92.00	100.00	90.00	100.00
5	Moisture	%	3.90	2.37	4.12	3.00	4.10	3.40	4.00
6	Aluminum	mg/kg	ND	ND	ND	ND	ND	ND	ND
7	Silica	mg/kg	7.30	7.68	8.90	9.30	9.10	8.90	9.60
8	Phosphate	mg/kg	5.20	4.99	4.09	5.25	9.00	3.28	10.40
9	Sulphate	mg/kg	759.00	849.00	555.00	496.00	768.00	732.00	496.00
10	Nitrite	mg/kg	0.11	0.11	0.10	0.10	0.12	0.10	0.11
11	Nitrate	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
12	Calcium	mg/kg	2765.00	1523.00	861.00	961.00	981.00	1162.00	2485.00
13	Magnesium	mg/kg	1372.00	1300.00	1020.00	1263.00	1032.00	1089.00	2065.00
14	Sodium	mg/kg	2410.0	2760.0	2644.0	2940.0	2722.0	1394.00	1082.00
15	Potassium	mg/kg	404.00	459.00	390.00	510.00	447.00	811.0	560.0
16	Chromium	mg/kg	61.30	71.90	66.00	53.30	56.40	42.80	49.70
17	Nickel	mg/kg	26.80	31.70	29.00	23.00	24.10	13.80	29.20
18	Copper	mg/kg	17.40	19.40	17.80	15.50	15.80	13.80	47.10
19	Zinc	mg/kg	43.40	55.80	49.80	41.80	46.00	32.00	64.30
20	Cadmium	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
21	Lead	mg/kg	5.20	6.20	5.70	9.80	8.40	12.00	BQL
22	Mercury	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL
23	Arsenic	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL

\*ND - Not Detected, BQL: Below Quantification Limit (NO<sub>3</sub>:10.0mg/kg, Cd: 1.0mg/kg, Hg: 1.0mg/kg, As: 1.0mg/kg).

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

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

\*ND - Not Detected, BQL: Below Quantification Limit (NO<sub>3</sub>:10.0 mg/kg, Cd: 1.0 mg/kg, Hg: 1.0mg/kg, As: 1.0mg/kg)

## **9.2 Discussion of Marine Sediment samples**

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

## **9.3 Conclusion**

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

## CHAPTER-11

### MARINE ECOLOGICAL MONITORING

## 10.0 INTRODUCTION:

### 10.1 Sampling Stations:

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

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

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

**TABLE 43. SAMPLING LOCATIONS**

monitoring requirement	Number of locations
Kandla creek	3 in Kandla creek
Nakti creek	2 in Nakti creek
Khori Creek	1 in Khori creek
Vadinar jetty	1 near Vadinar Jetty
SPM	1 near I <sup>st</sup> SPM
<b>Total Number of locations</b>	<b>8</b>

#### Sampling methodology adopted:

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

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

#### **Samples Processing for chlorophyll estimation:**

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

#### **PLANKTON:**

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

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

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

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

#### **Phytoplankton in the marine environment:**

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

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

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

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

#### **Zooplankton in the marine environment:**

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

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

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

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

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

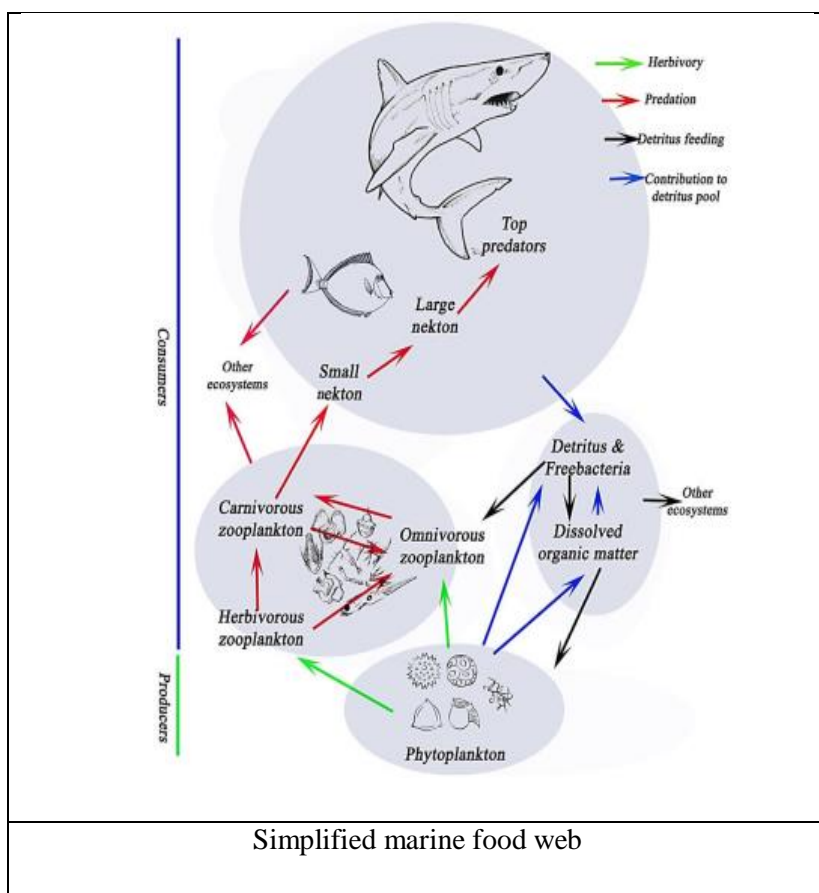
Among the zooplankton one group always dominate than others; members of sub class copepods (Phylum Athropoda) and Tintinids (Phylum Protozoa) among the net planktons. These small animals are of vital importance in marine ecosystem as one of the primary herbivores animals in the sea, and it is they provide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

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



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

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



### Spatial distribution of Plankton:

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

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

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

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

#### **Methodology adopted for Plankton sampling:**

##### **Preservation and storage:**

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

##### **Sample concentration:**

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

##### **Taxonomic evaluation:**

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

##### **Cell counts by drop count method:**

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

### **BENTHIC ORGANISMS:**

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

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

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

### **SAMPLING METHODOLOGY ADOPTED FOR SUB TIDAL REGION:**

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

#### **Sample sieving:**

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

#### **Sample staining:**

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

### **DIVERSITY INDICES:**

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

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

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

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

### **Simpson's diversity index**

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

The formula for calculating  $D$  is presented as:

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

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

$N$  = the total number of organisms of all species

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

Low species diversity suggests:

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

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

High species diversity suggests:

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

### **Species richness indices**

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

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

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

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

### **Shannon-Wiener's index:**

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

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

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

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

#### 10.2:- RESULTS:

##### CHLOROPHYLL-a:

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

In the sub surface water chlorophyll-a was varying from 0.472-0.969 mg/m<sup>3</sup> with an average value 0.645 mg/m<sup>3</sup> in harbour region of DPA in Kandla Creek during sampling done in spring tide period of November 2022. In the nearby creeks chlorophyll-a was varying from 0.359-0.717 mg/m<sup>3</sup> with an average value 0.552 mg/m<sup>3</sup> Pheophytin –a level was below detectable limit- the all the sampling stations during springtide. Even though the plankton diversity and abundance were more during the spring tide sampling, the chlorophyll-content was detected lesser than expected because, the phytoplankton communities were mainly represented by diatoms *Skeletonema* sp. *Coscinodiscus* sp. and *Chaetoceros* sp.

In the sub surface water chlorophyll-a was varying from 0.338-0.547 mg/m<sup>3</sup> with an average value 0.437 mg/m<sup>3</sup> in harbour region of DPA in Kandla Creek during sampling done in Neap tide period of November 2022. In the nearby creeks chlorophyll-a was varying from 0.205- 0.440mg/m<sup>3</sup> with an average value 0.370 mg/m<sup>3</sup>. Pheophytin–a level was below detectable limit- the all the sampling stations. During neap tide sampling phytoplankton communities were mainly represented by *Coscinodiscus* sp. and *Ditylum* sp.

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

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

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

BDL: Below Detectable Limit., ND: Not detected

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

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

BDL: Below Detectable Limit.ND: Not detected



### PHYTOPLANKTON POPULATION:

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

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by, Diatoms, blue green algae and Dinoflagellates during spring tide period. Diatoms were represented by 26 genera, Blue green algae were represented by 2 genera and Dinoflagellates were represented by 6 genera during the sampling conducted in spring tide in November, 2022. Phytoplankton of the sampling stations at sub surface layer in the harbour area and nearby creeks was varying from 39-243units/ L during high tide period and 115-199 units/L during low tide of Spring Tide. During spring tide sampling phytoplankton communities were dominated by *Skeletonema* sp almost forming a bloom in the Kandla creek and other nearby creek area and abundant population of *Coscinodiscus* sp. and *Chaetoceros* sp.

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

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

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

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

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

#### **Species Richness Indices and Diversity Indices:**

##### **Margalef's diversity index (Species Richness)**

Margalef's diversity index (Species Richness) of phytoplankton communities in the Kandla creek and nearby creeks sampling stations was varying from 2.184- 4.688 with an average of 3.346 during the sampling conducted in High tide period of spring tide. While Margalef's diversity index (Species Richness) S of phytoplankton communities in the Kandla creek region and nearby creeks was varying from 1.963- 3.589 with an average of 2.835 during the consecutive low tide period.

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

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

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

##### **Shannon-Wiener's index:**

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

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

communities in the sampling stations was in the range of 0.926- 1.001 between selected sampling stations with an average value of 0.951 during consecutive low tide at Kandla creek and nearby creeks. Shannon-Wiener's Index (H) of phytoplankton communities in the stations was 1.037 at OOT jetty area and 0.946 at SPM area during the sampling conducted in High tide period of spring tide. While Shannon-Wiener's Index (H) of phytoplankton communities in the path finder creek near OOT jetty was 1.043 and 0.982 at SPM during the consecutive low tide period of spring tide.

Shannon-Wiener's Index (H) of phytoplankton communities in the stations was 0.998 at OOT jetty area and 1.035 at SPM area during the sampling conducted in High tide period of Neap tide. While Shannon-Wiener's Index (H) of phytoplankton communities in the path finder creek near OOT jetty was 0.942 and at SPM area was 1.036 during the consecutive low tide period.

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

#### **Simpson's diversity index:**

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

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

Simpson diversity index (1-D) of phytoplankton communities in the stations was 0.863 at OOT jetty area and 0.820 at SPM area during the sampling conducted in High tide period of spring tide at Path finder creek. While Simpson diversity index (1-D) of phytoplankton communities in the path finder creek near OOT jetty was 0.876 and 0.867 at SPM during the consecutive low tide period in the path finder creek.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

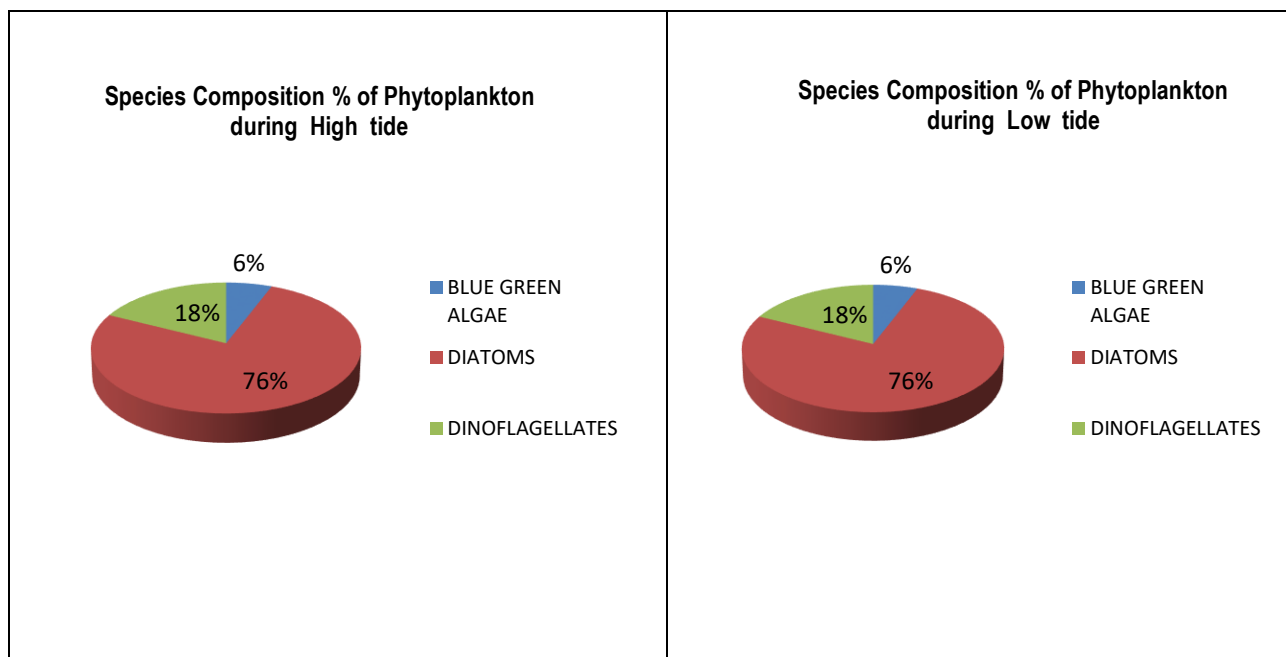
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	BLUE GREEN ALGAE	14-20	5/36	13.89
			DIATOMS	180-192	25/36	69.44
			DINOFLAGELLATES	3-6	6/36	16.67
			TOTAL PHYTO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

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

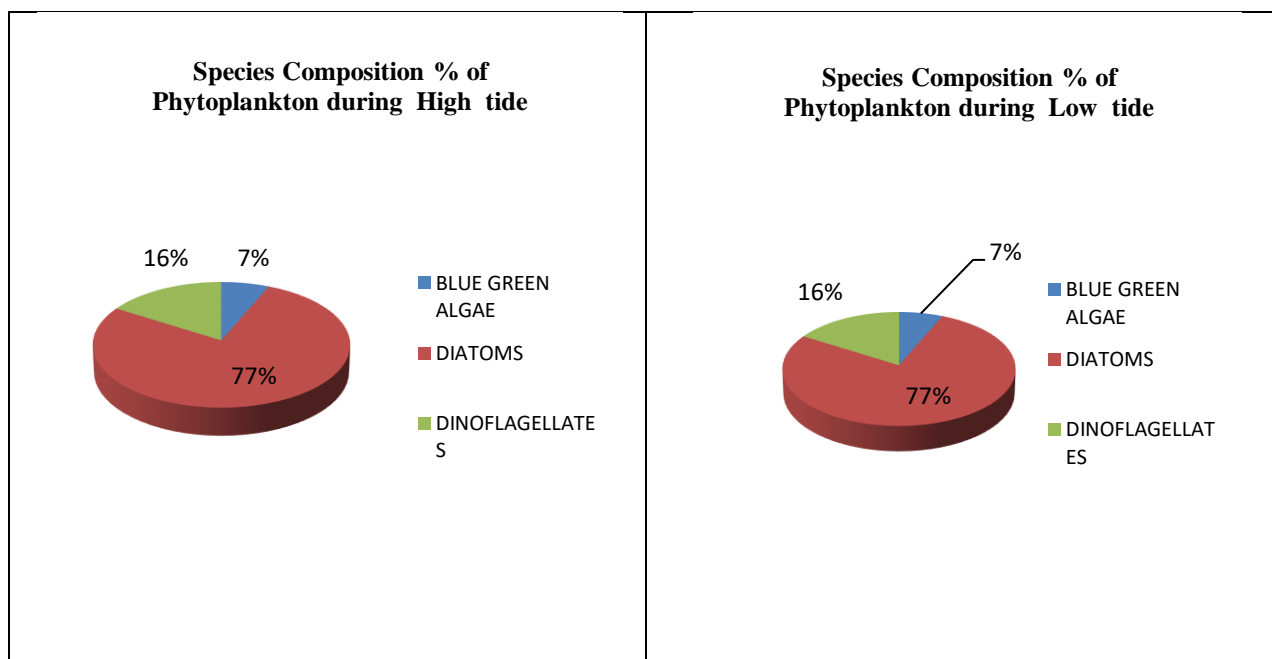
Tide	Surface	No of Sampling location	Group of phytoplankton	Phytoplankton Group range Units/L	Genera or species /total Phyto plankton	Species Composition % (Group level)
HIGH TIDE	Sub surface	2	BLUE GREEN ALGAE	5-7	4/42	9.52
			DIATOMS	238-248	32/42	76.19
			DINOFLAGELLATES	1-4	6/42	14.29
			TOTAL PHYTO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



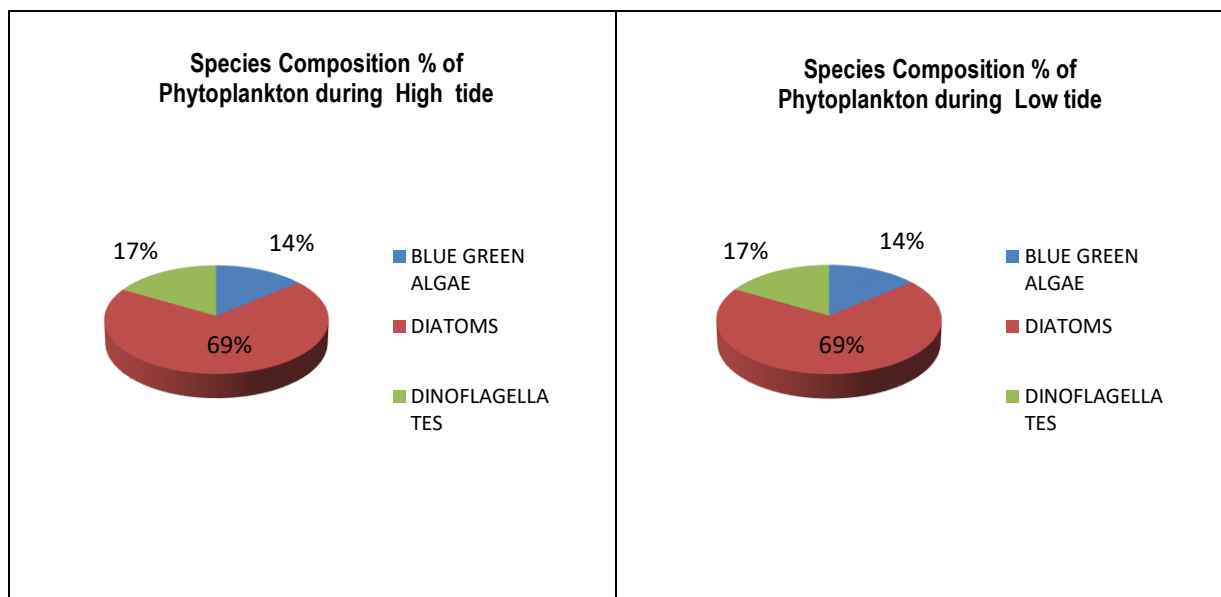
**Species Composition % of Phytoplankton during High tide and Low tide period during spring tide in Kandla creek and nearby creeks**



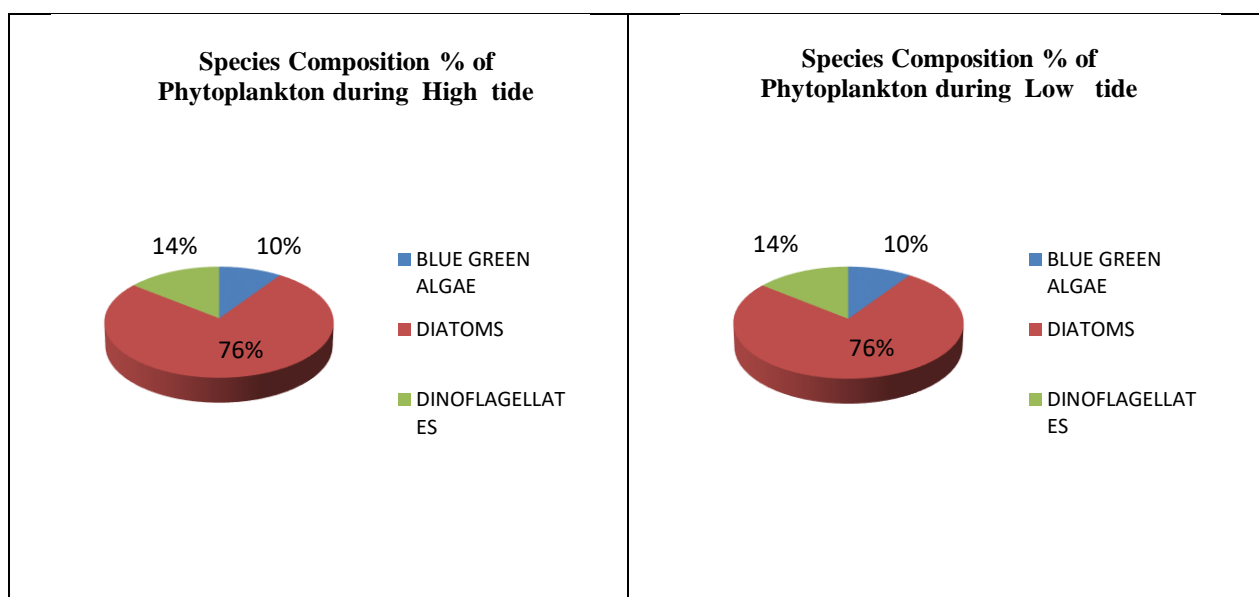
**Species Composition % of Phytoplankton during High tide and Low tide period during Neap tide in Kandla creek and nearby creeks**



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



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



### **ZOOPLANKTON POPULATION:**

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

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

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

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

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

Zooplankton of the sampling stations at sub surface layer in the DPA OOT Jetty area of path finder creek was  $91 \times 10^3 \text{ N/m}^3$  during high tide and  $86 \times 10^3 \text{ N/m}^3$  during low tide of Spring Tide period. Zooplankton of the sampling stations at sub surface layer in the DPA SPM area of path finder creek was  $101 \times 10^3 \text{ N/m}^3$  during high tide and  $70 \times 10^3 \text{ N/m}^3$  during low tide of spring Tide period.

Zooplankton of the sampling stations at sub surface layer in the DPA OOT jetty area in path finder creek was recorded  $87 \times 10^3 \text{ N/m}^3$  during high tide and  $65 \times 10^3 \text{ N/m}^3$  during consecutive low tide period of Neap tide. Zooplankton of the sampling stations at sub surface layer in the DPASPM area in path finder creek was recorded  $64 \times 10^3 \text{ N/m}^3$  during high tide and  $87 \times 10^3 \text{ N/m}^3$  during consecutive low tide period of Neap Tide.

### **Species Richness Indices and Diversity Indices:**

#### **Margalef's diversity index (Species Richness)**

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

Margalef's diversity index (Species Richness) of Zooplankton communities in the Kandla creek region and nearby creeks sampling stations were varying from 1.358-3.858 with an average of 2.930 during the sampling conducted in high tide and varying from 2.289- 4.618 with an average of 3.513 during the sampling conducted in low tide during Neap tide period.

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

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

#### **Shannon-Wiener's index:**

Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.778-1.164 between selected sampling stations with an average value of 0.939 during high tide period of spring tide. Shannon-Wiener's Index (H) of Zooplankton communities in the sampling stations in Kandla Harbour region and nearby creeks was in the range of 0.795-1.015 between selected sampling stations with an average value of 0.938 during consecutive low tide period.

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

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

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

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

**Simpson's diversity index:**

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

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

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

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

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

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

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

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

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

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $\times 10^3 / \text{m}^3$ Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	6	tintinnids	9-26	11/33	33.33
			Copepods	11-51	9/33	27.27
			Arrow worms	0-1	1/33	3.03
			Mysids	0-2	1/33	3.03
			Urochordata	1-6	2/33	6.06
			Ciliates	0-2	1/33	3.03
			Larval forms	4-50	8/33	24.25
			TOTAL ZOOPLANKTON N/ $\text{M}^3$	<b>25-128</b>	<b>33</b>	
LOW TIDE	Sub surface	5	Tintinnids	18-33	11/33	33.33
			Copepods	37-49	9/33	27.27
			Arrow worms	0-4	1/33	3.03
			Mysids	0-2	1/33	3.03
			Urochordata	0-2	2/33	6.06
			Ciliates	0-2	1/33	3.03
			Larval forms	41-65	8/33	24.25
			TOTAL ZOOPLANKTON N/ $\text{M}^3$	<b>103-144</b>	<b>33</b>	



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

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

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

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

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

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

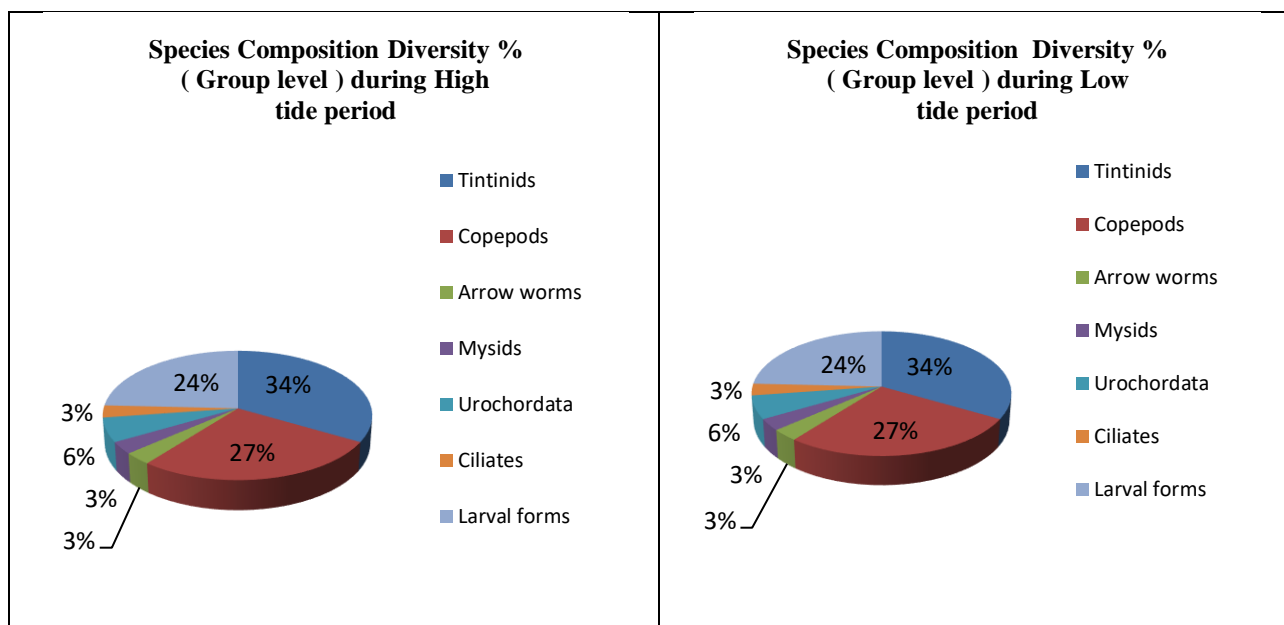
**Table:-61 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA OOT AREA AND PATH FINDER CREEK AND NEAR BY SPM DURING SPRING TIDE IN NOVEMBER 2022**

Tide	Surface	No of Sampling locations	Group of Zooplankton	Abundance of Zooplankton $\times 10^3 / m^3$ Group Range	Genera or species /total Zooplankton	Taxon Diversity % (Group level)
HIGH TIDE	Sub surface	2	Tintinnids	24-32	5/20	25.00
			Copepods	28-38	8/20	40.00
			Urochordata	1-2	2/20	10.00
			Ciliates	0-1	1/20	5.00
			Larval forms	30-36	4/20	20.00
			TOTAL ZOOPLANKTON	<b>91-101</b>	<b>20</b>	
LOW TIDE	Sub surface	2	Tintinnids	17-21	5/20	25.00
			Copepods	30-37	8/20	40.00
			Urochordata	0	2/20	10.00
			Ciliates	0	1/20	5.00
			Larval forms	19-32	4/20	20.00
			TOTAL ZOOPLANKTON	<b>70-86</b>	<b>20</b>	

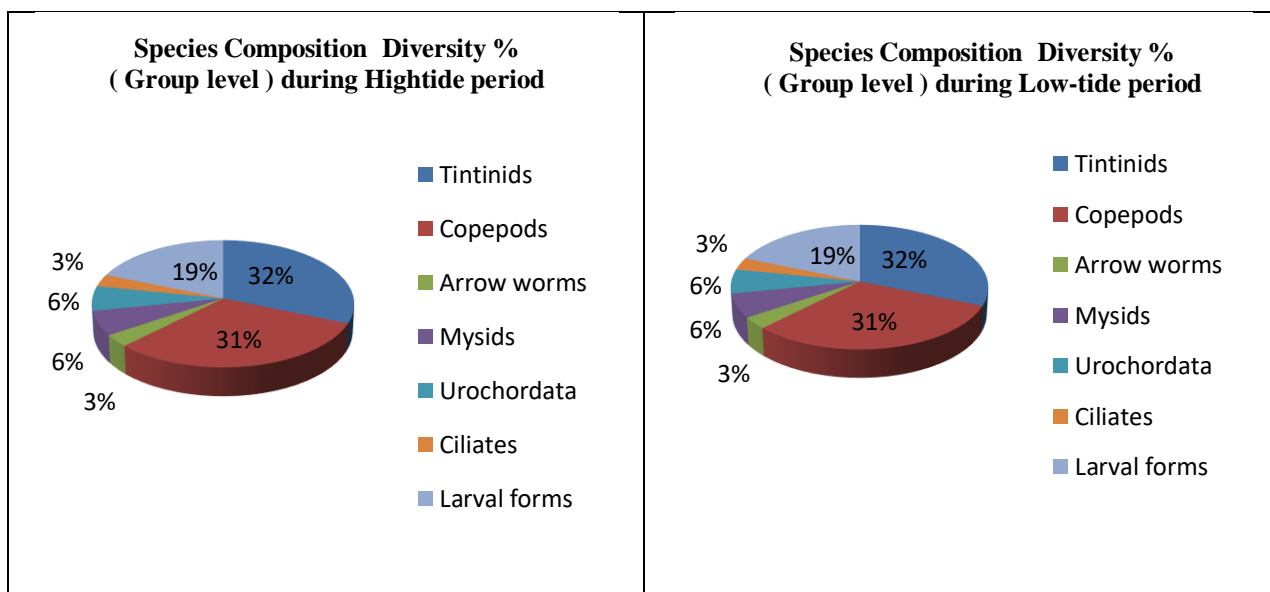
**TABLE:-62 ABUNDANCE OF ZOOPLANKTON IN SUBSURFACE SAMPLING STATIONS IN DPA OOT AREA AT PATH FINDER CREEK AND NEAR BY SPM DURING NEAP TIDE IN NOVEMBER 2022**

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

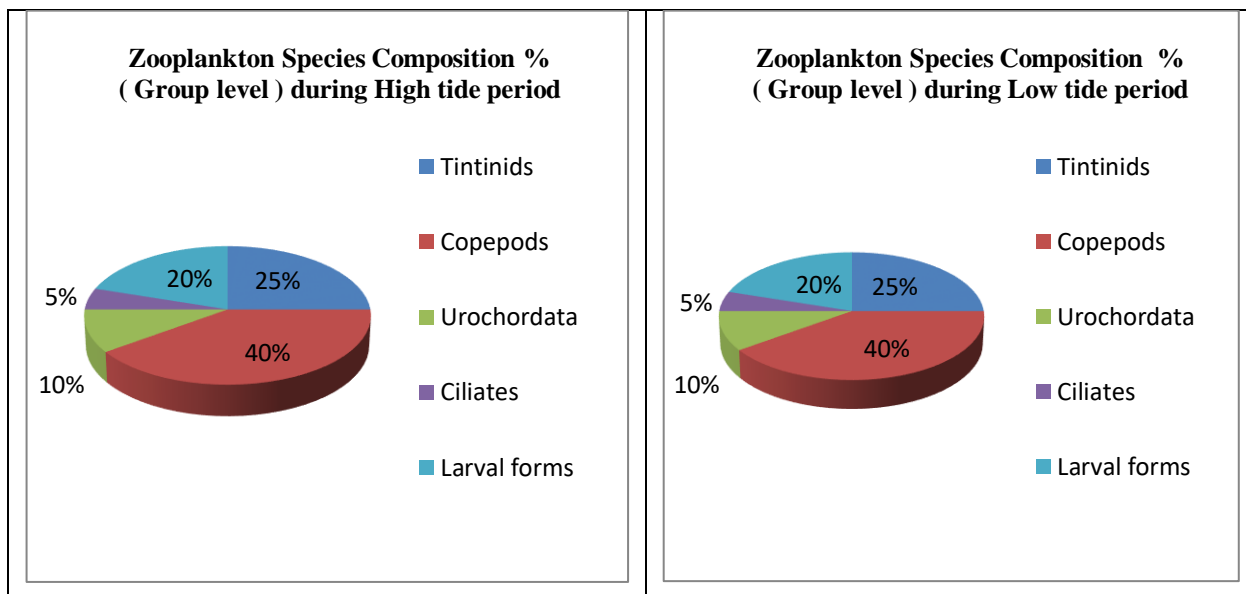
**Species Composition % of Zooplankton during High tide and Low tide period of spring tide In  
Kandla Creek and nearby Creeks**



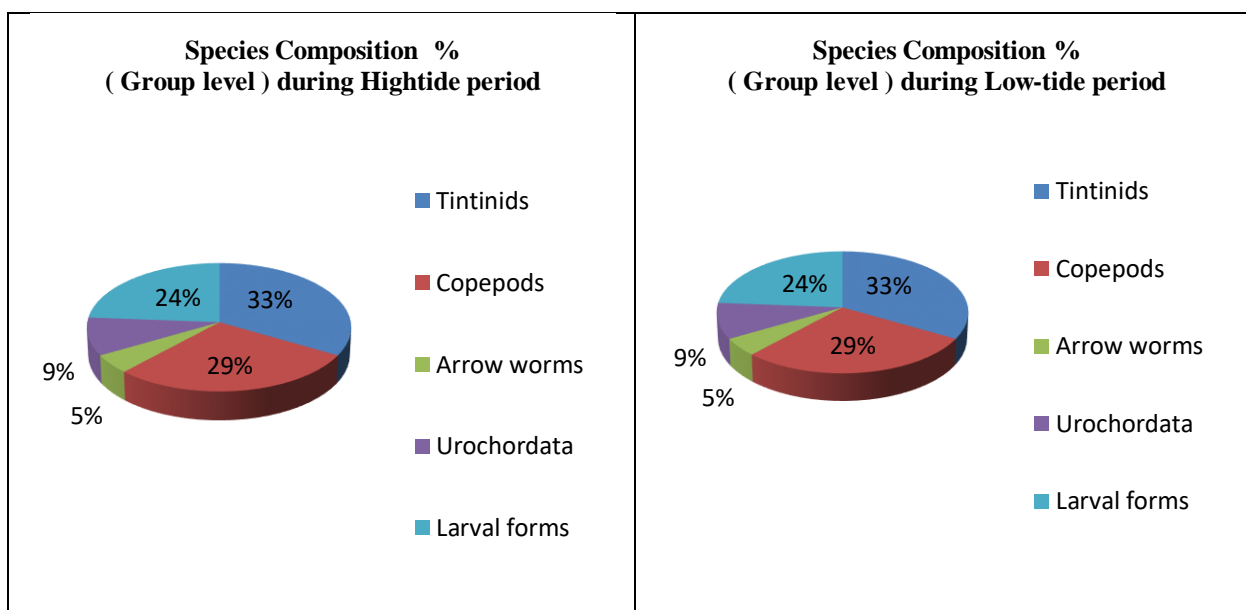
**Species Composition % of Zooplankton during High tide and Low tide period of Neap tide In  
Kandla Creek and nearby Creeks**



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



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



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

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

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

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

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



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

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

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

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

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

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

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

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

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

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

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

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



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

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

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

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

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

**BENTHIC ORGANISMS:**

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

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

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

NS: No sample

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

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

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

ABUNDANCE IN NO/M <sup>2</sup> DIFFERENT SAMPLING STATIONS		
REPRESENTATION BY GROUP	OOT Jetty Area	SPM area
<b>POLYCHAETES</b>		
Family : Glyceride <i>Glycerasp.</i>	20	40
Family : CIRRATULIDAE <i>Cirratulussp.</i>	0	20
Family: NEREIDAE <i>Nereis sp.</i>	30	10
<i>Amphipoda</i>	10	20
TOTAL Benthic Fauna NUMBER/ M <sup>2</sup>	60	80

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

ABUNDANCE IN NO/M <sup>2</sup> DIFFERENT SAMPLING STATIONS		
REPRESENTATION BY GROUP	OOT Jetty Area	SPM area
<b>POLYCHAETES</b>		
Family : Glyceridase <i>Glycera sp.</i>	20	40
Family: NEREIDAE <i>Nereis sp.</i>	30	10
TOTAL Benthic Fauna NUMBER/ M <sup>2</sup>	50	50

## **CHAPTER-11**

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

### 11.0 Conclusive Summary and Remedial measures Suggested

- The AAQ monitoring of six locations at Deendayal Port Authority indicates that the mean  $PM_{10}$  and  $PM_{2.5}$  values for four locations viz. Marine Bhavan, Oil Jetty, Estate Office and Coal storage area were found higher than the permissible limit (standards  $100 \mu g/m^3$ ,  $60 \mu g/m^3$ ). The higher concentration of Particulate matter at Marine Bhavan may be due to vehicles emissions during loading-unloading of food grains and timbers; at Estate office due to construction work, vehicles emission produced from trucks, heavy duty vehicles that pass through the road outside Kandla port and Oil jetty area; while at Coal Storage area lifting of coal from grab yard and other coal handling processes. Moreover, the transportation of coal produces pollution from heavy vehicles. At Tuna Port location, concentration of  $PM_{10}$  varied from  $88-175 \mu g/m^3$  and mean value was observed  $145 \mu g/m^3$  which was exceed the prescribed standard limit ( $100 \mu g/m^3$ ), concentration of  $PM_{2.5}$  was ranged from  $47-87 \mu g/m^3$  and mean was found  $71 \mu g/m^3$  which was exceed the standard limit ( $60 \mu g/m^3$ ). At Gopalpuri  $PM_{10}$  concentration ranged from  $67-168 \mu g/m^3$  and mean was  $127 \mu g/m^3$  while  $PM_{2.5}$  concentration ranged from  $34-94 \mu g/m^3$  and mean was  $66 \mu g/m^3$  were found exceed standard limit prescribed by NAAQS.
- At Vadinar, the average concentration of  $PM_{10}$  was  $114 \mu g/m^3$  and  $PM_{2.5}$  was  $74 \mu g/m^3$  at Admin Colony which was slightly exceed the standard limit while at Signal building the mean concentration  $PM_{10}$  was  $100 \mu g/m^3$  and  $PM_{2.5}$  was  $61 \mu g/m^3$  which were very close to standard limit.
- During winter, the concentration of  $PM_{10}$  and  $PM_{2.5}$  has been slowly augmented and reached a peak in the evening due to surface inversion of temperature after sunset. Thus, the pollutants are subsequently trapped in the lower layer of the atmosphere due to high atmospheric air pressure.
- Further, precautionary measures and management strategies to minimize the effect of particulate as well as gaseous pollutants have also been suggested for achieving its ambient levels in and around Kandla Port and Vadinar Port, Gujarat, India.
- Drinking water at all the twenty locations was found potable and it was found within in line of BIS standards (IS: 10500-2012).
- Transportation systems are the main source of noise pollution in project areas. Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading

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

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

#### **Reasons for higher Values of PM<sub>10</sub>**

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



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

### **Remedial Measures**

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

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

### **Solution towards the Green port:**

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

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

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

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

### **Green Ports Initiative**

- Deendayal Port is committed to sustainable development and adequate measures are being taken to maintain the Environmental well-being of the Port and its surrounding environs. Weighing in the environmental perspective for sustained growth, the Ministry of Shipping had started “Project Green Ports” which will help in making the Major Ports across India cleaner and greener. “Project Green Ports” will have two verticals - one is “Green Ports Initiatives” related to environmental issues and second is “Swachh Bharat Abhiyaan”.
- The Green Port Initiatives include twelve initiatives such as preparation and monitoring plan, acquiring equipments required for monitoring environmental pollution, acquiring dust suppression system, setting up of waste water treatment plants/ garbage disposal plant, setting up Green Cover area, projects for energy generation from renewable

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

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

## **CHAPTER-12**

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# **Annexure -IV**

## CSR Activities at Decadavul Port Trust

## Details of CSR

Sr. No	Year	Board Resolution For Budget Provision	Board Approved Budget Provision	Board Resolution for approval of the CSR activities	Board Approved Amount For CSR Activities	Actual exp. upto Nov'20 (Rs. In Lakhs)	Net balance (Rs. In Lakhs)	Remarks
1	2	3	4	5	6	7	6-7	
1	2011-2012	369 of 28.03.2012	3.00 Cr					
2	2012-2013	17 of 31.05.2012	4.00 Cr					
3	2013-2014	99 of 30.09.2013	6.43 Cr	64 of 30.08.2012	564.00 Lakh	564.00	Nil	Works completed
4	2014-2015	322 of 21.11.2014	1.07 Cr	20 of 16.04.2015	236.22 Lakh	188.18	8.04	Works in progress
5	2015-2016	151 of 12.02.2016	1.50 Cr	48 of 12.08.2016	28.00 Lakh	5.00	23.00	Works in progress
6	2016-2017	138 of 06.01.2017	2.60 Cr	52 of 2.8.2017	140.30 Lakh	146.00	-5.70	Works completed
7	2017-2018	41 of 2.08.2017	7.02 Cr	15 of 04.05.2018	155.10 Lakh	115.37	39.73	Works in progress
8	2018-19	51 of 07.08.2019	6.70 Cr	111 of 4.12.2018	154.90 Lakh	50.50	104.40	Works in progress
					1278.52 Lakh	1069.05	209.47	
9	2019-20	58 of 10.10.2019	5.49 Cr	92 of 06.12.2019	1838.57 Lakh	Nil		MoS approval is awaited
		Total	37.81 Cr		3117.09 Lakh	Spent in PM Fund for COVID-19-800 Lakhs		

Year-wise details of CSR works undertaken by DPT during 2012 – 13 to 2019 – 20 are given in **Tables 7.3a, 7.3b, 7.3c, 7.3d, 7.3e, 7.3f and 7.3g.**

**Table 7.3a: CSR Works Undertaken by DPT during 2011-12 and 2012 – 13**

Sl. No.	Name of Work	Cost (Rs. In lakhs)
1	Repair of road from Dr. Baba Saheb Ambedkar Circle to NH 8A (via Ganesh Nagar)	518
2	Repair of road from S.T. Bus Stand to Sunderpuri Cross Road via Collector Road	
3	Repair of road from NH 8A Railway Crossing to Maninagar (along railway track)	
4	Repair of road from Khanna Market Road (Collector Road) to Green Palace Hotel	
5	Construction of internal roads at “Shri Ram” Harijan Co-operative Housing Society (near Kidana)	
6	Construction of cremation ground and graveyard with other facilities at Vadinar	19.44
7	Providing cement concrete internal roads in Village Vadinar Stage - I	16.16
8	Approach road provided for developing tourism at Village Veera near Harsidhi Mata Temple	4.65
9	Water tank along with R.O. provided near developing tourism area	0.30
10	Creating facilities of flooring and steps surrounding lake to stop soil erosion and attract tourists at Village Veera.	4.80
	<b>TOTAL</b>	<b>563.35</b>

**Table 7.3b: CSR Works Undertaken by DPT during 2014-15**

Sl. No.	Name of Work	Cost (Rs. In lakhs)
1	Construction of community hall – cum – school at Maheshwari Nagar, Gandhidham	51.90
2	Renovation of “Muktidham” (cremation ground) at Kandla	10.65
3	Sunderpuri – 1 Valmiki Community Hall	5.00
4	Sunderpuri – 2 Valmiki Community Hall	5.00
5	Ganeshnagar Community Hall	10.00
6	Jagjivan Maheshwari Community Hall	10.00
7	Various works of road at Sapnanagar	99.19
8	Construction of compound wall in the dam of Jogninar Village	14.48
	<b>TOTAL</b>	<b>206.22</b>

**Table 7.3c: CSR Works Undertaken by DPT during 2015-16**

Sl. No.	Name of Work	Cost (Rs. In lakhs)
1	Construction of Bus Stand at Vadinar Village	10.00
2	Providing drainage system at Vadinar Village	6.00
3	Providing and laying of water supply lines in Vadinar Village	6.00
4	Road from Gandhidham Post Office to Merchantile Marine Department Office along with toilet facilities	60.00
5	Construction of toilets for girls / women at Khari Rohar, Village	3.00
6	Construction of toilets for girls at Mathak Primary School, Mathak, Village	3.00
	<b>TOTAL</b>	<b>88.00</b>

**Table 7.3d: CSR Works Approved by DPT Board for 2016-17**

Sl. No.	Name of Work	Cost (Rs. In lakhs)
1	RCC community hall at Harsidhi Mata Temple, Village Veera, Anjar Taluka	19.00
2	Fabricated Community Hall at Sanghad Village, Anjar Taluka	21.00
3	CSR Works for Shri Maheshwari Meghavad Samaj, Gandhidham at graveyard behind Redison Hotel	8.00
4	CSR Works for Shri Dhanraj Matiyadev Mukti Dham, Sector 14, Rotary Nagar, Gandhidham	30.50
5	CSR Works for Nirvasit Harijan Co-operative Housing Society, Gandhidham Health Cum Education Centre	41.00
6	CSR Works for Shri Rotary Nagar Primary School, Gandhidham	2.80
7	CSR Works at NU-4, NU-10(B) Sapnanagar & Saktinagar, Golden Jubilee Park at Gandhidham	18.00
	<b>TOTAL</b>	<b>140.30</b>

**Table 7.3e: CSR Works Approved for 2017-18**

Sl. No.	Name of Work	Proposal Received from / / Name of Organization / N.G.O	Cost (Rs. In lakhs)
1	CSR Works at Shri Ganesh Nagar High School, Gandhidham	Principal, Shri Ganesh Nagar Govt High School, Gandhidham	38.30 Lakhs
2	CSR Works for MOLANA AZAD Primary School, Kandla	Shri M L Bellani, Trustee, DPT, Shri Kandla Port Education Society, New Kandla	7.00 Lakhs
3	Grant financial contribution for facility of Army Cantonment for 50 nos. air coolers at Kutch Border Area	Shri Vinod L Chavda, MP	15 Lakhs
4	40% of the estimated cost of providing drainage lines at Tuna and Vandi villages under Swachh Bharat Abhiyan.	Shri Sarpanch, Tuna Village & Vandi village & Shri M L Bellani, Trustee, DPT	<b>Rs. 39.80 Lakhs</b> <i>Approx. estimated Cost Rs.99.50 Lakhs, of which 40% to be contributed by DPT.</i>
5	CSR works for S.H.N. Academy English School (managed by Indian Inst. Of Sindhology – Bharati Sindhu Vidyapeeth), Adipur	Director, S.H.N Academy English School	<b>40 Lakhs</b>
6	Construction of internal roads at Bhaktinagar Society, Kidana	Smt Maltiben Maheshwari, MLA	<b>15 Lakh</b>
	<b>TOTAL</b>		<b>155.10</b>

**Table 7.3f: CSR Works Approved for 2018-19**

Sl. No.	Name of Work	Proposal Received from / / Name of Organization / N.G.O	Cost (Rs. In lakhs)
1	CSR work to Donate 100 Nos of Computers to Daughters of Martyred Soldiers in the country under the "BETI BACHAO BETI PADHAO" program by Atharva Foundation, Mumbai	Chairman, Atharva Foundation, Mumbai	<b>24.00</b>
2	CSR work to Donate ONE (40 Seater) School Bus for Deaf Children Students for the Institute of Mata Lachmi Rotary Society, Adipur	Mata Lachmi Rotary Society, Adipur	<b>18.00</b>
3	CSR work to Providing One R.O Plant with Cooler at PanchyatPrathmikSala, Gadpadar Village for the ANARDE Foundation, Kandla&Gandhidham Center.	Dist. Rural Development Officer, Annarde Foundation-Kandla & Gandhidham	<b>1.50</b>
4	CSR work for Providing Drainage Line at MeghparBorichi village, AnjarTaluka	Shri Vasanbhai Ahir, MLA, Gujarat Govt	<b>25.00</b>
5	CSR work for Construction of Health Centre at Kidana Village	Shri Vinod L Chavda, MP	<b>13.00</b>
6	CSR work to provide 4 Nos. of Big Dust Bin for MithiRoharJuth Gram Panchayat.	Shri Sarapanch, Mithi RoharJuth Gram Panchayat	<b>3.40</b>

Sl. No.	Name of Work	Proposal Received from / / Name of Organization / N.G.O	Cost (Rs. In lakhs)
7	CSR work for Renovation & construction of shed at CharanSamaj, Gandhidham –Adipur.	Shri Vinod L Chavda, MP	10.00
8	CSR Work for Renovation/Repairing of Ceiling of School Building at A. P Vidhyalay, Kandla.	Smt Maltiben K. Maheshwary, MP, Gandhidham.	10.00
9	CSR work for Construction of Over Head Tank & Providing 10 Nos of Computers (for students) of NavjivanViklangSevashray, Bhachau, Kutch	Shri Jitendra Joshi, Founder Secretary, Shri Navjivan Viklang Sevashray, Bhachau, Kutch	9.50
10	CSR work to Provide Books & Tuition fees for Educational facilities to weaker section children of ValmikiSamaj, Kutch.	Shri Manohar Jala, Chairman of "National Commission of Safai Karamcharis"	2.00
11	CSR work to provide Water Purifier & Cooler for the ST. Joseph's Hospital, Gandhidham	Smt. Maltiben K Mahewari, MLA ,Gandhidham	1.50
12	CSR work for Construction of Second Floor (Phase – I) for Training Centre of "GarbhSanskran Kendra" "Samarth Bharat Abhiyan" of Kutch Kalyan Sangh, Gandhidham	Shri Vinod L Chavda, MP, Kutch	37.00
<b>TOTAL</b>			<b>154.90</b>

**Table 7.3g: CSR works approved for the year 2019-20 (approval from Ministry of Shipping still awaited)**

Sl. No.	Name of Work	Proposal Received from / / Name of Organization / N.G.O	Cost (Rs. In lakhs)
1	CSR activities for Providing Drainage line at Nani Nagalpar village.	Sarpanch of Village:-Nani Nagalpar, Taluk: Anjar.	3.00
2	CSR activities for Development of ANGANWADI Building at School no- 12 at Ward no 3 & 6 at Anjar.	Shri Vasanhbai Ahir, MLA	7.00
3	CSR activities for Improving the facilities of Garden at Sapna Nagar(NU-4)& (NU-10 B),Gandhidham.	Shri K P Maheshwari, Resident Sapnanagar, Gandhidham	18.00
4	CSR activities for Providing of Plastic Shredding Machine to Mirror Charitable Trust, Gandhidham.	Mirror Charitable Trust ,Gandhidham	4.75
5	CSR activities for development of School premises of Shri Guru Nanak Edu. Society, Gim.	Shri Guru Nanak Education Society, Gandhidham.	30.00
6	CSR activities for the improvement of the facilities at St. Joseph Hospital & Shantisadan at Gandhidham	St. Joseph Hospital Trust, Gandhidham	20.00
7	CSR activities for the improvement of the facilities at SVP (SardarValabhbbhai Patel ) Multipurpose Hall at Gandhidham	Request from MarwadiYuva Munch & UNION Gandhidham	500.00
8	Consideration of Expenditure for running of St Ann's High School at Vadinar of last 5 years 2014 to 2019 under CSR.	Proposal from COM, OOT Vadinar, DPT	825.00
9	CSR activities for development of school premises of Shri Adipur Group Kanya Sala no-1 at Adipur	Principal, Shri Adipur Group KanyaSala, Adipur	6.50
10	CSR activities for development of school premises of Shri Jagjivan Nagar Panchyat Prathmiksala, Gandhidham.	Principal, Shri Jagjivan Nagar Panchyat Prathmiksala, Gandhidham.	16.50
11	CSR activities for development of school premises of Ganeshnagar Government high school, Gandhidham.	Shri Vinod L Chavda, MP, Kutch	9.00
12	CSR activities for improving greenery, increase carbon sequestration and beat Pollution at Kandla, DPT reg.	Work awarded to Forest Department , Bhuj	352.32
13	CSR activities for providing infrastructures facilities at "Bhiratna Sarmas Kanya Chhatralaya" under the Trust of Samaj Nav- Nirman at Mirjapur highway, Ta Bhuj.	SamajNav- Nirman at Mirjapur highway, Ta Bhuj.	46.50
<b>TOTAL</b>			<b>1838.57</b>

**List of CSR applications received from various NGOs , Organizations , Village Sharpanchs etc for the FY 2021-22 .**

Sr.No	Name of Scheme	Proposal Received from / Name of Organization / N.G.O	Brief Details
1	CSR activities for the development of gardening at Sector -5 , Gim	Shri Sarvodaya Co-Operative Housing Society Ltd	<b>Appx Cost – Rs 25.00 Lakhs</b>  <b>Cost for –</b> Comp wall, Benches, Plantation, walkway, other facilities  (Land is reserved for Garden development only since from 50 years)
2	CSR activities for providing various facilities in SHRI GANESHNAGAR GOVT HIGHSCHOOL, GANDHIDHAM	Principal of School	<b>Appx cost –Rs 20.00 Lakhs</b>  (Two times CSR works carried out at school by DPT)
3	CSR activities for the VadhiyarVankarSamajvaadi, NaviSunderpuriGim	SmtMaltiben K Maheswari, MLA	<b>Appx Cost Rs 6.00 Lakhs</b>  Cost for Const. of Comp Wall
4	CSR activities for Construction work of Cabin at Oslo Area- Gim	SmtMaltiben& Shri VinadChavda	Cost not mentioned.
5	CSR activities & Land requirement forAkhil Kutch SamastaMeghvanshiGurjarmeghwal Charitable Trust ,Gim.	Shri Akhil Kutch SamastaMeghvanshiGurjarmeghwal Charitable Trust. Shri Dharmendra R Gohil	Cost Not mentioned.  (demand of Land for development of SAMAJ VADI in Gandhidham)
6	CSR Activities for providing Water supply pipe line, Play ground and sports equipment, electric facilities, drinking water facilities for poor people & Fishermen at VANDI Village.	Shri R RKhambhra, PRO , Collector Office, Bhuj.	<b>Appx Cost Rs 51.00 Lakhs</b>  (Last year also applied by village Sarpanch ) &  Recommended by Shri VASANBHAI AHIR, MLA, Shri V L Chavda, MP)
7	CSR activities for the Tuna village,	Sarpanch, Tuna village	<b>Appx Cost Rs. 25 Lakhs</b> <b>Cost for :-</b>



**List of CSR applications received from various NGOs , Organizations , Village Sharpnchs etc for the FY 2021-22 .**

Sr.No	Name of Scheme	Proposal Received from / Name of Organization / N.G.O	Brief Details
	Ta -Gim		2 No Fab shed 20'x20'x1250= 10 Lakh 2 Nos of Agnawadi =10 Lakh Fab shed for school=5 Lakh
8	CSR activities for the Global Vision India Foundation, Gim	Global vision India Foundation, G'dham	Requirement of Land –OR- Old building at Gandhidham for foundation of welfare activities.
9	CSR activities for the UNITED ORPHANAGE FOR THE DISABLED, TAMIL NADU	UNITED ORPHANAGE FOR THE DISABLED, TAMIL NADU	<b>Cost Rs 25,000.00</b>  (Winter sweaters for children)
10	CSR activities for the Garden Development on already bounded area with Compound wall near Plot no 448 Sector-1/A, Gandhidham.	Residents, near Plot no 448, Sector-1/A, Gim.	<b>AppxCost Rs 20.00 Lakhs</b>  (Requirement to provide benches, drinking water facility, plantation, lightings & walkways in side bounded area)
11	CSR activities for donation of Land for the Shri SUNDARPUI Govt Primary School, Gim	SmtMalti ben Maheshwari, MLA	(request for Land Requirement)
12	CSR activities for Extension of Adarsh Primary School building, Adipur	GandhidhamMatri Mandal, English Medium School, Adipur	<b>Appx Cost Rs. 40.00 Lakhs</b> (Construction for 4 Rooms extension)  (Trust registered under Societies Registration Act XXI -1860, Reg No F-42 dtd 23.9.1965. Land belong to Trust)
13	CSR Activities for providing HD projector for KANYA MAHA VIDYALAYA, Adipur	Principal, KANYA MAHA VIDYALAYA, Adipur	<b>Cost Rs 1.50 Lakhs</b>  (School Managed by G'dhamMaitry Mandal, Adipur)

**List of CSR applications received from various NGOs , Organizations , Village Sharpnchs etc for the FY 2021-22 .**

Sr.No	Name of Scheme	Proposal Received from / Name of Organization / N.G.O	Brief Details
14	CSR activities for DONATION various Medical Equipment for the Hospital of Gandhidham Jain SevaSamiti, Adipur	Gandhidham Jain SevaSamiti, Adipur	<b>Cost for :-</b> 1) Fresenius Haemodialysis Machine Rs 38.00 Lakh 2) Maltislice Helical CT Scanner- Rs 52.00 Lakhs 3) Others Rs 54.00 Lakhs <b>(Total Appx Cost Rs 144 Lakhs)</b>
15	CSR activities for SHRI VIDI JUTH GRAM PANCHAYAT, Vidi, Anjar	Sarpanch, Vidi Gram	<b>Appx Cost Rs 30.00 Lakhs</b>  Cost for- Drainage , Garbage vehicle, and Cattle shed  (Already applied earlier at Sr-5/12)
16	CSR activities for SOS CHILDREN'S VILLAGES INDIA, Madhapar, Bhuj	Director, SOS Children's Village of India-Bhuj	<b>Appx Cost Rs 31.00 Lakhs</b>  (request for Financial support towards parentless and abandoned Children Education support located at Bhuj ) & support to women working in SOS.
17	Gujarat Biodiversity Board, Gandhinagar invites to involved National & Global endeavour of conservation of biodiversity by creating financial partnership with GBB under CSR programme of expenditure to be incurred 187 Lakh.	GUJARAT BIODIVERSITY BOARD, GANDHINAGAR	<b>Requirement-</b> Financial Support from DPT for <b>AppxRs 1.88 Cr.</b>  (Cost for various meetings, collection of primary data from villagers , processing of documentation, printing , TA DA of Technical support & Miscexp for 150 Peoples Biodiversity Register (PBR).

**List of CSR applications received from various NGOs , Organizations , Village Sharpnachs etc for the FY 2021-22 .**

Sr.No	Name of Scheme	Proposal Received from / Name of Organization / N.G.O	Brief Details
18	CSR activities for providing furniture & Home appliances for ROJAVANAM TRUST at Madurai.	Shri Arul Kannan, Director	<b>Appx Cost Rs 30 Lakhs</b>  (seeking help to provide facilities to Aged & Homeless people living in Trust and Purchasing of New Ambulance)
19	CSR activities for providing Dialysis Machine for treatment of Kidney patients at "ST JOSEPH'S HOSPITAL TRUST" at Gandhidham.	Sr. Franciline, Administrator of Hospital.	<b>Appx Cost Rs 31.36 Lakhs</b>  (Cost of 5 Nos of Dialysis Machines for treatment of kidney patients)
20	CSR activities for providing facilities in Girls Hostel of Gasturba Gandhi BalikaVidhyalay, Gandhidham.	Shri Vinod L Chavda, MP	<b>Appx cost Rs 30 Lakhs.</b>  (Cost of Comp Wall, Entrance gate, Girls toilets etc)
21	CSR works for providing Oxygen Generator Plant and 45 KV Silent Generator for COVID HOSPITAL at Swami LilashahKutia, Adipur.	Secretary, BHARAT VIKAS PARISHAD, Gandhidham	<b>Appx Cost Rs 80.00 Lakhs</b>  (Facilities for 100 Beds of COVID patient which it to be extend upto 240 Beds)
22	CSR works for providing Two Numbers of Oxygen Concentrator and others medical equipment for the Trust ,Antarjal, Gim.	President SHRI SARV JEEV KALYAN TRUST, ANTARJAL, Gandhidham	<b>Appx Cost Rs21.50 Lakhs</b>  (Facilities to be provided for the treatment of CORONA PATIENTS at their trust.)
23	CSR works for providing Fabricated Shed , Construction of Compound Wall and Land levelling for the Cattle of <b>GauSevaSamiti-Tappar</b> at Gram-Tappar, Ta Anjar.	Shri Vinod Chavda, MP & Presedent , GauSevaSamiti, village Tappar, Ta-Anjar	<b>Appx Cost Rs84 Lakhs</b>  (Facilities to be provided for Cattle shelters at Village.) (Land belongs to Gram-panchayat)
24	CSR works for Construction of Auditorium Hall at RSETI (Rural Self Employment Training Institute) at	Shri Vinod Chavda, MP & Director of RSETI, Bhuj	<b>Cost not mentioned.</b>  (Facilities to be provided

**List of CSR applications received from various NGOs , Organizations , Village Sharpnchs etc for the FY 2021-22 .**

Sr.No	Name of Scheme	Proposal Received from / Name of Organization / N.G.O	Brief Details
	Bhujodi-Bhuj.		for the people needs Self-employment activities.)
25	CSR works for Providing of Furniture for the School "SHRI GALPADAR PANCHAYAT PRATHMIC KUMAR GROUP SALA " atGalpadar Village Ta Gim.	Principal, SHRI GALPADAR PANCHAYAT PRATHMIC KUMAR GROUP SALA " atGalpadar Village Ta Gim.	<b>Cost not mentioned.</b>  (Facilities to be provided for the Students of Workers & poor village people who study in the school.)
26	Construction of Shed, hall and Gate for the DADA Bhagwandas Charitable Trust, Adipur. (Sr no -4)	Shri Vinod Chavda, MP & DADA BHAGWANDAS CharitableTrust, Gandhidham	<u>As per CSR Guideline-</u> ➤ Promoting gender equality and empowering women ➤ Eradicating extreme hunger and poverty (Considered shed and hall )  Fab Shelter Shed - 30'x100' x 1250=37.00 Lakh & RCC Hall – 20'x100'x1500=30.00 Lakh  <b>(Appx Cost Rs67.00 Lakhs)</b> Land authority belongs to Trust given by GDA and NOC given by SRC.Doc submitted.
27	CSR work for reconstruction of the Internal Roads of the Sector-9B-C and Sector-10 area in Gandhidham.	President, Shri TejaKangad, The Gandhidham Chamber of Commerce and Industry, Gandhidham.	Cost not mentioned.

**List of CSR applications received from various NGOs , Organizations , Village Sharpanchsetc for the FY 2021-22 .**

Sr.No	Name of Scheme	Proposal Received from / Name of Organization / N.G.O	Brief Details
	<b><u>CSR Applications kept pending in last year Agenda:-</u></b>		
27	CSR Activities for providing Water supply pipe line, Play ground and sports equipment, electric facilities, drinking water facilities for poor people & Fishermen at VANDI Village. (Sr no-3)	Sarpanch ,Village-VANDI , Ta- Anjar  (Recommd. By Shri VASANBHAI AHIR, MLA, Shri V L Chavda, MP)	<u>As per CSR Guideline-</u> ➤ Env Sustainability ➤ Eradicating extreme hunger and poverty  (to be Consider for health Center ,Drainage line, Water sump etc activities) <b>(Appx Cost - 51.00 Lakhs )</b>  (Land authorization of Gram Panchayat)
28	Construction of Shed, hall and Gate for the DADA Bhagwandas Charitable Trust, Adipur. (Sr no -4)	DADA BHAGWANDAS CharitableTrust, Gandhidham  (Recommd. By Shri V L Chavda, MP)	<u>As per CSR Guideline-</u> ➤ Promoting gender equality and empowering women ➤ Eradicating extreme hunger and poverty (Considered shed and hall )  Fab Shed - 30'x100' x 1250=37.00 Lakh & RCC Hall – 20'x100'x1500=30.00 Lakh  <b>(Appx Cost Rs 67.00 Lakhs)</b> Land authority belongs to Trust given by GDA and NOC given by SRC. Doc submitted.
29	10 Nos of Computers required for ShirMaheswarinagar Panchayat Girls Primary School, Gandhidham& Boys Group School, Gandhidham. (Sr no-8)	Maheswarinagar Panchayat Primary Kanya Sala, Gandhidham  (Contact no 9913903686)	<b>AppxRs 5.00 Lakhs</b>  <u>As per CSR Guideline-</u> ➤ Promotion of Education (to be consider for 20 Computers)

**List of CSR applications received from various NGOs , Organizations , Village Sharpnchsetc for the FY 2021-22 .**

Sr.No	Name of Scheme	Proposal Received from / Name of Organization / N.G.O	Brief Details
			Visited the site. Land belongs to MahewariMeghwadSamaj given by SRC for school purpose, doc are awaited.
30	Construction of Shed and Roof at JeparMatiyadev, shamsanbhumi at Kidana village & Maheswari Community Hall at JuniSundarpuri, Gandhidham. (Sr no-10)	Shri VINOD CHAVDA, MP	<b>AppxRs 15.00 Lakhs</b>  (Land authorization not mentioned)
31	Drainage, road, Dust bins, & shed for Cattle shelters at VIDI Village, Ta –Anjar. (Sr no- 12)	Village- VIDI, Ta: Anjar	<b>AppxRs 30.00 Lakhs</b>  <u>As per CSR Guideline-</u> ➤ Env Sustainability ➤ Eradicating extreme hunger and poverty (Consider for Garbage vehicle & Drainage Cost)
32	Education, Women empowerment and Primary health care services at Kutch area. (Sr no-13)	Light of Life Trust, <b>Mumbai.</b>	Cost not mentioned.
33	Request for Help Divyang persons to employment by providing machineries. (Sr no-14)	Kutch DivyangSangthan, Gandhidham.	Cost not mentioned
34	Construction of 2 <sup>nd</sup> Floor of Shri MaheswariMeghwadSamaj, Gandhidham.  (Sr no-20)	Shri MaheswariMeghwadSamaj, Gandhidham	<b>AppxRs. 15.00 Lakhs</b>  (Visited the site and Land ownership documents awaited) (Name plate of DPT fixed at the Asset)

**List of CSR applications received from various NGOs , Organizations , Village Sharpanchsetc for the FY 2021-22 .**

Sr.No	Name of Scheme	Proposal Received from / Name of Organization / N.G.O	Brief Details
35	Installation of Mini Science Center at Anjar and Gandhidham. (Sr no-21)	STEM Learning Pvt Ltd, Mumbai.	Cost not mentioned.
36	CSR work for Shri Rampar Gram Panchayat. ➤ Wall Plastering for Cattles -7 Lakhs ➤ Shed for Cattel's-15 Lakhs  (Sr no-25)	Shri Sarpanch, Rampar Village.	<b>AppxRs 22.00 Lakhs</b>  (Land authorization of Gram Panchayat and under taking submitted by applicant)
37	CSR activities for the 45,000 Patients over the period of 3 years by "SMILE FOUNDATION", Mumbai.  1. Concept for Nutrition covering 3 years 2. Concept for Mobile Health Unit reaching beneficiaries for 3 years 3. Concept for Vocational Training with NGO (Sr no-29)	Proposal from "SMILE FOUNDATION " Mumbai.	Appx Cost- <b>Rs 539 Lakhs</b> for 3 years
38	Development of Park in Public utility plot in between Block "C" & "D" of Sapna Nagar (NU-4) , Gandhidham (Sr no -31)	Shri RAVI MAHESHWARI, DPT	Land belongs to DPT earmarked for recreational purpose.  (Total Cost – <b>Rs88.75 Lakhs</b> )
39	CSR works for NariJanshsktiVikas Foundation at Gandhidham near Shakti Nagar.  (Sr no-33)	NariJanshsktiVikas Foundation, Ahmedabad	➤ Promoting gender equality and empowering women ➤ Env Sustainability ➤ Under promotion of education  (Consider for Computers with printers, Sewing machine & RO plant <b>Cost Rs 48 Lakhs</b> )

# **Annexure -V**



## Annexure

**Subject:** Compliance of mitigation measures suggested in EIA report of the project “**Development of Integrated facilities (Stage II) within the existing Deendayal Port Trust (Erstwhile Kandla Port Trust) at District Kutch, Gujarat (1. Setting up of Oil Jetty No. 7 2. Setting up of Barge Jetty at Jafrabadi 3. Setting up of Barge port at Veera 4. An administrative office building at Tuna Tekra 5. the road connecting from Veera barge jetty to Tuna gate by M/s Deendayal Port Trust (Erstwhile Kandla Port Trust)**”

**Reference:** Specific Condition no. XXIII of Environmental and CRZ Clearance granted by MoEF&CC, GoI vide letter vide file no. 11-13/2015-IA-III dated 19/02/2020.

S.No.	Particulars	Location	Quantification	Proposed Measures	Compliance
1.	Generation of Particulates	Applicable to the proposed projects and surrounding	Not quantified	Spraying of water          Reducing speed of vehicles          Deploying vehicles with PUC certificate	To control dust pollution, regular sprinkling through tankers on roads and other area is being done.  DPA has installed Mist Canon at the Port area to minimize the dust.  DPA has issued Circular No. TF/SH/Circulars/2022/1341 dated 04/11/2022 considering the safety norms provided for smooth and continuous operation.  DPA has issued Circular regarding Implementation of RFID enabled access control system (e-Drishti); wherein, PUC certificate has been made mandatory for vehicle registration in e-Drishti portal to obtain valid permit for entry in the port premises.
2	Generation Noise	Along proposed projects	Not quantified	Restricted operation in the night time	DPA has issued Circular No. TF/SH/Circulars/2022/1341 dated

S.No.	Particulars	Location	Quantification	Proposed Measures	Compliance
				<p>Selection of machinery generating noise less than 72 db(A)</p> <p>Fitting on noise attenuation devices</p>	<p>04/11/2022 considering the safety norms provided for smooth and continuous operation.</p> <p>DPA has been conducting regular Monitoring of environmental parameters including noise since the year 2016 and the monitoring data has been regularly submitted to all the concerned authorities along with compliance reports submitted. The Environmental monitoring report submitted by M/s Detox Corporation, is enclosed with the EC compliance.</p> <p>Further, routine maintenance is being carried out to keep check on the efficiency and noise.</p>
Soil & Geology					
3	Soil erosion	Applicable to the proposed projects	Not quantified; initiates a chain of impacts	<p>Water bars; stabilization of slopes</p> <p>Controlled discharge of water</p> <p>Conducting construction activities in non-monsoon season</p> <p>Oil spill prevention measures</p>	<p>Topography at the site location is generally flat with average ground level of about 6.5 m CD with marshy topsoil. Kindly refer Section 3.4.1 Topography of the EIA report (<b>Copy attached as Annexure A</b>)</p> <p>Point noted</p> <p>The area falls under arid/semi-arid region, thus the rainfall is very scanty.</p> <p>DPA has Oil Spill Contingency Plan in place. Copy of the same is attached with the EC compliance report.</p>

S.No.	Particulars	Location	Quantification	Proposed Measures	Compliance
Hydrology					
4	Surface water contamination	At the proposed projects Soil erosion prone area	Not quantified	Soil erosion control measures	<p>For mitigating soil erosion, DPA entrusted work of green belt development in and around the Port area to the Forest Department, Gujarat at Rs. 352 lakhs (Area 32 hectares) and the work is already completed.</p> <p>For strengthening of the coastal resilience, DPA had already undertaken Mangrove Plantation in an area of 1500 Ha. till date since the year 2005. A statement showing details of the mangrove plantation and the cost incurred is already enclosed with the EC compliance report.</p> <p>Further, DPA is carrying out an additional mangrove plantation of 100 ha. with the consultation of the Gujarat Ecology Commission vide Work Order No. DD/WK/3050/Pt-I/GIM/PC-44 dated 02/06/2022 (Copy of the same is enclosed with the EC compliance report).</p> <p>DPA has been regularly monitoring environmental parameters including surface water since the year 2016 and the monitoring data has been regularly submitted to all the concerned authorities along with compliance reports submitted. The Environmental monitoring report submitted by M/s Detox Corporation, is enclosed with the EC compliance.</p>

S.No.	Particulars	Location	Quantification	Proposed Measures	Compliance
	Spillage and sanitary wastes			Waste management and spill control	For waste management, companies authorized by Central Pollution Control Board (CPCB) and State Pollution Control Board (SPCB) have been awarded the work of collection, transporting and disposal of solid waste by the DPA.  DPA has Oil Spill Contingency Plan in place. Copy of the same is attached with the EC compliance report.
5	Ground water contamination	Not expected			---
Land Use and Aesthetics					
6	Land use and Aesthetics	At project site  At campsites  At other utilities like scraper stations	Not quantifiable	Contouring of the affected areas    Cleaning the stretch immediately after the construction activities are over    Restoration and re-vegetation to the best possible	Topography at the site location is generally flat with average ground level of about 6.5 m CD with marshy topsoil. Kindly refer Section 3.4.1 Topography of the EIA report ( <b>Copy attached as Annexure A</b> )  DPA has included clause in tender/ Concession agreement for the contractor to undertake Clearance of site on completion and environmental protection measures. Copy of the relevant page of the tender is attached herewith as <b>Annexure B.</b>  DPA entrusted work of green belt development in and around the Port area to the Forest Department, Gujarat at Rs. 352 lakhs (Area

S.No.	Particulars	Location	Quantification	Proposed Measures	Compliance
				extent	<p>32 hectares) and the work is already completed.</p> <p>Further, DPA has appointed the Gujarat Institute of Desert Ecology (GUIDE) for "Green belt development in Deendayal Port Authority and its Surrounding Areas, Charcoal site' (Phase-I)" vide Work Order No.EG/WK/4757/Part [Greenbelt GUIDE, dated 31st May 2022.</p> <p>DPA had already undertaken Mangrove Plantation in an area of 1500 Ha. till date since the year 2005. A statement showing details of the mangrove plantation and the cost incurred is again attached with EC compliance report.</p> <p>Further, DPA is carrying out an additional mangrove plantation of 100 ha. with the consultation of the Gujarat Ecology Commission vide Work Order No. DD/WK/3050/Pt-I/GIM/PC-44 dated 02/06/2022 (Copy of the same is attached with EC Compliance report).</p>
Biological Environment: Flora and Vegetation					
7	Due to dusting on floral cover	At project site & approach road	Limited	Sprinkling of water for dust suppression.	<p>–DPA has installed Mist Canon at the Port area to minimize the dust.</p> <p>–Further, to control dust pollution in other area, regular sprinkling of treated water through tankers on roads is being done.</p>

S.No.	Particulars	Location	Quantification	Proposed Measures	Compliance
8	Removal of vegetation	At project site	Limited	Restoration and re-vegetation and plantation; Compensatory vegetation	<p>DPA entrusted work of green belt development in and around the Port area to the Forest Department, Gujarat at Rs. 352 lakhs (Area 32 hectares) and the work is already completed.</p> <p>Further, DPA has appointed the Gujarat Institute of Desert Ecology (GUIDE) for "Green belt development in Deendayal Port Authority and its Surrounding Areas, Charcoal site' (Phase-I)" vide Work Order No.EG/WK/4757/Part [Greenbelt GUIDE, dated 31st May 2022.</p> <p>DPA had already undertaken Mangrove Plantation in an area of 1500 Ha. till date since the year 2005. A statement showing details of the mangrove plantation and the cost incurred is attached with EC compliance report.</p> <p>Further, DPA is carrying out an additional mangrove plantation of 100 ha. with the consultation of the Gujarat Ecology Commission vide Work Order No. DD/WK/3050/Pt-I/GIM/PC-44 dated 02/06/2022 (Copy of the same is attached with EC compliance report).</p>
9	Due to Piling activity	At project site	Limited	Piling should be done in closed vessels to minimize the impact.	DPA has included clause in tender/ Concession agreement for the contractor to undertake piling installation in accordance with IS 2911. Copy of the relevant page of the tender is attached herewith as <b>Annexure C</b> .

S.No.	Particulars	Location	Quantification	Proposed Measures	Compliance
10	Due to dredging	At project site in Sea	Not quantified	Silt curtain should be used to minimize the impact.	The possibility of providing silt curtains to minimize the impacts while dredging activities in a study for "Comprehensive study for the Deepening of Navigational channel to increase the draught of Navigational channel at Deendayal Port Trust including Capital & Maintenance dredging requirements and Preparation of Technical & Commercial Feasibility Report" has been awarded to IIT, Madras.
11	Oil spillage & waste disposal from ships	Sea & creeks	Unlimited	Oily wastes and sewage should not be discharged directly; MARPOL norms should be followed.	DPA issued Grant of License/Permission to carry out the work of collection and disposal of "Hazardous Waste/Sludge/ Waste Oil" from Vessels calling at Deendayal Port" through DPA contractors. Further, it is to state that, all ships are required to follow DG Shipping circulars in line with MARPOL norm regarding the reception facilities at Swachh Sagar portal.
12	Fishes & Fishery	In project area	Limited	No legal fishery is in study area, major fish landing site is far from project site.	There is no fish landing centre in the study area. Kindly refer Sub-section D: Marine Fishes of Section 3.5.5 Fauna of the EIA report. (Copy of the relevant page is attached herewith as <b>Annexure D</b> ).
Fauna and Wildlife					
13	Loss of wildlife	No wildlife habitation in proximity	Not applicable	Strictly prohibiting hunting and similar activities	It is a custom bonded area, therefore, no hunting or similar activities are permitted in the port area. Moreover, in the study area of the KPT no National park, wildlife sanctuary or

S.No.	Particulars	Location	Quantification	Proposed Measures	Compliance
				<p>Restricting the speed of movement of vehicles</p> <p>Keeping “trench plugs” at strategic locations</p> <p>Shifting the nests, wherever possible</p>	<p>biosphere reserve is present. Kindly refer Section 3.5.5.4 Occurrence of National Park/Sanctuary/ Biosphere Reserve etc. of the EIA report (<b>Copy attached as Annexure E</b>).</p> <p>DPA has issued Circular No. TF/SH/Circulars/2022/1341 dated 04/11/2022 considering the safety norms provided for smooth and continuous operation.</p> <p>Point noted</p> <p>There is no considerable habitat of fauna in vicinity of the project site. Kindly refer Pg. 139, Section 4.3.1 Noise generation during Construction Phase (<b>Copy attached as Annexure F</b>).</p>
Socio-Economic and Cultural Environmental					
14	Human habitations affected	No habitation falling within the project site	Not quantified, but critical locations are identified	Villagers in the proximity will kept informed on the project activities	DPA has already given advertisement regarding grant of Environmental & CRZ clearance in two local news papers viz. KUTCHMITRA (In Gujarati) dated 23/2/2020 and in the Indian Express (In English) dated 23/02/2020 and also forwarded to the Regional Office , MoEF&CC, Bhopal vide letter dated 28/2/2020 (Copy of the same placed with EC&CRZ compliance report).
15	Economic implications	Along the project site	Not quantified. The implications	Compensation to the affected people; Employment, wherever possible, to	The law of the land will be followed by the BOT operator for employment. As per the



S.No.	Particulars	Location	Quantification	Proposed Measures	Compliance
			with regard to loss of seasonal crops and plantations are identified	the unskilled local people	Guidelines issued by the Ministry of Ports, Shipping & Waterways, Government of India, the CSR activities are being carried out by the DPA (Details attached with the EC compliance report).
16	Agriculture lands	At project site	No agriculture land involved	Restoration of the land; Management of topsoil	<p>No agriculture land is involved.</p> <p>For topsoil management, DPA entrusted work of green belt development in and around the Port area to the Forest Department, Gujarat at Rs. 352 lakhs (Area 32 hectares) and the work is already completed.</p> <p>Further, DPA has appointed the Gujarat Institute of Desert Ecology (GUIDE) for "Green belt development in Deendayal Port Authority and its Surrounding Areas, Charcoal site' (Phase-I)" vide Work Order No.EG/WK/4757/Part [Greenbelt GUIDE, dated 31st May 2022.</p>
17	Infrastructure	Near human habitations; Road and railway crossings	Not quantified	Rehabilitation of the affected infrastructure components; Leaving behind the infrastructure facilities like approach roads and facilities at the campsites for the local inhabitants	N/A
18	Social conflicts	Surrounding the proposed project.	Not quantifiable	Keeping good relationship with the local people; Keeping them informed on the project and project development.	As per the Guidelines issued by the Ministry of Ports, Shipping & Waterways, Government of India, the CSR activities are being carried out by the DPA (Details attached with the EC compliance report).

S.No.	Particulars	Location	Quantification	Proposed Measures	Compliance
					DPA has already given advertisement regarding grant of Environmental & CRZ clearance in two local news papers viz. KUTCHMITRA (In Gujarati) dated 23/2/2020 and in the Indian Express (In English) dated 23/02/2020 and also forwarded to the Regional Office , MoEF&CC, Bhopal vide letter dated 28/2/2020 (Copy of the same placed with EC&CRZ compliance report).
19	Political conflicts	-	Not quantifiable	Keeping the key players informed on the pros and cons of the project.	The key players shall be informed on the pros and cons of the project.
20	Historic and archaeological importance	Surrounding the 15.0 Km. radius from the proposed project.	No structure on the surface possibilities are there of sub-surface structure	Inform the concerned authority in case of coming across any structure of archaeological significance.	Point noted.  Further, it is relevant to mention here that, no area of cultural importance is present near the project. Kindly refer point h) of Section 2.5 Size or magnitude of operation. <b>(Copy attached as Annexure G).</b>

# **Annexure -A**

**Electrical Conductivity (EC)**

Electrical Conductivity (EC) varies from 56.3 to 62.1 mS/cm at various surface water sampling stations. Likewise EC in the bottom water samples ranged from 56 to 60.9 mS/cm. No significant variation in EC levels in surface and bottom water samples was observed.

**Calcium**

The calcium concentration ranged from 380 to 480 mg/l at various sampling location covered as part of the study.

**Magnesium**

The Magnesium concentration ranged from 1100 to 1500 mg/l at various sampling location covered as part of the study.

**Sodium**

The sodium concentration ranged from 12100 to 12800 mg/l at various sampling location covered as part of the study.

**Chloride**

The concentration of chloride ranged from 20700 to 23800 mg/l at various sampling location covered as part of the study. No significant variation in surface and bottom water samples was observed, which could be attributed to mixing due to tidal action.

**Nitrate**

The concentration of nitrate ranged from 0.086 to 0.122 mg/l at various sampling location covered as part of the study. No significant variation in surface and bottom water samples was observed.

**3.4 Land Environment**

**3.4.1 Topography**

Kandla is situated at the eastern end of the Gulf of Kutch and western bank of the Kandla Creek, on the west coast, north of Mumbai. Founded in 1952, and declared a major port



EIA EMP Report for Development of Integrated Facilities (Stage-II) within the Existing Kandla Port at Kandla, Gandhidham, Gujarat

in 1964, Kandla is a natural harbour and serves as an effective shelter, even in stormy weather. Kandla's natural advantage is its dry weather and mild monsoon, which minimizes loss of man-days, as well as damage to the cargo. The Port of Kandla is located on the Gulf of Kutch on the northwestern coast of India some 256 nautical miles southeast of the Port of Karachi in Pakistan and over 430 nautical miles north-northwest of the Port of Mumbai (Bombay). Topography at the site location is generally flat with average ground level of about 6.5 m CD. Topsoil appears mainly:

The 6th major port in India, Kandla is a key one in the region, and plays a major role in the country's international trade. Having notched up a string of successes, it has emerged as a forerunner, and has carved a niche for itself, by its steady growth and economy of operations. Maximum output, excellent infrastructure, all-round services and cost-effectiveness have all made Kandla the No.1 Indian port among 11 major ports in the country.

3.4.2 Land Use Classification of the Study Area

The land use/land cover map has been prepared based on Satellite Imagery for the year 2011. Land Use Classification of the study area with respect to major land use categories are presented in Table 35 and shown in Figure 38 given below.

Table 35: Land Use Classification based on Satellite Image

S.N.	Land use Type	Area in Ha	Percentage (%)
1	Settlement	5171	7.8
2	Barren Land	5251	7.9
3	Vegetation	9761	14.7
4	Mangrove	7431	11.2
5	Agriculture	6951	10.3
6	Barren Land	5081	7.7
7	Water Bodies	18321	27.6
8	Salt Pan	8431	12.7
	Total	66298	100

The maximum area covered in the study area falls under Water bodies (27.6%). Study area comprises of water flowing through creek, merging into sea at Gulf of Kutch. There



# **Annexure -B**

Clause 5.3). In case where on particular specification is given for any article or materials to be used workmanship employed shall be the best of their respective kinds in all respects and in accordance with the requirements, instructions and to the satisfaction of the Engineer/Engineer-in- Charge.

**5.06 CLEARANCE OF SITE ON COMPLETION**

On the completion of the works the Contractor shall clear away and remove from site as required all temporary works of every kind, constructional plants and also all surplus materials dismantled or otherwise, earth and rubbish and leave the whole site and works clean and in a workmanlike condition to the satisfaction of the Engineer/Engineer-in charge or the Representative.

**5.06.1** The Contractor shall clear the site prior to issuance of Completion Certificate. Site clearance means clearing of work site, site office, labour camps and any other structure constructed/erected by the contract

**5.07** The provision in special condition which form a part of the contract shall have precedence over those specified in General Conditions of Contract in case of diversity if any.

**5.08** Work is to be carried out as per detailed specification laid down in IS specification. MOST specification for road works, Latest IRC standard, and CPWD manual however the provisions made in contract documents and KPT SOR shall prevail.

**5.09** In case of items where no specifications is defined under IS, MOST or CPWD manual or KPT SOR or tender document superior quality of material available in market shall be applicable.

**5.10** The following clauses of the INSTRUCTION TO THE BIDDERS (Section– I) will not be applicable

Clause 1.8.2 (Bidding documents)

Clause 1.19.1, 1.19.2, 1.19.3 (sealing and marking of bids)

Clause 1.22.2.& 1.22.5 (Modification of withdrawal of Bid)

Clause 1.23.2, 1.23.3 (Withdrawal)

Clause 1.27.1, 1.27.2 (Correction of errors)

Clause 1.36.1 (Conciliator)

- 5.11**
- a) The clauses C & D of the SPECIMEN FOR FORM OF BID will not be applicable
  - b) Contractor Bid (Section -2) Contract price is not applicable.
  - c) Conciliator is not applicable under contract date of (section – 4)
  - d) Price Adjustment (i. e. Escalation) is not applicable under section – 4. However, Price Adjustment is applicable as per clause no 3.47 of Section -3

# **Annexure -C**



grabbing equipment using reversed or direct mud circulation method. The walls of the piles shall be stabilized by use of casing of M.S. liner upto depth as directed by the Nodal Officer and bentonite may be used for stabilized the pipe wall below M. S. liner. The size of cutting tool shall not be less than the diameter of the pile by more than 75 mm.

### **5.69.3 EQUIPMENT AND ACCESSORIES**

- (i) The contractor shall provide all equipment and accessories including consumables and temporary works for handling, fabricating, pitching during guiding and drying of liners if necessary.
- (ii) The contractor shall submit to the Nodal Officer or his nominee for his approval, full details of his proposed piling equipment, accessories, temporary works and method of pile construction, including the sequence of construction of the piles and cleaning up of work area. The contractor shall make such amendments or alterations as the Nodal Officer or his nominee may direct and no driving or boring shall start unless the method has been approved by the Nodal Officer.

### **5.69.4 LABOUR**

The Contractor shall maintain at the site qualified and experienced foremen and necessary gangs of trained workmen experienced in all piling work.

## **5.70 EXECUTION**

### **5.70.1 GENERAL**

Piling installation shall generally be in accordance with IS 2911. To avoid deflection of piles during construction stage, the contractor has to provide at his own cost temporary bracing of structural steel immediately after casting of bored in-situ piles till the piles are interconnected by R.C.C. deck beams. The design and provision of temporary bracings shall be contractors' responsibility entirely.

### **5.70.2 SEQUENCE PILING**

Piles shall be installed in such a sequence that the carrying capacity of previously installed piles is not reduced nor is there an appreciable upheaval of ground causing unusual soil resistance to rest of the pile driving. The Contractor shall submit the sequence order and programme chart to the Nodal Officer or his nominee.

### **5.70.3 BOTTOM LEVEL FOR PILES**

The liner should be driven to refusal. The boring within the liner shall be continued by chiseling, bailer grabbing etc. to a level to be approved by the Nodal Officer or his nominee. The embedment's indicated in the drawing are in the strata to be approved by the Nodal Officer. The walls of the piles shall be stabilized by use of casing of M.S. liner upto depth as shown in the drawings or refusal and by bentonite slurry below liner as directed by the Nodal Officer or his nominee. Jetting shall not be done except when permitted by the Nodal Officer.

# **Annexure -D**

#### D. Marine Fishes:

The proposed projects of Kandla port trust are lying in the existing industrial area. Several jetties of KPT, HPCL, Indian oil, fertilizer plant of IFCO, etc. are lying in the close proximity to each other. Since Kandla Port is one of the major port in India and major portion of the study area is occupied by Kandla port and other operators, fishing activities are very limited in the study area. There are 19 fish landing centres in Kutch district but there is no fish landing centre in the study area. As per the information collected from the department of fisheries office at Gandhidham, there is no fish pond as well, in the study area. However, small fishing activities with mechanized and traditional fishing crafts are operating from the Kandla creek. The major fish found in Kutch area are listed in the below table:

Table 46: List of common fish species found in the area

Scientific Name	Common Name	Local Name
<i>Carcharias domoieri</i>	White-shark shark	Chari mudi
<i>Carcharias australis</i>	Spot Tail Shark	Bulu
<i>Squalodon lalandi</i>	Yellow-fin shark	Chomudi
<i>Rhynchobutis sp.</i>	Shoof-nose ray	Ranudi
<i>Dasyatis sp.</i>	Shog-eye	Fakar
<i>Acipenser</i>	Sturgeon sea cat fish	Shomudi
<i>Chirocentrus dorsalis</i>	Wolf herring	Kandi
<i>Sardinella longirostris</i>	Orange scale sardine	Pobbi
<i>Sardinella longiceps</i>	Oil sardine	Tardi
<i>Uchis fish</i>	Indian hadd	Kudi
<i>Solepistes indicus</i>	White hadd	Kandi
<i>Solepistes indicus</i>	Indian anchovy	Dindag
<i>Prampolus indicus</i>	Bombay duck	Shomudi
<i>Sardinia kumbil</i>	Lizard fish	Chor bumbil
<i>Carillo decemmaculatus</i>	Anchovy	Mandi
<i>Epinephelus decemmaculatus</i>	Groupers	Gudra
<i>Channa argus</i>	Catfish	Chomudi
<i>Lutjanus niloticus</i>	Ribbon fish	Bulu
<i>Decapoda</i>	Russell's Scud	Tell bangad
<i>Crangon</i>	Traveller	Kat Bangad
<i>Leptocottus armatus</i>	Pony fish	Kat
<i>Leptocottus armatus</i>	Black Pomfret	Chomudi
<i>Pampus argenteus</i>	Silver Pomfret	Somudi
<i>Mastigaster kungur</i>	Mackerel	Shomudi
<i>Scomberomorus</i>	Sea fish	Shomudi
<i>Arctomelanus</i>	Frigate mackerel	Bugudi



# **Annexure -E**

**3.5.5.3 RET Species Flora/ Fauna (IUCN/ Indian Wildlife Act, 1972)**

**A. Flora under RET**

The project influenced area consists of sparse and patchy vegetation which is general in occurrence. No herb, shrub and tree species is falling in the list of Rare/threatened/endangered of Red Data Book of Indian Plants and IUCN.

**B. Fauna under RET**

No rare or threatened species are falling in the project influenced area.

**3.5.5.4 Occurrence of National Park / Sanctuary/ Biosphere Reserve etc.**

In the study area of the KPT no National park, wildlife sanctuary or biosphere reserve is present. However, Marine National Park and Marine Sanctuary in the Gulf of Katchchh is present on the southern part of the Gulf along the Jamnagar district. The sanctuary was declared in 1980 & Narsim park was in 1982. The aerial distance from the proposed project site to these areas is ranging approximately from 50-60 km.

**3.5.6 Trend analysis of fishing activity at Kandla creek & Tuna creek**

The survey of fishery resources along the Gujarat coast by the Fisheries Survey of India (FSI), GOI during 1979 to 1992 indicates that for a coastline of 1600 km covering a shelf area of 1,64,183 sq. km, the maximum sustainable yield is 7.73 lakhs MT and the value of marine fish landing in 1997-98 was 7.02 lakhs M.T. The northern areas of Kachchh were found to be the most productive areas and had a dominance of Silver Grouper and Cut Fish species. The fisheries statistics in the Kachchh coast (of 400 km length) reveals a fish production of about 71,787 tonnes in the year 1997-98, which is 10.22 % of the total fish production in Gujarat. Of this 70% of the landings i.e., 50193 occurred at Khori Creek and the coastal centres along the Arabian Sea (Okha). Most of the fishing landings occur at Vensul, Jakhau, Jafarbad, Shiyabot and Okha. In Kachchh, the largest fish landings occur at Jakhau (66.2%), while Kandla and Mitha Port account only for 3% of the Kachchh landings.

Fisheries are not prevalent in Tuna probably due to fish stock being low, relative to the other areas in the Gulf of Kachchh like Jakhau. It has been found that high tidal movements and unusually strong currents make trawling or gill netting for fish difficult



# **Annexure -F**

road & ground can effectively implemented to control the coal dust problem. During the operation phase proper EMP shall be in place for handling of coal.

The impact of the air pollution due these will be very negligible as the proposed project is in the coastal area. Due to the considerable wind speed the gaseous pollutant from these sources will get dispersed as soon as they are emitted and hence there will be no considerable impacts on air due the operation of the project. The short term increase in SO<sub>2</sub> will be insignificant enough to have any adverse effect. Moreover it is proposed to develop greenbelt in and along the premises, which will mitigate any adverse impacts on ambient air.

It is therefore concluded that there will no significant impacts on the air environment due to the proposed project.

#### 4.3 Noise Environment

Sources of noise during construction and operational phases and their predicted impacts are discussed below:

##### 4.3.1 Noise Generation during Construction Phase

The major impact on noise level of the proposed project, during the construction phase, is envisaged due to the noise generation by the operation of the machineries, equipments and some mechanical works. There are many equipments and machineries likely to be used during the construction. These are mainly recognized to be Dozers, Cranes, Excavators, Trailers, Generators, and Concrete Conveyor etc. It is envisaged that noise level due to this equipments will be around 70 dB(A) at receptor point at associated work/construction area. 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 & ear muffs) for the personnel likely to be exposed to high noise level. The noise level of these machineries / equipments shall be minimized by proper lubrication, modernization, maintenance, muffling and provision of silencers wherever possible.

The affected area will be the project site under construction activities for development of the proposed projects and nearby area of the region. The area of the projects is in port area and does not have any residential area in the range of noise propagation to cause adverse influence on environment. Further, construction activity would be carried out at daytime to prevent increase in noise level during night time.

There is no considerable habitat of fauna in vicinity of the project site. The major effects of the noise due to the predicted sources will be limited to the workers exposed to the high noise

# **Annexure -G**



## 2.5 Size or Magnitude of Operation

- a) Setting up of Oil Jetty No.7: The Oil jetty is proposed at Kandla with capacity of 2.0 MMTPA of size 110 x 12.40 mts. with approach of 210 mts. and back up area 01 ha. The capital dredging in Oil jetty will be 72,000 m<sup>3</sup> with maintenance dredging @ 15% per annum.
- b) Setting up of Barge Jetty at Jafarwadi (ON BOT BASIS) with capacity of 3.00 MMTPA, size of 180 x 20 mts. with back up area of 20ha. The capital dredging in barge jetty will be 80,000.00 m<sup>3</sup> with maintenance dredging @ 15% per annum.
- c) Setting up of Barge port at Veera (ON BOT BASIS) with capacity of 6.29 MMTPA, size of 160x60 mts. with back up area of 20ha. The dredging at Veera is not proposed.
- d) Construction of Administrative Office (AO) building at Tuna Ticks to provide infrastructure facilities with a built up area of 1600sq' on a plot of size 15,000sq'. The building will have 12 rooms including conference room, canteen and toilets etc.
- e) Road connecting from Veera barge jetty to Tuna gate with proposed length of 15.5km. The width of this proposed road will be 7.30 m with 1.50m shoulders on both sides.
- f) It is estimated that 30,600 KL water will be required. The source of water is to be arranged by the contractor and respective BOT operators.
- g) Total estimated cost of the project is 395.82 Crores.
- h) No biosphere reserves, wildlife sanctuary, national park or area of cultural importance is present near the project.
- i) The project site comes under coastal zone and CRZ clearance will be required. The project site does not touch any State or National boundary.
- j) The project site comes under Seismic zone-V. The site is connected by Road NH-8A, by train Gandhinagar Railway station.
- k) The terrain is flat with elevation from sea level to 3mt MSL.
- l) Kandla Port Trust area is No Fishing Zone.
- m) The project is located near Kandla creek. No diversion is proposed for implementation of the project. No shoreline change is envisaged.
- n) The Kandla Port Trust will make arrangements for Rain Water Harvesting. Adjacent to the AO Building, an underground tank of five kilo litre capacity will be provided. Also, adjacent to the container terminal office building, five kilo litre of rain water harvesting underground tank will be provided.

# **Annexure -VI**



## GUJARAT POLLUTION CONTROL BOARD

PARYAVARAN BHAVAN

Sector-10-A, Gandhinagar 382010

Phone : (079) 23222425

(079) 23222152

Fax : (079) 23232156

Website : www.gpcb.gov.in

### Application For CTE after EC

File No : GPCB/ (PCB ID. - 48573)

To,

M/s. Kandla Port Trust(Developing Integrated Facilities-Stage II).

within existing Kandla Port Trust Limit at Kandla, Administrative Office Building, Post

Box no.50,

City : Gandhidham ,

Dist : Kutch East ,

Taluka : Gandhidham

Sub: Consent to Establish (After obtaining Environment Clearance) under Section 25 of Water Act 1974 and Section 21 of Air Act 1981.

Ref: (1) Your online application No. 181633 dated 03/09/2020

(1) Environment Clearance issued by Central Authority vide their letter no. 11-13/2015-IA-III Dated 19/02/2020

Sir,

Without prejudice to the powers of this Board under the Water (Prevention and Control of Pollution) Act-1974, the Air Act-1981 and the Environment (Protection) Act-1986 and without reducing your responsibilities under the said Acts in any way, this is to inform you that this Board grants **Consent to Establish (After obtaining Environment Clearance) under Section 25 of Water Act 1974 and Section 21 of Air Act 1981** for manufacturing of products as mentioned into the Environment Clearance (EC) granted vide letter under reference no (2) above.

#### **Consent To Establish Is Granted Subject To The Following Conditions: -**

- 1) The validity period of this CTE shall be Seven Years from the issue of this order.
- 2) Applicant shall strictly comply with all conditions stipulated by competent authority in the order of Environment Clearance issued vide letter under reference No. : 2 above.
- 3) The applicant shall, however, not without the prior concern of the Board, bring into use any new or altered outlet for the discharge of effluent or gaseous emission or sewage waste from the proposed industrial plant. The applicant is required to make applications to this Board for this purpose in the prescribed forms under the provisions of the water Act - 1974, the Air - 1981 and the Environment (Protection) Act - 1986.

For and on behalf of  
Gujarat Pollution Control Board

K. B. Chaudhary  
ROH Head - Kutch East

- This order is issued to within existing Kandla Port Trust Limit at Kandla, Administrative Office Building, Post Box no.50, City : Gandhidham, Dist : Kutch East, Taluka : Gandhidham (48573) for CTE amendment after obtaining EC.

# **Annexure -2**

**Monitoring the implemental Safe guards**  
**Ministry of Environment, Forests and Climate Change**  
**Regional office (WZ), Gandhinagar.**  
**Monitoring Report (for the period up to November 2022)**  
**DATA SHEET**

Sr. No.	Particulars	Reply		
1.	Project type: River valley/ Mining/Industry/ thermal/nuclear/Other (specify)	Infrastructure and Miscellaneous Projects + CRZ		
2.	Name of the project	Development of Integrated facilities (Stage-II) within the existing Deendayal Port Trust (Erstwhile Kandla Port Trust) at District Kutch, Gujarat. (1. Setting up of Oil Jetty No.7. 2. Setting up of Barge jetty at Jafarwadi 3. Setting up of Barge port at Veera; 4. Administrative office building at Tuna Tekra; 5. Road connecting from Veera barge jetty to Tuna gate by Deendayal Port Authority (Erstwhile: Deendayal Port Trust)		
3.	Clearance Letter (s). OM no and date	Environmental/ CRZ Clearance accorded by the MoEF&CC vide File No. 11-13/2015-1A.III dated 19/02/2020.		
4.	Location a) District (s) b) State (s) c) Location/latitude/longitude	<b>Project</b>	<b>Location</b>	<b>Coordinates</b>
		Setting up of oil jetty No. 7	Old Kandla, Kachchh, Gujarat	70°13'14.09" E 23°02'22.21" N
		Setting up of Barge Jetty	Jafrawadi, Kachchh, Gujarat	70°12'36.4" E 23°04'33.6" N
		Setting up of Barge Jetty	Veera, Kachchh, Gujarat	70°01'21.08" E 22°54'26.3" N
		Administrative Office Building	Tuna Tekra, Kachchh, Gujarat	70°06'00.0" E 22°56'02" N
		Road	Veera Barge Jetty to Tuna Gate, Kachchh, Gujarat	70°01'21.0" E to 22°54'26.3" N 70°05'35" E to 22°58'22" N
5.	Address for Correspondence a) address of Concerned Project Chief Engineer (with pin code & telephone/telex/fax numbers)	Chief Engineer, Deendayal Port Authority, A.O. Building, Annex, Post-Box No.-50, Gandhidham- Kutch, Gujarat Pin – 370201 Tel: 02836-233192, Fax-02836-220050.  Chief Engineer, Deendayal Port Authority, A.O. Building, Annex,		



	<p>b) Others (please indicate whether these figures are based on any scientific and systematic survey carried out of only provisional figures, if a survey is carried out give details and years of survey).</p>	
10.	<p>Financial details</p> <p>a) Project cost as originally planned and subsequent revised estimates and the year of prices reference</p> <p>b) Allocation made for environmental management plans with item wise and year wise break-up</p> <p>c) Benefit cost ratio/Internal rate of Return and the year of assessment Whether (c) includes the cost of environmental management plans so far.</p> <p>d) Actual expenditure incurred on the project</p>	<p>Estimated project cost: Rs. 395.82 Cr.</p> <ol style="list-style-type: none"> <li>1. <u>Setting up of Oil Jetty No.7</u> : Cost - Rs. 72 Crores</li> <li>2. <u>Setting up of Barge jetty at Jafarwadi (On BOT Basis)</u> : Cost - Rs. 105 Crores).</li> <li>3. <u>Setting up of Barge port at Veera (On BOT Basis)</u> : Cost - Rs. 160 Crores).</li> <li>4. <u>Construction of Administrative office (Port Operational) building at Tuna Tekra</u> : Cost – Rs. 10 Crores.</li> <li>5. <u>Road connecting from Veera barge jetty to Tuna Gate</u> : Cost – Rs. 48.82 Crores.</li> </ol> <p>The allocation made under the “Environmental Services &amp; Clearance thereof other related Expenditure” scheme during BE 2022-2023 is Rs. 345 Lakhs.</p> <p>IRR: 12.5.%</p> <ol style="list-style-type: none"> <li>1. <u>Setting up of Oil Jetty No.7</u> : Cost - Rs. 36.00 Crores.</li> <li>2. <u>Setting up of Barge jetty at Jafarwadi (On BOT Basis)</u> : Construction not yet started</li> <li>3. <u>Setting up of Barge port at Veera (On BOT Basis)</u> : Construction not yet started</li> <li>4. <u>Construction of Administrative office (Port Operational) building at Tuna Tekra</u> : Construction not yet started.</li> <li>5. <u>Road connecting from Veera barge jetty to Tuna Gate</u> : Construction not yet started.</li> </ol> <p>The expenditure made by DPA under the scheme of</p>

	e) Actual expenditure incurred on the environmental management plans so far.	"Environmental Services & Clearance thereof other related Expenditure" is Rs. 275.36 Lakhs for period up to November, 2022.
11.	<p>Forest land requirement</p> <p>a) The status of approval for diversion of forest land for non-forestry use</p> <p>b) The status of clear felling</p> <p>c) The status of compensatory a forestation, if any</p> <p>d) Comments on the viability &amp; sustainability of compensatory a forestation programmed in the light of actual field experience so far</p>	<p>Nil</p> <p>Nil</p> <p>NIL</p> <p>Nil</p> <p>None</p>
12.	The status of clear felling in non-forest areas (such as submergence area of reservoir, approach roads), if any with quantitative information.	NA, no tree felling is required
13.	<p>Status of construction</p> <p>a) Date of commencement (Actual and/or planned)</p> <p>b) Date of completion (Actual and/or planned)</p>	<p><u>Setting up of Oil Jetty No.7</u> Construction under progress. The work of Jetty head, Central Platform, Berthing Dolphin, Pump House and Approach Jetty completed The work of mooring dolphin is in progress. a)Date of commencement (Actual and/or planned): 24/03/2020 b)Date of completion (Actual and/or planned) : Till 31/12/2022.</p> <p><u>Setting up of Barge jetty at Jafarwadi</u> No work started – project under planning stage</p> <p><u>Setting up of Barge port at Veera</u> No work started - project under planning stage</p>



		<p><u>The administrative office building at Tuna Tekra</u> No work started - project under planning stage</p> <p><u>A road connecting from Veera barge jetty to Tuna gate</u> No work started - project under planning stage</p>
1.	Reasons for the delay if the Project is yet to start	---
2.	<p>Date of site visited</p> <p>a) The dates on which the project was monitored by the regional office on pervious occasion. if any</p> <p>b) The date site visit for this monitoring report</p>	---
3.	<p>Details of the correspondence with project authorities for obtaining action plans/information on status of compliance to safeguard other than the routine letters for logistic support for site visit.</p> <p>(The first monitoring report may contain the details of all the letters issued so far but the later reports may cover only the letters issued subsequently.)</p>	---