DEENDAYAL PORT AUTHORITY
(Erstwhile: DEENDAYAL PORT TRUST)

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EG/WK/5202 (D)/ Part (CRZ 2) /364 Date: /8/09/2023

To,
The Deputy Director General of Forests,
Ministry of Environment, Forest & Climate Change
Integrated Regional Office, Gandhinagar,
A wing- 407 & 409, Aryan Bhawan,
Near CH-3 Circle,
Sector 10 A, Gandhinagar – 382 010.

Sub: Creation of water front facilities (Oil Jetties 8, 9, 10 & 11) and development of land of area 554 acres for associated facilities for storage at Old Kandla, Gandhidham, Kutch, Gujarat by M/s Deendayal Port Trust - Environmental & CRZ Clearance – **Submission of Six Monthly Compliance report for the stipulated conditions in EC&CRZ Clearance and Monitoring Report in Data sheet reg.**

Ref.: 1) EC & CRZ Clearance accorded by the MoEF&CC, GoI, New Delhi vide no. 10-1/2017-IA-III dated 20/11/2020.
2) Integrated Regional Office, Gandhinagar, MoEF&CC, GoI, Bhopal letter vide F. No. 6-1/2021 (ENV)/918 dated 10/3/2021 (Received by DPT on 19/3/2021).
3) DPT letter no. EG/WK/5202 (D)/ Part (CRZ 2) Dated 19/04/2021 – Submission of details asked by the R.O., MoEF&CC, GoI, Bhopal reg.
4) DPT letter no. EG/WK/5202 (D)/ Part (CRZ 2)/30 Dated 29/06/2021 – Submission of compliance report (Period upto May, 2021).
5) DPT letter no. EG/WK/5202 (D)/ Part (CRZ 2)/140 Dated 08/02/2022 – Submission of compliance report (Period June to Nov 2021).
6) DPA letter no. EG/WK/5202 (D)/ Part (CRZ 2)/127 dated 30/06/2022- Submission of compliance report (Period December to May, 2022)
7) DPA letter no. EG/WK/5202 (D)/ Part (CRZ 2)/295 dated 05/05/2023- Submission of compliance report (Period December to November, 2022)

Sir,

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

In this regard, it is to state that, with reference to the Integrated Regional Office, MoEF&CC, GoI, Bhopal letter dated 10/03/2021 (ref. 2), DPA vide above letter dated 19/4/2021 (ref. 3) has submitted details/information asked by the Regional Office, MoEF&CC, GoI, Bhopal in connection with the EC & CRZ Clearance granted by the MoEF&CC, GoI dated 20/11/2020 for the subject mentioned above. Subsequently,

.....cont.....

DPA vide above cited letters had submitted compliance report of stipulated condition in EC&CRZ Clearances to the Regional Office, MoEF&CC, GoI.

Now, as directed in the above referred letter dated 10/3/2021 of the Regional Office, MoEF&CC, GoI, Bhopal, kindly find enclosed herewith compliance report of stipulated conditions mentioned in the EC & CRZ Clearance granted by the MoEF&CC, GoI dated 20/11/2020 **(Annexure I)** & Monitoring Report in Data Sheet **(Annexure II) (Period upto May, 2023)** for kind information and record please.

Further, as per the MoEF&CC, Notification S.O.5845 (E) dated 26.11.2018, in which it is mentioned 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 above, in CD as well as through e-mail in ID rowz.bpl-mef@nic.in & eccompliance-guj@gov.in.

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

Yours faithfully,

Manager(Env.)
Deendayal Port Authority

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

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

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

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

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

ANNEXURE I

CURRENT STATUS OF WORK PROGRESS (Up to May, 2023)

Sr. No	Name of Project	Status
1	Oil Jetty No. 8 (Jetty & allied facilities)	Deendayal Port Authority issued work order to M/s Kargwal KM Joint Venture; Mumbai vide letter no. CN/WK/1571/Work/243 dated 3/2/2021. Work is in progress.
2	Oil Jetties no. 9, 10 & 11 to be implemented on BOT/PPP Mode.	The SFC recommendation and the MoPSW, GoI approval for Oil Jetties 9, 10 & 11, under PPP mode, has been received on 19/04/2021. a) The RFQ pre-qualification process concluded. Four out of five bidders have been prequalified to participate in the RFP (Bid) Stage. b) Bid due date of RFP extended up to 22/12/2022 • RFQ for OJ-10 shall be initiated only after 4 months of 'award of concession' for Oil Jetty no 9. Same analogy with OJ-11, in context of OJ-10. No construction activity started yet on project site.
3	Development of Land (area 554 acres) for associated facilities for storage.	DPA has issued work order to the Contractor, M/s Neelkanth Infratech Pvt. Ltd., Gandhidham on 14/12/2022 40% work of filling up of the entire back up area by quarry material is completed.

Annexure 1

COMPLIANCE REPORT (For the of period of December 2022 to May 2023)

Subject: Point wise compliance of stipulated conditions of EC & CRZ Clearance for ***"Creation of water front facilities (Oil Jetties 8, 9, 10 & 11) and development of land of area 554 acres for associated facilities for storage at Old Kandla, Gandhidham, Kutch, Gujarat by M/s Deendayal Port Authority (Erstwhile Deendayal Port Trust)".***

Reference: Environment and CRZ clearance accorded by the MoEF&CC, GoI vide file no. 10-1/2017-IA-III dated 20/11/2020.

Sr. No	Stipulated Conditions	Compliance
i	The Environmental and CRZ Clearance to the project is primarily under provisions of EIA Notification, 2006 and CRZ Notification, 2011. It does not tantamount to approvals/ consent/ permissions etc. required to be obtained under any other Act/Rule/regulation. The Project Proponent is under obligation to obtain approvals/ clearances under any other Acts/ Regulations or Statutes as applicable to the project.	The Consent to Establish (CTE) from the GPCB had already been obtained vide CTE No. 94118 granted by the GPCB vide letter no. PC/CCA-KUTCH 1524/GPCB ID 56985 dated 23/7/2018. Copy already submitted with the compliance report submitted on 05/05/2023 Further DPA has applied for the extension of the validity of the above mentioned CTE Copy already submitted with the compliance report submitted on 05/05/2023
ii	The project proponent shall abide by all the commitments and recommendations made in the Form-II, EIA and EMP report and also that have been made during their presentation to EAC.	Work is in progress (Oil Jetty No. 8 - Jetty & allied facilities and development of backup area of oil jetty no. 8 to 11 (Phase I)). It is hereby assured that DPA will abide by all the commitments and recommendations made in the Form-II, EIA and EMP report and also that have been made during presentation to EAC.
iii	Construction activity shall be carried out strictly according to the provisions of the CRZ Notification, 2011. No construction works other than those permitted in Coastal Regulation Zone Notification shall be carried out in Coastal Regulation Zone area.	Work is in progress (Oil Jetty No. 8 - Jetty & allied facilities and development of backup area of oil jetty no. 8 to 11 (Phase I)). Construction activity is being carried out strictly as per the provisions of the CRZ notification, 2011. Further, it is also assured that, no activity other than those permissible in Coastal Regulation Notification is being carried out in CRZ area.
iv	All the recommendations and conditions specified by the Gujarat Coastal Zone Management Authority (GCZMA) vide letter No. ENV-I0-2018-24-T cell dated 30th July, 2020 shall be complied with.	The compliance report of CRZ Recommendation issued by the GCZMA dated 30/7/2020 is attached herewith as **Annexure I**
v	The Project proponent shall ensure that no creeks or rivers are blocked due to any activities at the project site and free flow of water is maintained. Creek water monitoring program shall be implemented during the construction phase.	Work is in progress (Oil Jetty No. 8 - Jetty & allied facilities and development of backup area of oil jetty no. 8 to 11 (Phase I)). It is hereby assured that, no creeks or rivers is being blocked, due to any activities at the project site and free flow of water is maintained.
	Dredging shall not be carried out during the fish breeding season. Dredging, etc. shall be carried out in confined manner to reduce the impacts on marine environment. Silt curtains shall be used to minimize spreading of silt plume during dredging using online monitoring system. Turbidity	Point noted for compliance. However, No dredging activities have been started yet w.r.t. subject project.

	should be monitored during the dredging. No removal of silt curtain unless baseline values are achieved.	
vii	As proposed the dredged material can be used to provide an engineered base for marine terminal i. e., oil jetties 8 -11 and construction yard . The impact of dredging on the marine environment should be monitored and necessary measures shall be taken on priority basis if any adverse impact is observed.	Work is in progress (Oil Jetty No. 8 - Jetty & allied facilities and development of backup area of oil jetty no. 8 to 11 (Phase I)). Point noted for compliance.
viii	Marine ecological monitoring and its mitigation measures for protection of phytoplankton, zooplanktons, macrobenthos, estuaries, sea-grass, algae, sea weeds, Crustaceans, Fishes, coral reefs and mangroves and migratory birds etc. as given in the EIA-EMP Report shall be complied with in letter and spirit through a reputed university/institute with financial support as desired. Six monthly reports of the studies to be provided to the regional office of MoEFCC.	Work is in progress (Oil Jetty No. 8 - Jetty & allied facilities and development of backup area of oil jetty no. 8 to 11 (Phase I)). DPA assigned work to M/s GUIDE, Bhuj vide work order dated 3/5/2021 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 reg. (for three years (2021-2024)). The second year Monsoon season report for the year 2022-2023 submitted is attached herewith as **Annexure II** DPA has been regularly submitting the reports with the six-monthly compliance report to the regional office of MoEF&CC.
ix	Continuous online monitoring of air and water covering the total area shall be carried out and the compliance report of the same shall be submitted along with the 6 monthly compliance report to the regional office of MoEF&CC.	DPA appointed NABL Accredited laboratory for regular Monitoring of environmental parameters since the year 2016 in continuation of this DPA appointed M/s Gujarat Environment Management Institute (GEMI), Gandhinagar (NABL Accredited laboratory) for regular Monitoring of environmental parameters vide work order dated 15/02/2023. The work is in progress & DPA is submitting the monitoring data regularly to all the concerned authorities along with compliance reports submitted. A copy of monitoring report is attached herewith as **Annexure III** DPA already invited the tender for Continuous Ambient Air Quality Monitoring System (CAAQMS). However, bidders participated were disqualified as they have not satisfied the tender criteria. Further, it is relevant to mention here that, the process for re-inviting tender has been initiated for which EOIs were invited and scrutinization of the same is under progress.
x	The actions shall be in accordance with proposed landscape planning concepts to minimise major landscape changes. The change in land use pattern shall be limited to the proposed port limits and be carried out in such a way as to ensure proper drainage by providing surface drainage systems including storm water network.	Point Noted. DPA vide EC&CRZ Clearance accorded by MoEF&CC, GoI vide letter dated 20/11/2020 has proposed provision for storm water collection for harvesting the rainwater and using it for irrigation or fire-fighting purpose

		which will also act as a buffer to cater for the risk for flooding due high intensity rainfall coincident with the high tide.
xi	Suitable preventive measures be taken to trap spillage of fuel / engine oil and lubricants from the construction site. Measures should be taken to contain, control and recover the accidental spills of fuel during cargo handling.	Work is in progress (Oil Jetty No. 8 - Jetty & allied facilities and development of backup area of oil jetty no. 8 to 11 (Phase I)). And no construction started yet at oil Jetty 10 and 11. DPA is already having Oil Spill Contingency Plan to meet with the any accidental oil spill.
xii	All the mitigation measures submitted in the EIA report shall be prepared in a matrix format and the compliance for each mitigation plan shall be submitted to the RO, MoEF&CC along with half yearly compliance report.	The compliance of the mitigation measures submitted in the EIA report prepared in matrix format is attached herewith as **Annexure IV**
xiii	The company shall draw up and implement Corporate Social Responsibility Plan as per the Company's Act of 20l3.	As per the CSR Guidelines issued by the Ministry of Ports, Shipping & Waterways, Government of India, from time to time, DPA have been undertaken CSR activities since the year 2011-12. The details of CSR Activities undertaken & planned is attached herewith as **Annexure V**
xiv	As per the Ministry's Office Memorandum F. No. 22-65/2017-IA.III dated 30th September, 2020, the project proponent, based on the commitments made during the public hearing, shall include all the activities required to be taken to fulfill these commitments in the Environment Management Plan along with cost estimates of these activities, in addition to the activities proposed as per recommendations of EIA Studies and the same shall be submitted to the ministry as part of the EIA Report. The EMP shall be implemented at the project cost or any other funding source available with the project proponent.	Public Hearing is exempted. However, as specified in the Environmental Management Plan, DPA NABL Accredited laboratory for regular Monitoring of environmental parameters since the year 2016 in continuation of this DPA appointed M/s Gujarat Environment Management Institute (GEMI), Gandhinagar (NABL Accredited laboratory) for regular Monitoring of environmental parameters vide work order dated 15/02/2023. The work is in progress & DPA is submitting the monitoring data regularly to all the concerned authorities along with compliance reports submitted. A copy of monitoring report is attached herewith as **Annexure III** DPA issued work order to M/s GUIDE vide its letter no. EG/WK/ 4751 /Part (Marine Ecology Monitoring)/12 dated 03/05/2021 for preparation of Detailed marine biodiversity plan. The second year monsoon season report is attached herewith as **Annexure II.** DPA had already taken up the greenbelt Development activity through Forest Department, GoG, at the cost of 352.32 lakhs (Green Belt development in DPA area in an area of 31.942 Ha.) Further, DPA has appointed the Gujarat Institute of Desert Ecology (GUIDE) for "Green belt development in Deendayal Port Authority and its Surrounding Areas, Charcoal site' (Phase-l)" vide Work Order No.EG/WK/4757/Part [Greenbelt GUIDE, dated 31st May 2022. The work is completed a copy is attached herewith as **Annexure VI**

		Further DPA has accorded the work of "Green belt development in DPA and its surrounding area (Phase II) to Gujarat Institute of Desert Ecology (GUIDE), Bhuj for the plantation of 10000 saplings of suitable species vide work order dated 23/06/2023. The same is in process it is relevant to mention here that, DPA already issued Grant of License/Permission to carry out the work of collection and disposal of "Hazardous Waste/Sludge/ Waste Oil" from Vessels calling at Deendayal Port through DPA contractors. Further, it is to state that, all ships are required to follow DG Shipping circulars regarding the reception facilities at Swachch Sagar portal.
xv	In pursuance o f Ministry's OM No. stated above the project proponent shall add one annexure in the EIA Report indicating all the commitments made by the PP to the public during public hearing and submit it to the Ministry and the EAC.	Public Hearing is exempted. Hence, Not applicable.
B. STANDARD CONDITIONS: **I. Statutory compliance:**		
i.	Construction activity shall be carried out strictly according to the provisions of CRZ Notification, 2011 and the State Coastal Zone Management Plan as drawn up by the State Government. No construction work other than those permitted in Coastal Regulation Zone Notification shall be carried out in Coastal Regulation Zone area.	Work is in progress (Oil Jetty No. 8 - Jetty & allied facilities and development of backup area of oil jetty no. 8 to 11 (Phase I)). Construction activity is being carried out strictly as per the provisions of the CRZ notification, 2011. Further, it is also assured that, no activity other than those permissible in Coastal Regulation Notification will be carried out in CRZ area. No construction started yet at oil Jetty 10 and 11.
ii	A certificate of adequacy of available power from the agency supplying power to the project along with the load allowed for the project should be obtained.	Work is in progress (Oil Jetty No. 8 - Jetty & allied facilities). Necessary certificate of adequacy of available power will be provided in due course.
iii	All other statutory clearances such as the approvals for storage of diesel from Chief Controller of Explosives, Fire Department, Coast Guard, Civil Aviation Department shall be obtained, as applicable by project proponents from the respective competent authorities.	Point Noted for compliance.
II. Air quality monitoring and, preservation:		
i.	The project proponent shall install system to carryout Ambient Air Quality monitoring for common/criterion parameters relevant to the main pollutants released (e.g. PM 10 and PM 2.5 in reference to PM emission, and S02 and NOx in reference to S02 and NOx emissions) within and outside the project area at least at four locations, covering upwind and downwind directions.	Work is in progress (Oil Jetty No. 8 - Jetty & allied facilities and development of backup area of oil jetty no. 8 to 11 (Phase I)). However, for DPA area, it is also relevant to mention here that, DPA has been conducting regular Monitoring of environmental parameters since the year 2016 through NABL Accredited laboratories. The work is in progress & DPA submitted monitoring data regularly to all the concerned authorities along with compliance reports submitted. The latest

		monitoring report are attached herewith as **Annexure III**
ii.	Appropriate Air Pollution Control (APC) system shall be provided for all the dust generating points including fugitive dust from all vulnerable sources, so as to comply prescribed emission standards.	– DPA has installed Mist Canon at the Port area to minimize the dust. – Further, to control dust pollution in other area, regular sprinkling through tankers on roads and other staking yards is being done. – Further, it is relevant to mention here that, DPA had already issued general circular vide dated 3/9/2019 regarding Construction and Demolition Waste Management for strict implementation in DPA. Copy submitted with compliance report submitted on 05/05/2023.
iii.	Shrouding shall be carried out in the work site enclosing the dock/proposed facility area. This will act as dust curtain as well achieving zero dust discharge from the site. These curtain or shroud will be immensely effective in restricting disturbance from wind in affecting the dry dock operations, preventing waste dispersion, improving working conditions through provision of shade for the workers.	DPA has included clause in the tender to take all the necessary measures to reduce dust.
ix.	Dust collectors shall be deployed in all areas where blasting (surface cleaning) and painting operations are to be carried out, supplemented by stacks for effective dispersion.	Point noted for compliance.
x.	The Vessels shall comply the emission norms prescribed from time to time.	Point noted for compliance.
xi	Diesel power generating sets proposed as source of backup power should be of enclosed type and conform to rules made under the Environment (Protection) Act, 1986. The height of stack of DG sets should be equal to the height needed for the combined capacity of all proposed DG sets. Use of low sulphur diesel. The location of the DG sets may be decided with in consultation with State Pollution Control Board.	Point noted for compliance.
xii	A detailed traffic management and traffic decongestion plan shall be drawn up to ensure that the current level of service of the roads within a 05 kms radius of the project is maintained and improved upon after the implementation of the project. This plan should be based on cumulative impact of all development and increased habitation being carried out or proposed to be carried out by the project or other agencies in this 05 Kms radius of the site in different scenarios of space and time and the traffic management plan shall be duly validated and certified by the State Urban Development department and the P.W.D.! competent authority for road augmentation and shall also have their consent to the implementation of components of the plan which involve the participation of these departments.	DPA appointed M/s Tata Consulting Engineers Limited for traffic studies and management as a part of Master Plan preparation for the SIPC Location 1(Adipur) & Location 2(Kandla) in 2016. Further, for diversion of port-related traffic and transportation, DPA has obtained Environmental & CRZ Clearance from SEIAA, GoG vide letter dated 19/06/2020 for construction of Interchange cum Road Over Bridge. The work is currently under progress.
III. Water quality monitoring and preservation:		
i.	The project proponent shall ensure that no creeks or rivers are blocked due to any activities at the project site and free flow of water is maintained.	It is assured that no creeks are blocked due to any activities at the project site and free flow of water is maintained.
ii	Appropriate measures must be taken while undertaking digging activities to avoid any likely degradation of water quality. Silt curtains shall	Point Noted for compliance. Dredging activities not started yet for this project.

	be used to contain the spreading of suspended sediment during dredging within the dredging area.	
iii	No ships docking at the proposed project site will discharge its on-board waste water untreated in to the estuary/ channel. All such wastewater load will be diverted to the proposed Effluent Treatment Plant of the project site.	Point Noted for compliance. Further, it is relevant to mention here that, DPA already issued Grant of License/Permission to carry out the work of collection and disposal of "Hazardous Waste/Sludge/ Waste Oil" from Vessels calling at Deendayal Port through DPA contractors. Further, it is to state that, all ships are required to follow DG Shipping circulars regarding the reception facilities at Swachch Sagar portal.
iv	Measures should be taken to contain, control and recover the accidental spills of fuel and cargo handle.	Point Noted for compliance. It is also relevant to mention here that DPA is already having Oil Spill Contingency Plan.
v	The project proponents will draw up and implement a plan for the management of temperature differences between intake waters and discharge waters.	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. Further, the treated sewage will be utilized for plantation and gardening purposes.
vi	Spillage of fuel/engine oil and lubricants from the construction site are a source of organic pollution which impacts marine life. This shall be prevented by suitable precautions and also by providing necessary mechanisms to trap the spillage.	DPA has included clause in the tender to not let any oil and greasy wastes in the sea water.
vii	Total fresh water use shall not exceed the proposed requirement as provided in the project details. Prior permission from competent authority shall be obtained for use of fresh water.	Agreed with the condition.
viii	Sewage Treatment Plant shall be provided to treat the wastewater generated from the project. Treated water shall be reused for horticulture, flushing, backwash, BVAC purposes and dust suppression.	Waste water will be treated in the existing STP of DPA (1.5 MLD). Treated water is being reused for plantation/gardening.
ix	A certificate from the competent authority for discharging treated effluent/ untreated effluents into the Public sewer/ disposal/drainage systems along with the final disposal point should be obtained.	No effluent will be generated. The sewage generated will be treated in the Sewage treatment plant and the treated water will be reused for plantation/gardening.
x	No diversion of the natural course of the river shall be made without prior permission from the Ministry of Water resources.	Point Noted.
xi	All the erosion control measures shall be taken at water front facilities. Earth protection work shall be carried out to avoid erosion of soil from the shoreline/boundary line from the land area into the marine water body.	Work is in progress (Oil Jetty No. 8 - Jetty & allied facilities and development of backup area of oil jetty no. 8 to 11 (Phase I)). It is relevant to mention here that, for strengthening of coastal resilience as per the directions of the GCZMA and MoEF&CC, GoI, till date, DPA had already undertaken Mangrove Plantation in an area of 1600 Ha. till date since the year 2005. A statement showing details of mangrove plantation at various locations with cost incurred is placed at **Annexure VII**.
IV. Noise monitoring and prevention:		
i	Noise level survey shall be carried as per the	Work is in progress (Oil Jetty No. 8 - Jetty & allied facilities and development of backup

	prescribed guidelines and report in this regard shall be submitted to Regional Officer of the Ministry as a part of six-monthly compliance report.	area of oil jetty no. 8 to 11 (Phase I)). DPA has been conducting regular Monitoring of environmental parameters including noise level survey since the year 2016 through NABL Accredited laboratories. The work is in progress & DPA submitted monitoring data regularly to all the concerned authorities along with compliance reports submitted. The latest monitoring report are attached herewith as **Annexure III**
ii	Noise from vehicles, power machinery and equipment on-site should not exceed the prescribed limit. Equipment should be regularly serviced. Attention should also be given to muffler maintenance and enclosure of noisy equipments.	Work is in progress (Oil Jetty No. 8 - Jetty & allied facilities and development of backup area of oil jetty no. 8 to 11 (Phase I)). For DPA area, regular Monitoring of environmental parameters including noise level is being conducted since the year 2016 through NABL Accredited laboratories. The latest monitoring report are attached herewith as **Annexure III**
iii	Acoustic enclosures for DG sets, noise barriers for ground-run bays, ear plugs for operating personnel shall be implemented as mitigation measures for noise impact due to ground sources.	Work is in progress (Oil Jetty No. 8 - Jetty & allied facilities and development of backup area of oil jetty no. 8 to 11 (Phase I)). DPA has included clause in the tender for the contractor to provide protective clothing or other appliances for security of operating personnel. 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. The work is completed a copy is attached herewith as **Annexure VI** Further DPA has accorded the work of "Green belt development in DPA and its surrounding area (Phase II) to Gujarat Institute of Desert Ecology (GUIDE), Bhuj for the plantation of 10000 saplings of suitable species vide work order dated 23/06/2023. The same is in process
iv	The ambient noise levels should conform to the standards prescribed under E(P)A Rules, 1986 viz. 75 dB(A) during day time and 70 dB(A) during night time.	Work is in progress (Oil Jetty No. 8 - Jetty & allied facilities and development of backup area of oil jetty no. 8 to 11 (Phase I However, for DPA area, it is also relevant to mention here that, DPA has been conducting regular Monitoring of environmental parameters since the year 2016 through NABL Accredited laboratories. The latest monitoring report are attached herewith as **Annexure III**
V. Energy Conservation measures:		
i	Provide solar power generation on roof tops of buildings, for solar light system for all common areas, street lights, parking around project area and maintain the same regularly;	Work is in progress (Oil Jetty No. 8 - Jetty & allied facilities and development of backup area of oil jetty no. 8 to 11 (Phase I)). It is assured that, the stipulated condition will be complied with.

		Further, it is relevant to mention here that, DPA has commissioned a 45 kWP Solar Plant at Gandhidham on 7th July, 2022. DPA has installed 400 KWP solar plant and 600 KWP to be installed this year by PPP operator. 4000 Acres of land has been identified for developing 150 MW Hybrid (Solar Cum Wind) Energy Park.
ii	Provide LED lights in their offices and port areas.	In this regard, it is to state that, 1500 LED has been installed in port area.
VI. Waste management:		
i.	Dredged material shall be disposed safely in the designated areas.	The dredged material will be disposed at designated dumping ground (Latitude 22°51'00" N & Longitude 70°10'00" E).
ii	Shoreline should not be disturbed due to dumping. Periodical study on shore line changes shall be conducted and mitigation carried out, if necessary. The details shall be submitted along with the six monthly monitoring reports.	DPA assigned the work "Shoreline Change Study for Deendayal Port Authority (Erstwhile Deendayal Port Authority), Kandla, Kachchh District, Gujarat, to Study the Effect of Dumping, if any" vide their work order dated 12/10/2021 to NCSCM, Chennai. The work has been completed and the final report is attached herewith as **Annexure. Copy submitted with compliance report submitted on 05/05/2023**
iii	Necessary arrangements for the treatment of the effluents and solid wastes must be made and it must be ensured that they conform to the standards laid down by the competent authorities including the Central or State Pollution Control Board and under the Environment (Protection) Act, 1986.	Sewage generated in the port area is treated in the STP (1.5 MLD capacity) at Kandla and the treated sewage is utilized for gardening/ plantation purposes. Further, DPA has been conducting regular Monitoring of environmental parameters including STP monitoring since the year 2016 through NABL Accredited laboratories. The latest monitoring report are attached herewith as **Annexure III**
iv	The solid wastes shall be managed and disposed as per the norms of the Solid Waste Management Rules, 2016.	Work is in progress (Oil Jetty No. 8 - Jetty & allied facilities and development of backup area of oil jetty no. 8 to 11 (Phase I)). DPA has included clause in the tender for the Contractor to implement procedures regarding Construction Waste Management and disposal.
v	Any wastes from construction and demolition activities related thereto shall be managed so as to strictly conform to the Construction and Demolition Waste Management Rules, 2016.	Work is in progress (Oil Jetty No. 8 - Jetty & allied facilities and development of backup area of oil jetty no. 8 to 11 (Phase I)). And, implementation of Oil jetties 9,10 and 11 by BOT/PPP mode is under bidding stage. DPA has included clause in the tender for the Contractor to implement procedures regarding Construction Waste Management and disposal. DPA had already issued general circular vide dated 3/9/2019) regarding Construction and Demolition Waste Management for strict implementation in DPA. Copy submitted with the compliance report submitted on 05/05/2023.

vi	A certificate from the competent authority handling municipal solid wastes should be obtained, indicating the existing civic capacities of handling and their adequacy to cater to the M.S.W. generated from project.	Work is in progress (Oil Jetty No. 8 - Jetty & allied facilities and development of backup area of oil jetty no. 8 to 11 (Phase I)). However, it is assured that necessary certification from the competent authority will be obtained.
vii	Used CFLs and TFLs should be properly collected and disposed off/sent for recycling as per the prevailing guidelines/ rules of the regulatory authority to avoid mercury contamination.	Point Noted for compliance.
viii	Oil spill contingency plan shall be prepared and part of DMP to tackle emergencies. The equipment and recovery of oil from a spill would be assessed. Guidelines given in MARPOL and Shipping Acts for oil spill management would be followed. Mechanism for integration of terminals oil contingency plan with the overall area contingency plan under the co-ordination of Coast should be covered.	DPA is already having Oil Spill Contingency Plan and Disaster Management Plan Copy submitted with the compliance report submitted on 30/06/2022.
VII. Green Belt:		
i	Green belt shall be developed in area as provided in project details with a native tree species in accordance with CPCB guidelines.	Work is in progress (Oil Jetty No. 8 - Jetty & allied facilities and development of backup area of oil jetty no. 8 to 11 (Phase I)). However, it is assured that necessary Green belt will be provided as per the condition stipulated. Further, it is relevant to mention that, DPA had already taken up the greenbelt Development activity through Forest Department, GoG, at the cost of 352.32 lakhs (Green Belt development in DPA area in an area of 31.942 Ha.) Further, 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. The work is completed a copy is attached herewith as **Annexure VI** Further DPA has accorded the work of "Green belt development in DPA and its surrounding area (Phase II) to Gujarat Institute of Desert Ecology (GUIDE), Bhuj for the plantation of 10000 saplings of suitable species vide work order dated 23/06/2023. The same is in process
ii	Top soil shall be separately stored and used in the development of green belt.	Point noted for compliance.
VIII. Marine Ecology:		
i	The dredging schedule shall be so planned that the turbidity developed is dispersed soon enough to prevent any stress on the fish population.	It is assured that DPA will comply with the condition stipulated. No dredging activity started yet on project site.
ii	While carrying out dredging, an independent monitoring shall be carried out through a Government Agency/Institute to assess the impact and necessary measures shall be taken on priority	Point Noted for compliance. No dredging activity started yet on project site.

	basis if any adverse impact is observed.	
iii	A detailed marine biodiversity management plan shall be prepared through the NIO or any other institute of repute on marine, brackish water and fresh water ecology and biodiversity and submitted to and implemented to the satisfaction of the State Biodiversity Board and the CRZ authority. The report shall be based on a study of the impact of the project activities on the intertidal biotopes, corals and coral communities, molluscs, sea grasses, sea weeds, sub-tidal habitats, fishes, other marine and aquatic micro, macro and mega flora and fauna including benthos, plankton, turtles, birds etc. as also the productivity. The data collection and impact assessment shall be as per standards survey methods and include underwater photography.	Further, it is once again to submit here that, DPA issued work order to M/s GUIDE vide its letter no. EG/WK/ 4751 /Part (Marine Ecology Monitoring) /12 dated 03/05/2021 for preparation of Detailed marine biodiversity plan. The copy of the second year monsoon season report for the year 2022-23 is attached herewith as **Annexure II .**
iv	Marine ecology shall be monitored regularly also in terms of sea weeds, sea grasses, mudflats, sand dunes, fisheries, echinoderms, shrimps, turtles, corals, coastal vegetation, mangroves and other marine biodiversity components including all micro, macro and mega floral and faunal components of marine biodiversity.	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 has been submitted to the Regional Office, MoEF&CC, GoI, Gandhinagar as well as to the MoEF&CC, GoI, New Delhi along with compliance reports submitted. The final report for the Holistic Marine Ecological Monitoring for the period upto May 2021 was submitted on 22.05.2021. Copy of the report was communicated vide earlier compliance report submitted vide letter **dated 29/6/2021**. Further, it is once again to submit her that, DPA issued 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 second year monsoon season report for the year 2022-23 is attached as **Annexure III.**
v	The project proponent shall ensure that water traffic does not impact the aquatic wildlife sanctuaries that fall along the stretch of the river.	Not applicable.
IX. Public hearing and human health issues		
i	The work space shall be maintained as per international standards for occupational health and safety with provision of fresh air respirators, blowers, and fans to prevent any accumulation and inhalation of undesirable levels of pollutants including VOCs.	Work is in progress (Oil Jetty No. 8 - Jetty & allied facilities and development of backup area of oil jetty no. 8 to 11 (Phase I)). Point Noted for compliance.
ii	Workers shall be strictly enforced to wear personal protective equipment's like dust mask, ear muffs or ear plugs, whenever and wherever necessary/ required. Special visco-elastic gloves will be used by labour exposed to hazards from vibration.	Work is in progress (Oil Jetty No. 8 - Jetty & allied facilities and development of backup area of oil jetty no. 8 to 11 (Phase I)). DPA has included clause in the tender for the Contractor to provide protective clothing or other appliances for security of his workers.

iii	Safety training shall be given to all workers specific to their work area and every worker and employee will be engaged in fire hazard awareness training and mock drills which will be conducted regularly, All standard safety and occupational hazard measures shall be implemented and monitored by the concerned officials to prevent the occurrence of untoward incidents/ accidents.	Work is in progress (Oil Jetty No. 8 - Jetty & allied facilities and development of backup area of oil jetty no. 8 to 11 (Phase I)). Point Noted for compliance.
iv	Emergency preparedness plan based on the Hazard identification and Risk Assessment (HIRA) and Disaster Management Plan shall be implemented.	It is assured that Emergency preparedness plan based on the Hazard identification and Risk Assessment (HIRA) and Disaster Management Plan will be implemented.
v	Provision shall be made for the housing of construction labour within the site with all necessary infrastructure and facilities such as fuel for cooking, mobile toilets, mobile STP, safe drinking water, medical health care, creche etc. The housing may be in the form of temporary structures to be removed after the completion of the project.	Work is in progress (Oil Jetty No. 8 - Jetty & allied facilities and development of backup area of oil jetty no. 8 to 11 (Phase I)). DPA has included clause in the tender for the Contractor to make provisions for the construction labour with necessary infrastructure.
vi	Occupational health surveillance of the workers shall be done on a regular basis.	Work is in progress (Oil Jetty No. 8 - Jetty & allied facilities and development of backup area of oil jetty no. 8 to 11 (Phase I)). DPA has included clause in the tender for the Contractor to comply with the Health and Safety requirements of the workers.
X. Environment Responsibility:		
i	The company shall have a well laid down environmental policy duly approved by the Board of Directors. The environmental policy should prescribe for standard operating procedures to have proper checks and balances and to bring into focus any infringements/deviation/violation of the environmental/forest /wildlife norms/ conditions. The company shall have defined system of reporting infringements / deviation / violation of the environmental/ forest / wildlife norms / conditions and / or shareholders / stake holders. The copy of the board resolution in this regard shall be submitted to the MoEF&CC as a part of six-monthly report.	DPA is already having Environmental Policy **Copy submitted along with the compliance report submitted with 05/05/2023**
ii	A separate Environmental Cell both at the project and company head quarter level, with qualified personnel shall be set up under the control of senior Executive, who will directly report to the head of the organization.	DPA is already having Environment Management cell. Further, DPA has also appointed expert agency for providing Environmental Experts from time to time. Recently, DPA appointed M/s Precitech Laboratories, Vapi for providing Environmental Experts vide work order dated 5/2/2021 **Copy submitted along with the compliance report submitted with 05/05/2023** Further DPA has appointed Environmental Manager on contractual basis for the period of 3+2 years.A copy of office order is attached herewith as **Copy submitted along with the compliance report submitted with 05/05/2023**

iii	Action plan for implementing EMP and environmental conditions along with responsibility matrix of the company shall be prepared and shall be duly approved by competent authority. The year wise funds earmarked for environmental protection measures shall be kept in separate account and not to be diverted for any other purpose. Year wise progress of implementation of action plan shall be reported to the Ministry/Regional Office along with the Six Monthly Compliance Report.	The allocation made under the "Environmental Services & Clearance of other related Expenditure" scheme during BE 2023- 24 is Rs. 274 Lakhs. and BE 2022-2023 is Rs. 73.9 Lakhs.
iv	Self-environmental audit shall be conducted annually. Every three years third party environmental audit shall be carried out.	Point Noted for compliance.
XI. **Miscellaneous:**		
i	The project proponent shall make public the environmental clearance granted for their project along with the environmental conditions and safeguards at their cost by prominently advertising it at least in two local newspapers of the District or State, of which one shall be in the vernacular language within seven days and in addition this shall also be displayed in the project proponent's website permanently.	DPA has given advertisement in two local newspapers regarding Environmental Clearance granted by the MoEF&CC, GoI for the subject project as under : **1)** In English – EXIM INDIA dated 27/11/2020. **2)** In Gujarati – AAJ KAL dated 25/11/2020. **Copy submitted along with the compliance report submitted with 05/05/2023**
ii	The copies of the environmental clearance shall be submitted by the project proponents to the Heads of local bodies, Panchayats and Municipal Bodies in addition to the relevant offices of the Government who in turn has to display the same for 30 days from the date of receipt.	DPA vide letter dated 23 (26)/11/2020 has already been communicated copy of EC & CRZ Clearance accorded by the MoEF&CC, GoI dated 20/11/2020 to the Heads of Local bodies, Panchayats and Municiple Bodies etc. **Copy submitted along with the compliance report submitted with 05/05/2023**
iii	The project proponent shall upload the status of compliance of the stipulated environment clearance conditions, including results of monitored data on their website and update the same on half-yearly basis.	DPA has been regularly submitting the six-monthly compliance reports of the stipulated environment clearances including results of monitored data to MoEF&CC. The same is also uploaded on the official website of Deendayal Port Authority (www.deendayalport.gov.in).
iv	The project proponent shall submit six-monthly reports on the status of the compliance of the stipulated environmental conditions on the website of the ministry of Environment, Forest and Climate Change at environment clearance portal.	DPA has been regularly submitting the six-monthly reports on the status of the compliance of the stipulated environmental conditions to MoEF&CC, GoI. Last compliance submitted on 05/05/2023.
v	The project proponent shall submit the environmental statement for each financial year in Form-V to the concerned State Pollution Control Board as prescribed under the Environment (Protection) Rules, 1986, as amended subsequently and put on the website of the company.	Point noted for compliance
vi	The criteria pollutant levels namely; $PM_{2.5}$, PM_{10}, SO_2, NO_x (ambient levels) or critical sectoral parameters, indicated for the project shall be monitored and displayed at a convenient location near the main gate of the company in the public domain.	Point Noted for compliance. However, monitoring reports of entire DPA area already enclosed at **Annexure III**
vii	The project proponent shall inform the Regional Office as well as the Ministry, the date of financial closure and final approval of the project by the concerned authorities, commencing the land development work and start of production operation by the project.	As per the stipulated condition, DPA vide letter dated 10/2/2021 has already informed about the work to be started for "Construction of Oil Jetty no. 8 at Kandla" and also incorporating that for balance Oil Jetties no. 9, 10 & 11 to be implemented on BOT/PPP Mode (under

		approval stage) and for development of Land (under approval stage), the requisite details will be communicated in due course. Further DPA vide letter dated 05/05/2023 informed regional office details w.r.t to the development of back up area of Oil Jetty no. 8 to 11 (Phase I). Copy is attached herewith as **Annexure VIII.**
viii	The project authorities must strictly adhere to the stipulations made by the State Pollution Control Board and the State Government.	Point Noted.
ix	The project proponent shall abide by all the commitments and recommendations made in the EIA/EMP report, commitment made during Public Hearing and also that during their presentation to the Expert Appraisal Committee.	Public Hearing was exempted for this project.
x	No further expansion or modifications in the port. Area shall be carried out without prior approval of the Ministry of Environment, Forests and Climate Change (MoEF&CC).	Point Noted for compliance.
xi	Concealing factual data or submission of false/fabricated data may result in revocation of this environmental clearance and attract action under the provisions of Environment (Protection) Act, 1986.	Point Noted.
xii	The Ministry may revoke or suspend the clearance, if implementation of any of the above conditions is not satisfactory.	Point Noted.
xiii	The Ministry reserves the right to stipulate additional conditions if found necessary. The Company in a time bound manner shall implement these conditions.	Point Noted.
xiv	The Regional Office of this Ministry shall monitor compliance of the stipulated conditions. The project authorities should extend full cooperation to the officer (s) of the Regional Office by furnishing the requisite data / information/monitoring reports.	It is assured that DPA will extend full cooperation to the officer (s) of the Regional Office & will also furnish all the requisite data/information/monitoring reports etc. to them as and when asked by them.
xv	The above conditions shall be enforced, inter-alia under the provisions of the Water (Prevention & Control of Pollution) Act, 1974, the Air (Prevention & Control of Pollution) Act, 1981, the Environment (Protection) Act, 1986, Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 and the Public Liability Insurance Act, 1991 along with their amendments and Rules and any other orders passed by the Hon'ble Supreme Court of India / High Courts and any other Court of Law relating to the subject matter.	Point Noted.
xvi	Any appeal against this EC shall lie with the National Green Tribunal, if preferred, within a period of 30 days as prescribed under Section 16 of the National Green Tribunal Act,2010.	Point noted

ANNEXURE – I

compliance report of CRZ Recommendation issued by the GCZMA dated 30/7/2020

DEENDAYAL PORT AUTHORITY
(Erstwhile: DEENDAYAL PORT TRUST)

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

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

www.deendayalport.gov.in

EG/WK/5202 (D)/Part (CRZ)/ 363

Dated 18/09/2023

To,
The Director (Environment) &
Member Secretary, GCZMA,
Forest & Environment Department,
Govt. of Gujarat,
Block No.14, 8th floor, New Sachivalaya,
Gandhinagar - 382 010.

Sub: CRZ Clearance for "Creation of water front facilities (Oil Jetties 8, 9, 10 & 11) and development of land of area 554 acres for associated facilities for storage at Old Kandla, Gandhidham, Kutch, Gujarat by M/s Deendayal Port Authority" - **Submission of six-monthly Compliances of the stipulated conditions in CRZ Recommendations reg.**

Ref.: (1) Letter No. ENV-10-2018-24-T Cell dated 30/7/2020 of Director (Environment) & Additional Secretary, Forest & Environment Department, GoG.
(2) DPT letter no. EG/WK/5202 (D)/ Part (CRZ 2)/28 dated 29/06/2021
(3) DPT letter no. EG/WK/5202 (D)/ Part (CRZ 2)/142 dated 08/02/2022
(4) DPA letter no. EG/WK/5202 (D)/ Part (CRZ 2)/128 dated 30/06/2022
(5) DPA letter no. EG/WK/5202 (D)/ Part (CRZ 2)/296 dated 05/05/2023

Sir,

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

In this connection, it is to state that, the Gujarat Coastal Zone Management Authority vide above referred letter dated 30/7/2020 had recommended the subject project of Deendayal Port Authority. Subsequently, the MoEF&CC, GoI had accorded the Environmental & CRZ Clearance vide letter dated 20/10/2020 for the subject project. Subsequently, DPA vide above cited letters had submitted compliance report of the stipulated conditions in CRZ recommendations to GCZMA.

Now, as directed under Specific Condition No. 26 mentioned in the CRZ Clearance letter dated 30/7/2020 i.e. ***A six-monthly report on compliance of the conditions mentioned in this letter shall have to be furnished by the DPA on a regular basis to this Department and MoEF&CC, GoI,*** please find enclosed herewith compliance report of the stipulated conditions for period upto November, 2022 along with necessary annexures, for kind information & record please **(Annexure I).**

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Further, as per the MoEF&CC, Notification 5.0.5845 (E) dated 26.11.2018, in which it is mentioned that, "***In the said notification, in paragraph 10, in subparagraph (ii), for the words "hard and soft copies" the words "soft copy" shall be substituted***".

Accordingly, we are submitting herewith soft copy of the same via e-mail in ID **gczma.crz@gmail.com** & **direnv@gujarat.gov.in** .

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

Yours Faithfully,

Manager(Env.)

Deendayal Port Authority

Copy to: -

Shri Amardeep Raju, MoEF&CC,GoI
Scientist E, Ministry of Environment, Forest and Climate Change,
& Member Secretary (EAC-Infra.1),
Indira Paryavaran Bhavan,
3rd Floor, Vayu Wing, Jor Bagh Road, Aliganj,
New Delhi-110003.
Email ID: ad.raju@nic.in

Annexure 1

Compliance Report (For the period up to May, 2023)

Subject: Point-wise Compliance of conditions stipulated in CRZ Recommendations for project "Creation of water front facilities (oil jetties 8,9,10 and 11) and development of land (1432 acres – revised area 554 acres) for associated facilities for storage at old Kandla, Tal: Gandhidham Dist. Kutch, Gujarat by Deendayal Port Authority (Erstwhile Deendayal Port Trust)" -reg.

Ref No: - CRZ recommendation issued by GCZMA vide Letter No- ENV-10-2018-24- T Cell dated 30.07.2020

S.No	CRZ Conditions	Compliance Status
	SPECIFIC CONDITIONS	
1.	The DPA shall strictly adhere to the provisions of the CRZ Notification, 2011 issued by the Ministry of Environment, Forests and Climate Change, Government of India	It is assured that, the provisions of the CRZ Notification, 2011 shall be strictly adhere to by the DPA.
2.	Necessary permissions from different departments/ agencies under different laws/ acts shall be obtained before commencing any activity (including the construction)	The Consent to Establish (CTE) from the GPCB had already been obtained vide CTE No. 94118 granted by the GPCB vide letter no. PC/CCA-KUTCH 1524/GPCB ID 56985 dated 23/7/2018 **Copy submitted along with the compliance report submitted with 05/05/2023** Further DPA has applied for the extension of the validity of the above mentioned CTE (Application copy **Copy submitted along with the compliance report submitted with 05/05/2023**
3.	The DPA shall ensure that the all the provisions of CRZ Notification 2011 shall be complied with and storage facilities in CRZ areas shall be in compliance with Annexure-ll of the above said Notification	It is assured that all the provisions of CRZ Notification, 2011 will be complied with and only storage of permissible cargo as per CRZ Notification, 2011, Annexure II will be allowed to store in storage facilities to be developed.
4.	There shall not be any blockage of creek due to laying of pipeline and free flow of water shall be maintained.	Work is in progress (Oil Jetty No. 8 - Jetty & allied facilities). It is hereby assured that, no creeks or rivers shall be blocked, due to any activities at the project site and free flow of water will be maintained.
5.	There shall not be any mangrove destruction/ damage due to proposed activities and adequate buffer zone of 70 metres shall be maintained from mangrove areas	It is assured that all the proposed activities shall be carried out strictly as per the EC & CRZ Clearance accorded by the MoEF&CC, GoI dated 20/11/2020.
	The DPA shall effectively implement the Mangrove Development, Protection & Management plan for control of indirect impact on mangrove habitat	As per the directions of the GCZMA and MoEF&CC, GoI, DPA had already undertaken Mangrove Plantation in an area of 1600 Ha. till date since the year 2005. A statement showing details of mangrove plantation at various locations with cost incurred is placed at **Annexure A**. It is also relevant to submit here that, as per the direction of the Gujarat Coastal Zone Management Authority, DPA had already prepared & submitted a report on mangrove conservation and management plan formulated by Gujarat Institute of Desert Ecology during the study period of Jan-April, 2015 (Report already submitted along with earlier compliance reports submitted).

		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 for the year 2021 to 2022 is attached herewith as **Annexure <u>Copy submitted along with the compliance report submitted with 05/05/2023</u>**
7.	The DPA shall have to make a provision that mangrove areas get proper flushing water and free flow of water shall not be obstructed	It is assured that necessary provisions will be made so that mangrove area get proper flushing water and to maintain free flow of water.
8.	The DPA shall have to dispose of the dredged material at the designated dredged material disposal point based on scientific study and approved by the MOEF&CC, GOI	No dredging activity has been started yet. However, it is assured that dredging activity will be carried out strictly as per the requirement of the condition and the same shall be disposed at designated dumping ground (25° 51′ 00″ N & 70°10′ 00″ E).
9.	The DPA shall have to maintain the record for generation and disposal of capital dredging and maintenance dredging	No dredging activity has been started yet. However, it is assured that necessary record will be maintained as per the requirement of the condition.
10.	No dredging, reclamation or any other project related activities shall be carried out in the CRZ area categorized as CRZ I (i) (A) and it shall have to be ensured that the mangrove habitat and other ecologically important and significant areas, if any, in the region are not affected due to any of the project activities.	It is assured that all the project related activities will be strictly carried out as per the EC & CRZ Clearance accorded by the MoEF&CC, GoI dated 20/11/2020.
11.	The DPA shall ensure that construction activities like dredging etc. shall be caried out in confined manner to reduce the impact on marine environment.	No dredging activities have been started yet. However, it is assured that construction activities like dredging will be carried out as per the requirement of the condition.
12.	The DPA shall ensure that the dredging shall not be carried out during the fish breeding season.	No dredging activities have been started yet. Point Noted for compliance.
13.	Construction waste including debris and dredged material shall be disposed safely in the designed areas as approved by MoEF&CC, GoI and it shall be ensured that there shall be no impact on flora and fauna	DPA had already issued general circular vide dated 3/9/2019 regarding Construction and Demolition Waste Management for strict implementation in DPA. **<u>Copy submitted along with the compliance report submitted with 05/05/2023</u>**
14.	No effluent or sewage shall be discharged into the sea / creek or in the CRZ area and shall be treated to conform the norms prescribed by the Gujarat Pollution Control Board and would be reused / recycled as per the approval of the Board.	It is assured that No effluent or sewage will be discharged into the Sea/creek or in the CRZ area. Further, the same will be treated in STP as per the norms prescribed by the GPCB.
15.	All the recommendations and suggestions given by the Cholamandalam MS Risk Services Limited in their Environment Impact Assessment report shall be implemented strictly by DPA	The compliance of the recommendations and suggestions is given by the EIA Consultant, M/s SV Enviro, Vizag in EIA Report is attached herewith as **Annexure B**
16.	The DPA shall exercise extra precautions to ensure the navigation safety and mitigation of the risk associated with the project activities especially due to collision, sinking or accidents of the vessels and would deploy the latest communication and navigation aids for this purpose. The proposed facilities shall also be covered under the VTMS being developed by the GMB	In this regard, it is to state that, Deendayal Port Authority had already contributed Rs. 41.25 crores for installing and operating the VTMS in the Gulf of Kachchh.

17.	The cost of the external agency that may be appointed by this department for supervision / monitoring of the project activities during construction/ operational phases shall be paid by DPA	Point Noted.
18.	The DPA shall contribute financially for any common study or project that may be proposed by this Department for environmental management / conservation / improvement for the Gulf Kutch	Point noted for compliance.
19.	The piling activities debris and any other type of waste shall not be discharged into the sea or creek or in the CRZ areas. The debris shall be removed from the site immediately after the piling activities are over.	Work is in progress (Oil Jetty No. 8 - Jetty & allied facilities). DPA has included clause in the tender for the Contractor to undertake precautions for safeguarding the environment during the course of the construction work.
20.	The camps shall be located outside the CRZ area and the labour shall be provided with the necessary amenities, including sanitation, water supply and fuel and it shall be ensured that the environmental conditions are not deteriorated by the labours.	Point Noted for compliance.
21.	The DPA shall prepare and regularly update their Local Oil Spill Contingency and Disaster Management Plan in consonance with the National Oil Spill and Disaster Contingency Plan	Point Noted for compliance. DPA is already having Local Oil Spill contingency plan and updated DMP.
22.	The DPA 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 groundwater shall not be tapped to meet with the water requirements in any case	Water requirements will be met through procurement from GWSSB or private tankers. It is hereby assured that no groundwater shall be tapped.
24.	DPA shall take up greenbelt development activities in consultation with the Gujarat institute of Desert Ecology / Forest Department / Gujarat Ecology Commission	DPA has already developed Green belt in and around the Port area. Further, DPA assigned work for Green belt development in an area of about 32 hectares to the Forest Department, Govt. of Gujarat during 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 Gandhidham area. Further, DPA also assigned the work of ***"Greenbelt Development in Deendayal Port Authority and its surrounding areas Charcoal Site (Phase I)"*** vide Work Order dated 31/05/2022 at the cost of Rs. 33.22 lakhs. The work is completed. The final report is attached herewith as **Annexure C** Further DPA has accorded the work of "Green belt development in DPA and its surrounding area (Phase II) to Gujarat Institute of Desert Ecology (GUIDE), Bhuj for the plantation of 10000 saplings of suitable species vide work order dated 23/06/2023. The same is in process
25.	The DPA shall have to contribute financially for taking up the socio-economic upliftment activities	Point noted for compliance. Work is in progress (Oil jetty No. 8 and allied

	in this region in consultation with the Forests and Environment Department and the District Collector / District Development Officer	facilities) As per the CSR Guidelines issued by the Ministry of Ports, Shipping & Waterways, Government of India, from time to time, DPA had undertaken CSR activities since the year 2011-12. The details of CSR Activities undertaken & planned is attached herewith as **Annexure D**
26.	A six-monthly report on compliance of the conditions mentioned in this letter shall have to be furnished by DPA on a regular basis to this Department and MoEF&CC, GoI.	DPA has been regularly submitting the six-monthly report on compliance of the conditions mentioned in the CRZ Recommendation letter dated 30/7/2020 to the CRZ Authority and to the MoEF&CC, GoI.
27.	The DPA shall ensure that the numbers of the Vessels and machinery deployed during marine construction, which are a source of low level organic and PHC pollution will be optimized to minimize risks of accidents involving these vessels.	Point Noted for compliance. Work is in progress (Oil Jetty No. 8 - Jetty & allied facilities).
28.	The noise level during transport and construction of marine facilities shall be kept minimum.	DPA appointed NABL Accredited laboratory for regular Monitoring of environmental parameters since the year 2016 in continuation of this DPA appointed M/s Gujarat Environment Management Institute (GEMI), Gandhinagar (NABL Accredited laboratory) for regular Monitoring of environmental parameters vide work order dated 15/02/2023. The work is in progress & DPA is submitting the monitoring data regularly to all the concerned authorities along with compliance reports submitted. The Environmental Monitoring Reports are attached herewith as **Annexure E**
29.	The DPA shall regularly conduct the surveys to identify changes in the channel bathymetry to minimize navigation hazards. Proper navigational aids and guidance should be provided to ships navigating the channel and there should be a properly structured vessels traffic management strategy to avoid accidents.	Point noted for compliance. Further, it is to state that, Deendayal Port Authority had already contributed Rs. 41.25 crores for installing and operating the VTMS in the Gulf of Kachchh.
30.	The DPA shall carry out separate study for further erosion and deposition pattern in the area after dredging through a reputed agency and shall follow the suggestions of the study done by reputed agency, for maintenance dredging, the recommendations/ suggestions of the reputed agency shall be follow by the DPA.	No dredging activity has been started yet. However, it is assured that necessary will be conducted as per the requirement of the condition.
31.	Any other condition that may be stipulated by this Department and MoEF&CC, GoI from time to time for environmental protection / management purpose shall also have to be complied with by DPA.	Point noted.

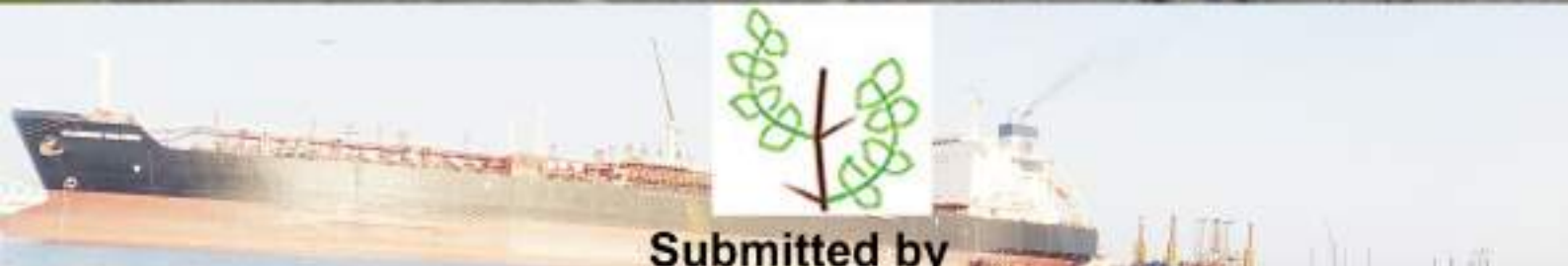
ANNEXURE – II

Regular Monitoring of Marine Ecology in and around the Deendayal Port Authority – Second Season report

Second year Post-Monsoon Report
October 2022-January 2023

Regular Monitoring of Marine Ecology in and around the Deendayal Port Trust 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

March 2023

Second year Post-Monsoon Report
October 2022-January 2023

Regular Monitoring of Marine Ecology in and around the Deendayal Port Trust 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
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Snapshot

Post-monsoon (October2022 to January 2023)

S. No	Components of the Study	Remarks
1	MoEF & CC sanction letter and details	(i). EC & CRZ clearance granted by the MoEF &CC, GoI dated 19/12/16 Dev. Of 7 integrated facilities – specific condition no. xviii. (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 waterfront facilities (OJ 8 to 11- Para VIII Marine Ecology, specific condition iv.
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 Post-Monsoon season (October 2022 to January 2023)
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	**Components of the report**	
7a	Mangroves	The overall average density was 3011 trees/ha of *A. marina* during Post-monsoon 2022-2023. Among the 12 sampling sites, the mean plant density was maximum at Tuna creek (4371/ ha), followed by Jangi creek (3210/ Ha). Considering the sampling sites individually the highest tree density was reported at S12 in the Tuna creek area (6515/Ha). The lowest average tree density of individual sites was reported in S-5 (1491 trees/ Ha) sampling site located at Phang creek. In terms of creeks, the lowest average density was recorded at Kharo creek in which only one sampling site is located S-7 (2291/ha.
7b	Mudflats	The highest TOC value (0.87%) was recorded at station S-6 followed by S-10 site. The lowest TOC value was reported at S-1. 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.

7c	Zooplankton	The zooplankton identified from the 15 stations falls under 10 phyla and 45 genera which are described 15 groups. The phylum Arthropoda was the predominant represented with 30 genera, including copepods, crabs, shrimps and their larvae. The highest percentage was due to the calanoid copepods (40.4%) followed by Decapoda (16.4%) and Gastropoda (6.4%).
7d	Phytoplankton	The generic number recorded during the monsoon period ranged from 22 to 26 at the sampling stations with remarkable variations concerning the composition. The maximum number (26 genera) was observed at S-3 &S-9, and the minimum from S-8 represented 22 genera. The percentage composition of the various groups varied from 1 % to 61 %, of which the centrales and pennales are the dominant, constituting 61% and 38%, respectively.
7e	Intertidal Fauna	The intertidal fauna and the species diversity of the invertebrates showed the maximum for phylum Mollusca (8 species) followed by Arthropoda (6 species). The phylum Chordata was represented by one species. The overall percentage composition of the four groups of intertidal fauna at the 15 sites revealed the Arthropoda (31.6%), Mollusca (42.1%), Nematoda, Nemertea and Chordata (each 5.3%).
7f	Sub-tidal Macrobenthos	The DPA port environment revealed that Mollusca (13 species) and Annelida (6 species) were the major constituents, followed by Arthropoda (2 species) and Cnidaria (1 species). The phylum Mollusca constituted the maximum (59%) share of the subtidal Fauna, followed by Annelida (27%), least number of percentage was contributed by Cnidaria (5%).
7g	Seaweeds	No seaweed is reported in the DPA area.
7h	Seagrass	No seagrass is reported in the DPA area.
7i	Marine reptiles	One species of reptile was recorded from the DPA area.
7j	Marine mammals	Two species of marine mammal was recorded from the DPA area.
7k	Halophytes	Four halophytes were recorded along the selected Deendayal Port Authority sites during the Monsoon sampling; among the halophyte species recorded, *Salicornia brachiata* alone was found in the 3 sampling locations. The percentage of *Salicornia brachiata* was found to be the highest at stations S-11 (100%) and the lowest at S-3.
7l	Avifauna	A total of 79 species belonging to 9 orders, 32families and 59 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 to127 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

Parameters	
Water	**Mangrove & Other Flora**
• pH	**Mangrove**
• 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)	**Halophytes:**
Nutrients	• Percentage of distribution
Nitrate (NO_3)	• Diversity
• Nitrite (NO_2)	
• Total Nitrogen	**Seagrass and Seaweed**
• **Sediment**	• Occurrence, distribution, and diversity.
• Texture	**Intertidal fauna**
• Total organic carbon (TOC)	• Composition, distribution, diversity, density and other characteristics.
• **Biological Parameters**	**Avifauna**
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 per sulphate 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^2 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_2 is used and O_2 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^2 (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^2 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 Post-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^2 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^2).

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^2. 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^2. 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 quadrate 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 kilometress 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 reflectsthe 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 H2SO4) by utilizing the heat evolved with the addition of H_2SO4. 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 Quadrate 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^2 for regeneration and 2×2 m^2 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, quadrate 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 quadrate 1 x 1m^2 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 quadrate 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 Post-monsoon October 2022 to January 2023). 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

3.1. 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 during post-monsoon are presented in Table1.

Temperature (°C) and pH

The water temperature at the sampling sites ranged from 9°C to 28°C with average of 19°C .The maximum temperature of seawater was reported at S-6 and the minimum at S-9 in Kandla (Navlaki) creek. The pH of creek water ranged from 7.1 to 8.1 with average of 7.9. The highest pH was reported at sites S-2 and S-5 and the lowest pH 7.1 was noticed at S-11 in Janghi creek. The overall observation along the port environment revealed that the temperature fluctuation might be due to the low atmospheric temperature(winter) in the month of December and the pH range showed minor fluctuations among the sampling locations.

Salinity (ppt)

The salinity of Deendayal Port authority ranged from 12 ppt to 43 ppt with the average value of 39 ppt. The minimum salinity was observed at S-10 and maximum at S-9. The hypersaline condition of creek system during post-monsoon season might be due release of brine water from salt pan in to this creek system.

Dissolved oxygen (DO)

The dissolved oxygen in the coastal waters of Deendayal port authority area ranged from 3.9 mg/L to 7.7 mg/L with the average of 6.8 mg/L. The highest dissolved oxygen concentration was observed at S-6 and the lowest was observed at S-5. The concentration of dissolved oxygen varies mainly due to the rate of 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).

Suspended Solids (TSS)

The total suspended solids (TSS) concentration at the 15 sampling sites ranged from 140 mg/L to 640 mg/L with the average of 209 mg/L. The highest TSS values was reported at S-8 in the Navlaki creek . The minimum TSS value was recorded at S-12 which was 140 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 in creek water system . The TDS of the samples varied from 32,200mg/L to 45,700 mg/L with an average of 39,500 mg/L. The maximum value was reported at S-2 which may be due to replenishment dissolved solids due to the gulf current system and movement s of cargo in the navigation channel of Kandla creek system.

Turbidity

The turbidity of the water samples from the study sites ranged between 46 NTU and 342 NTU with the average of 190 NTU. The lowest value was reported at S-15 and the highest value at S-6 followed by S-9.

Water nutrients (Nitrate, Nitrite and Total Phosphorus)

The nutrients influence growth, metabolic actions and reproduction of biotic components in the aquatic environment. The distribution of nutrients mainly depends upon tidal conditions, types of season and fresh water influx from land. The nitrate concentration ranged from 0.003 mg/L to 0.140 mg/L with an average of 0.060 mg/L. The highest nitrate concentration was observed at station S-9 and the lowest at station S-1. Very miniature variation was noticed concentration of nitrate among the study station. Likewise, nitrite values varied between 0.007 mg/L to 0.021 mg/L. The highest concentration was observed at station S-1 and lowest concentration was observed at station S-9. The Total phosphorus values among the study station ranged from 0.67 mg/L to 2.02 mg/L with in average of 1.26 mg/L. The highest phosphorus concentration was observed at station S-3 near oil jetty of Kandla creek and the lowest concentration was observed at S-12 inTuna creek . Highest concentration might be due to leaching of phosphatic fertilizers while handling of cargo port area**.**

Petroleum Hydrocarbons (PHs)

Petroleum Hydrocarbons (PHs) represent the most commercially utilized fossil fuels (Adelaja, 2015). Reports have indicated that their consumption is projected to rise exponentially from 85 million barrels in 2016 to 106.6 million barrels by 2030 (Igunnu et. al, 2014). They are used as raw materials in many industries and primary energy sources. However, they also represent one of the prioritized and widespread contaminants posing serious threats to the ecology owing to their stability and robustness (Cozzarelli et. al, 2014; Pablo et. al, 2020; Uddin et. al, 2021).

PHs comprise the polycyclic aromatic hydrocarbons (PAHs), alkanes, paraffin, cycloalkanes, organic pollutants, and non-hydrocarbon components like phenol, sulfur compounds, thiol, metalloporphyrin, heterocyclic nitrogen, naphthenic acid, and asphaltene. The introduction of the PHs immediately alters the composition of that particular ecological niche/ecosystem, subsequently reducing the overall functionality and inducing weathering. This weathering of the PHs triggers a series of influences which may be either chemical (auto-oxidation/photo-oxidation), physical (dispersion), physiochemical (sorption, dissolution, evaporation), or biological (microbial and plant catabolism of hydrocarbons) (Truskewycz et. al, 2019). Marine organisms get affected by the presence of the PHs. The bioaccumulation of lethal PHs in the aquatic food chain persists for many years and in turn influences the primary producers, primary consumers, and secondary consumers. About 90% of the PHs discharge can be associated with anthropogenic activities (oil spills) in both, the terrestrial as well as marine environments. It has been reported that around 8.8 million metric tonnes of oil are annually discharged into the aquatic environment (Dadrasnia and Agamuthu, 2013).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 1.45 µg/L to 8.75 µg/L. The PHs detected from the individual sites have been represented in (Fig…..). The highest concentration of the PHs was detected at S-1 site (Tuna creek) while the lowest was noted for S-11 (Janghi creek). A moderate level of the PH content was noted down at site S-2 (7.65 µg/L) and S-6 (7.25 µg/L) followed by S-9 (6.8 µg/L) and the rest of the sites.

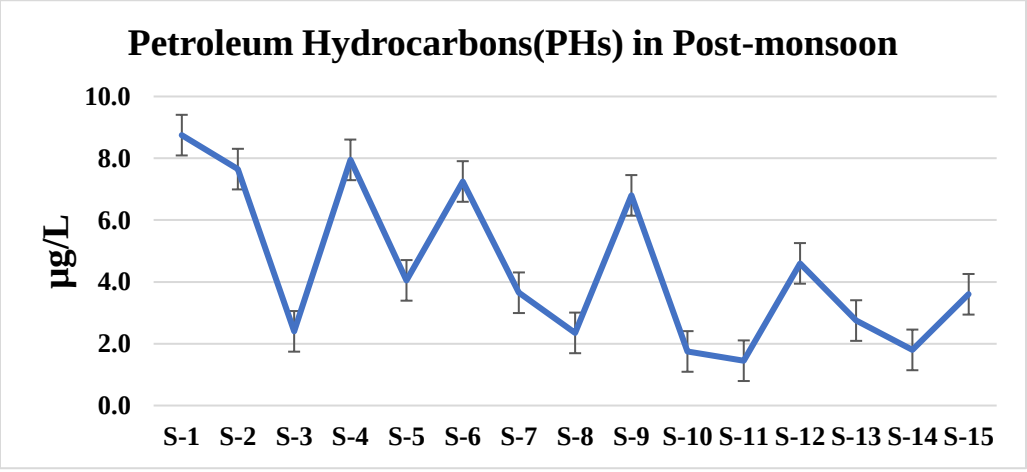

Figure 2: Petroleum hydrocarbons in water (µg/L) during Post-monsoon 2022-2023

Table 2: Physico-chemical characteristics of coastal waters during Post-monsoon 2022-2023

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)	24	24	21	21	32	30	20	14	12	29	23	23	19	18	26
Temp (°C) (Water)	20	20	21	20	24	28	17	10	9	20	16	17	16	19	24
pH	7.8	8.1	8	7.9	8.1	7.9	7.9	8	7.8	7.8	7.1	8	8	7.9	8
Salinity (ppt)	39	38	39	41	41	41	42	41	43	12	39	40	43	41	40
Dissolved oxygen (mg/L)	7	7	7	7	4	8	8	6	7	7	6	7	7	7	7
Total Suspended Solids (TSS) (mg/L)	207	163	199	181	160	219	165	640	232	148	175	140	192	158	154
Total Dissolved solids (TDS) (mg/L)	40000	41200	39300	39200	39700	40000	39600	45700	35100	39300	41500	40600	38100	32200	41000
Turbidity (NTU)	265	235	218	139	73	132	209	249	342	273	228	227	167	49	46
Nitrate (NO_3) (mg/L)	0.003	0.034	0.136	0.059	0.015	0.026	0.066	0.111	0.140	0.034	0.074	0.029	0.131	0.029	0.018
Nitrite (NO_2) (mg/L)	0.012	0.017	0.008	0.014	0.021	0.015	0.015	0.011	0.007	0.015	0.014	0.017	0.016	0.007	0.007
Total Phosphorus (mg/L)	1.83	0.87	2.02	1.54	1.06	1.83	0.96	0.87	1.35	0.77	1.25	0.67	0.87	1.35	1.73
PHs (µg/L)	8.75	7.65	2.4	7.95	4.05	7.25	3.65	2.35	6.8	1.75	1.45	4.6	2.75	1.8	3.6
Chlorophyll a (mg/L)	0.58	0.49	0.14	0.25	0.32	0.80	1.00	0.64	0.22	1.14	0.34	0.65	0.16	0.28	0.83

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,(Texture) sand, silt and clay, among the stations. In the present study the highest percentage of clay was reported at S-7 followed by S-2. The highest percentage of sand was observed at S-11 followed by S-15 station. As per the observations, the percentage of silt content was less compared to clay and sand in many sampling sites except S-15. The nature of soil texture was characterized by the proportion of clay, sand and silt fractions. The Soil texture (Percetnage) revealed the dominance of sandy-clay type in all the stations with less variations among them. This consistently high clay-loam value may be attributed to the sifting 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.

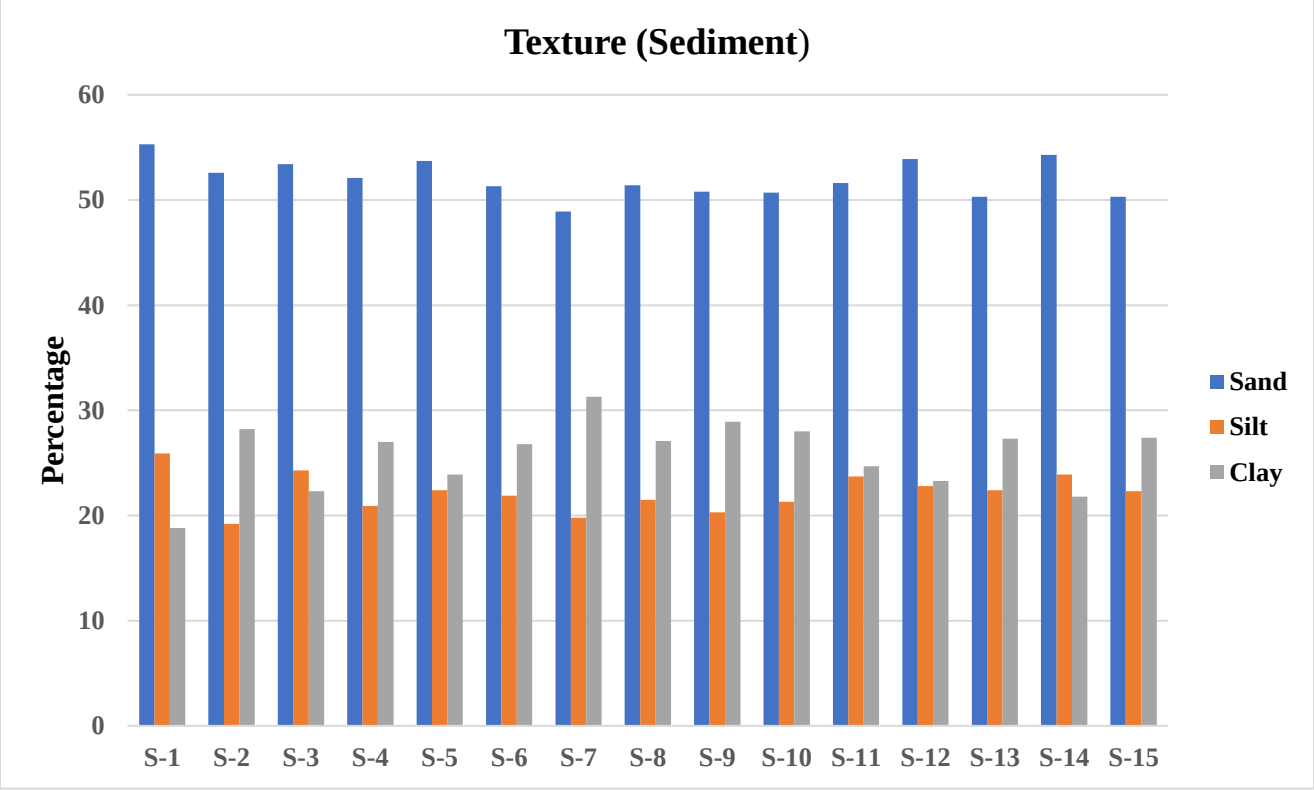

Figure 3: Textural characteristic of sediment at DPA in Post-monsoon 2022-2023

Total Organic Carbon (TOC)

In the present study, the total organic carbon content in the sediment varied from 0.60% to 1.06% (Fig.4). The highest value-of TOC were reported at S-6 followed by S-9. The lowest TOC value was recorded at S-15. 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.

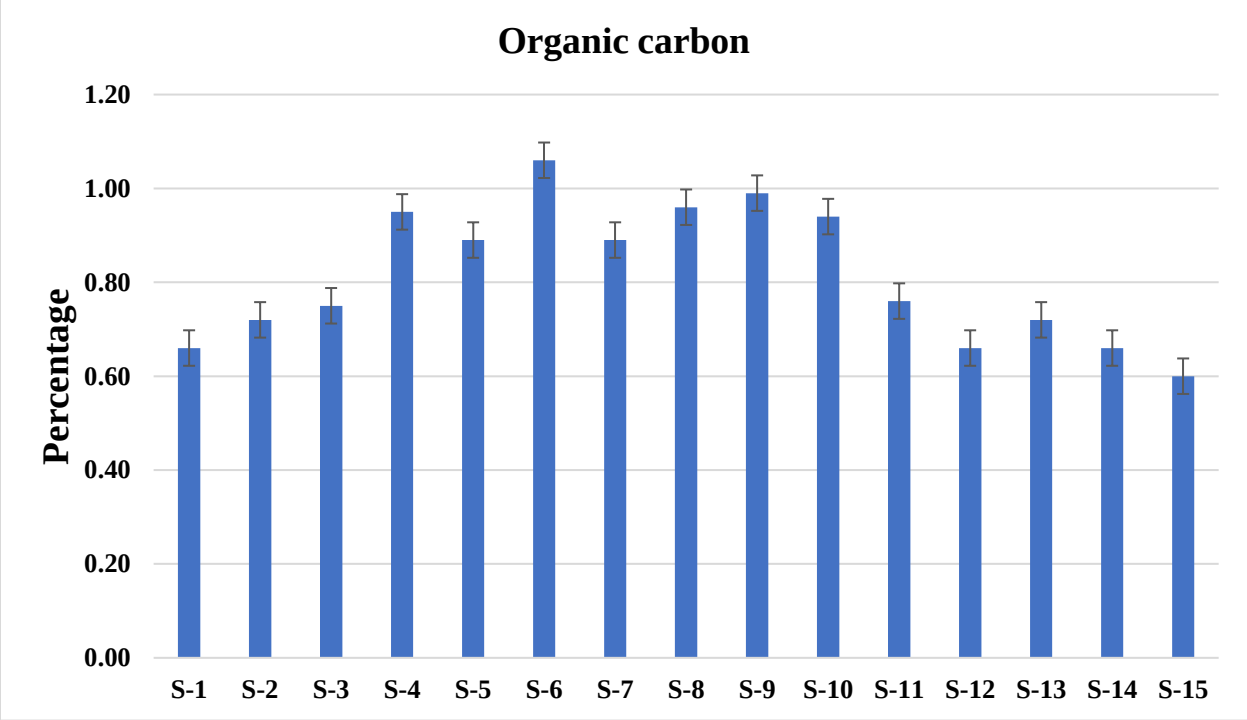

Figure 4: Total Organic Carbon content (%) in DPA during Post-monsoon 2022-2023

3.3. Biological characteristics of water and sediment

Primary productivity

Chlorophyll ‘a’ the photosynthetic pigment which can be used as a representation for phytoplankton productivity and thus is an vital 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 fluctuated from 0.14 mg/L to 1.14 mg/L with average of 0.52 mg/L. The highest concentration 1.14 mg/L was reported at S-10 (Fig.5) followed by S-7 (1.00) . The photosynthetic pigment chlorophyll a which is a measure of the population density of phytoplankton during the Post-monsoon period showed wide range of variations among the sites. The Chlorophyll ‘a’ content was very low at S-3.

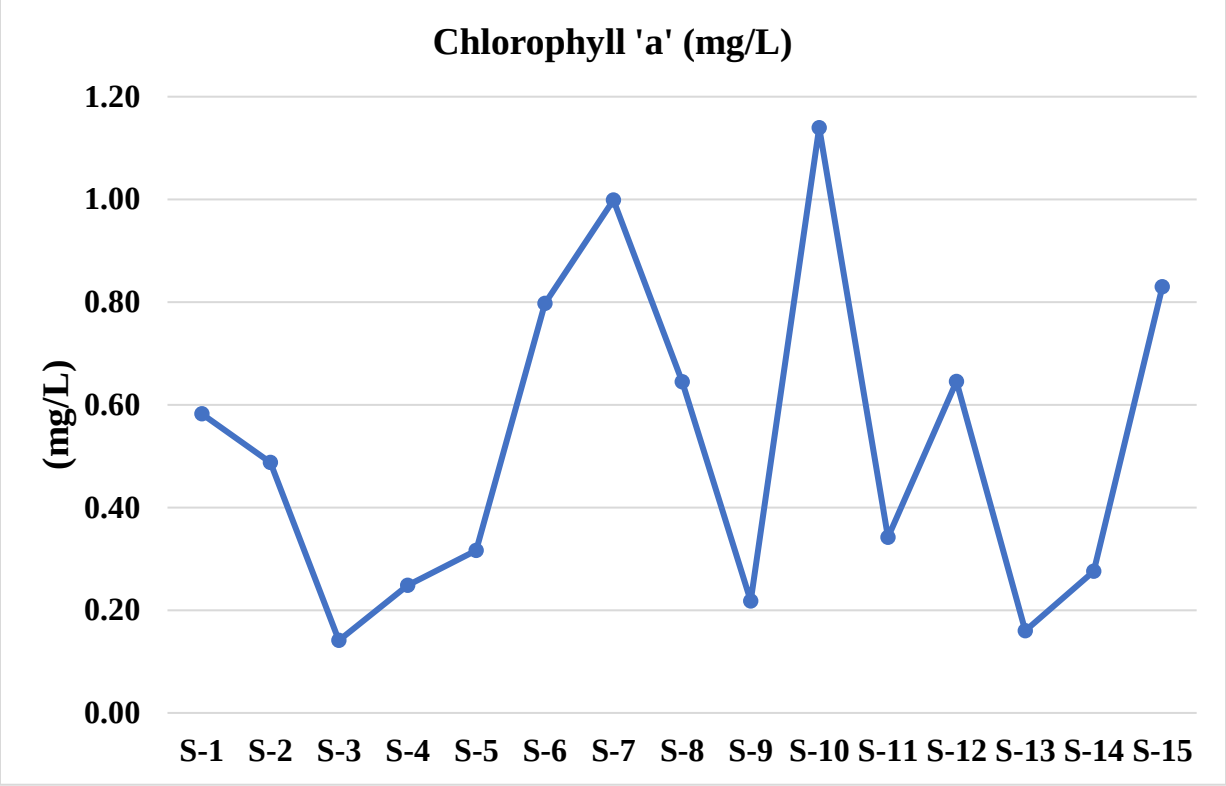

Figure 5: Chlorophyll ‘a’ concentration at the study stations in Post-monsoon 2022-2023

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 Post-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 Post-monsoon period varied between was 22 to 26 at the 15 sampling stations. The maximum number genera (26) was observed at S-3,S-9 and S-12 and the minimum from S-8 representing 22 genera. As far as generic status is concerned the centrales diatom contributed a greater number of genera (16) followed by Pennales (9) (Fig.6 & Table 3). Among the diatoms of phytoplankton, the genera Coscinodiscus ,and Thalassionema were primarily dominated at all the study stations. The genera representing of the groups Dinophyceae and Cyanophyceae encountered in minimum numbers.

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 1 % to 61 % of which the pennales and centrales are the dominant constituting 38% and 61% respectively. The diatoms pennales and centrales together formed 99% of the phytoplankton population by number of genera as well as number of individuals while the rest 1% is constituted by Dinophyceae during the Post-monsoon 2022-2023.

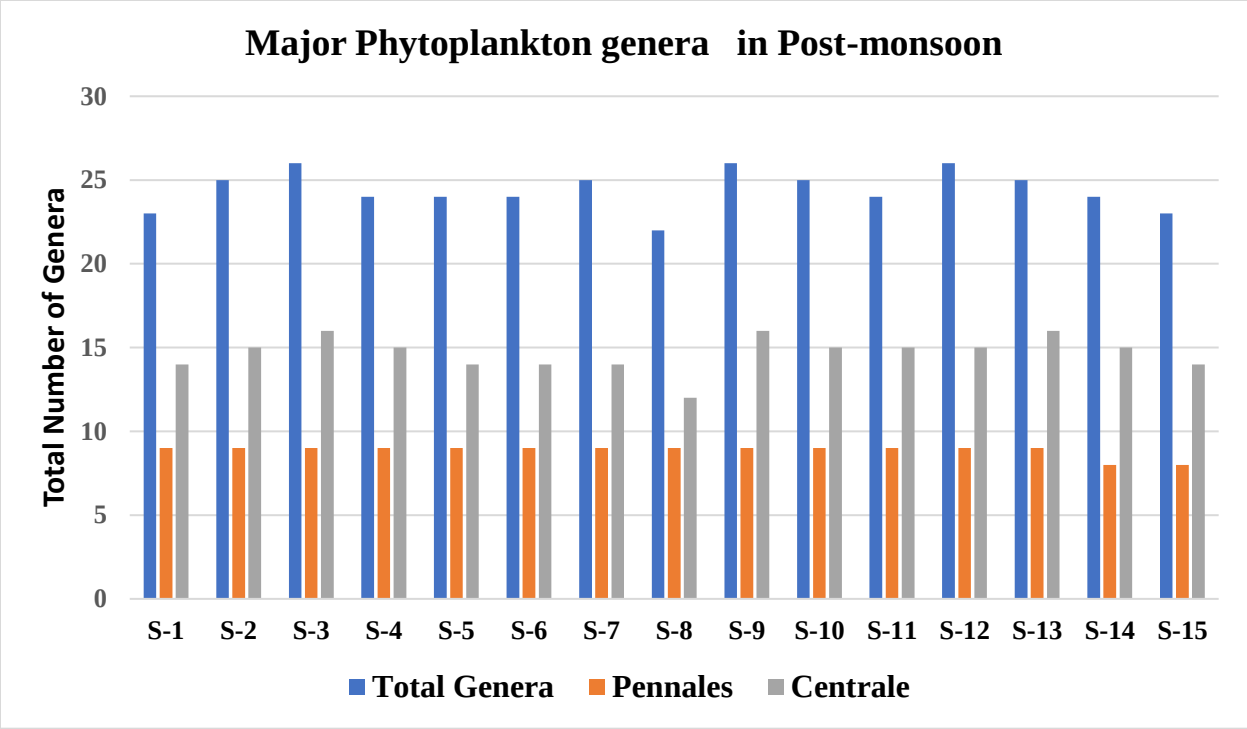

Figure 6: Number of Phytoplankton genera in Post-monsoon 2022-2023

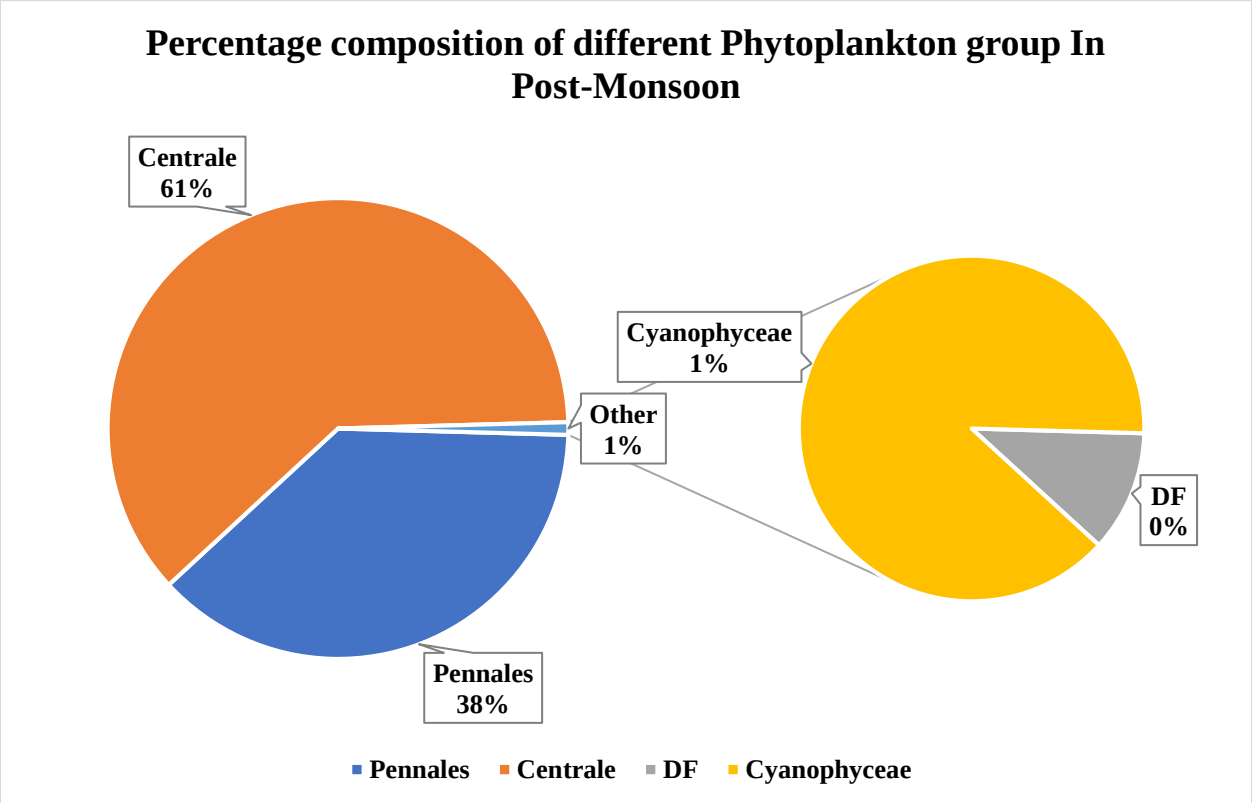

Figure 7: Percentage composition of phytoplankton groups in Post-monsoon 2022-2023

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 13% to 100% with an average of 87%. Nineteen phytoplankton genera have the highest percentage of occurrence (100%) (fig 8) followed by Planktoniella (80%) occurrence during the Post-monsoon season 2022-2023.

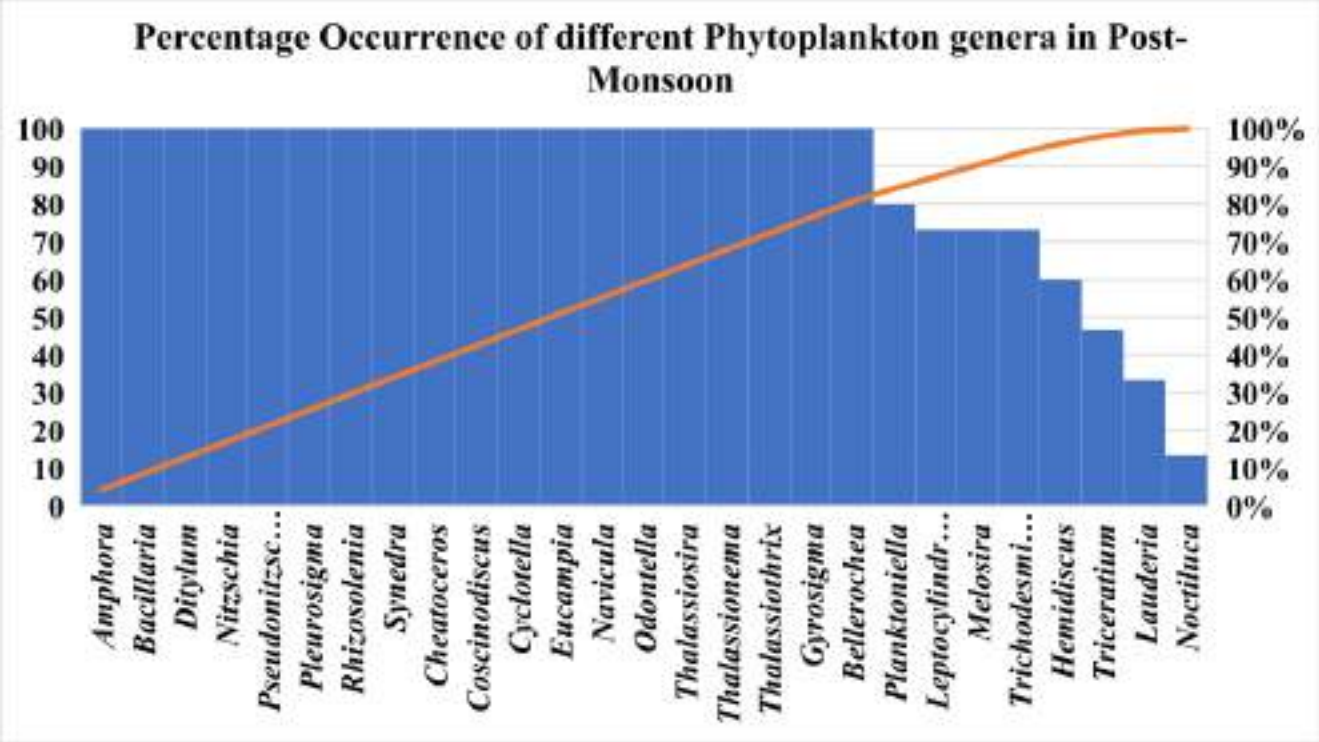

Figure 8: Percentage occurrence of phytoplankton genera in Post-monsoon 2022-2023

Phytoplankton density and diversity

The density signifies the abundance of plankton which is measured as cell/ individual/L. The phytoplankton density varied from 16,320No/L to 35,040 No/L with the average 21,887 No/L. The highest phytoplankton density was observed at station S-13 (35,040 No/L) followed by S-14 (30,080 No/L), whereas the lowest 16,320 No/L at S-6(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 factors and behavioral patterns of biotic communities. Among the different stations, the number of phytoplankton taxa varied from 22 to 26 (Table-4). During Post-monsoon the Margalef and Menhinik richness indices were maximum at stations S-12 &S-6 (2.50 & 0.19 respectively). The Shannon diversity index was maximum 3.04 (S-9) and minimum 2.81 at S-7. The Simpson index clearly reflects the species dominance (genera) at S-9 (0.95) and the low value (0.92) was noticed at S-17.

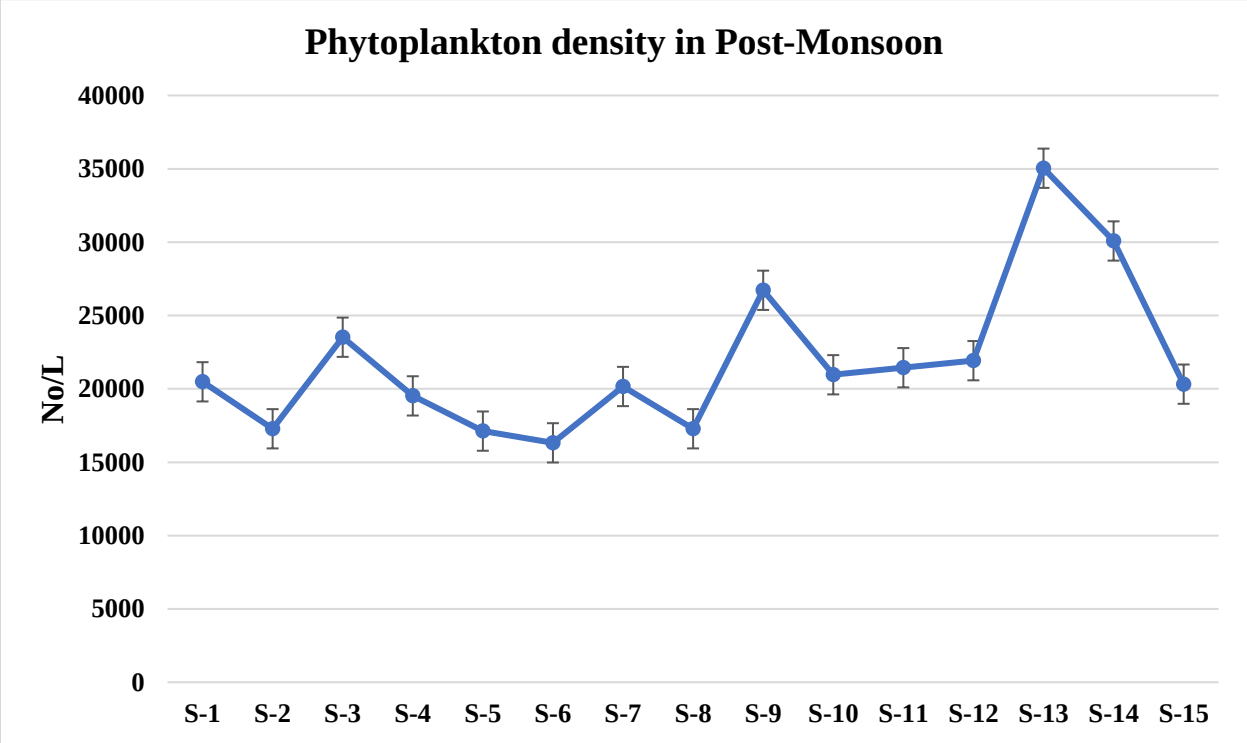

Figure 9: Phytoplankton density in Post-monsoon 2022-2023

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 2.81 to 3.04 representing the poor quality of environmental status dominated by the few genera such as *Coscinodiscus* and *Thalassionema*. 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 (Fig.10).

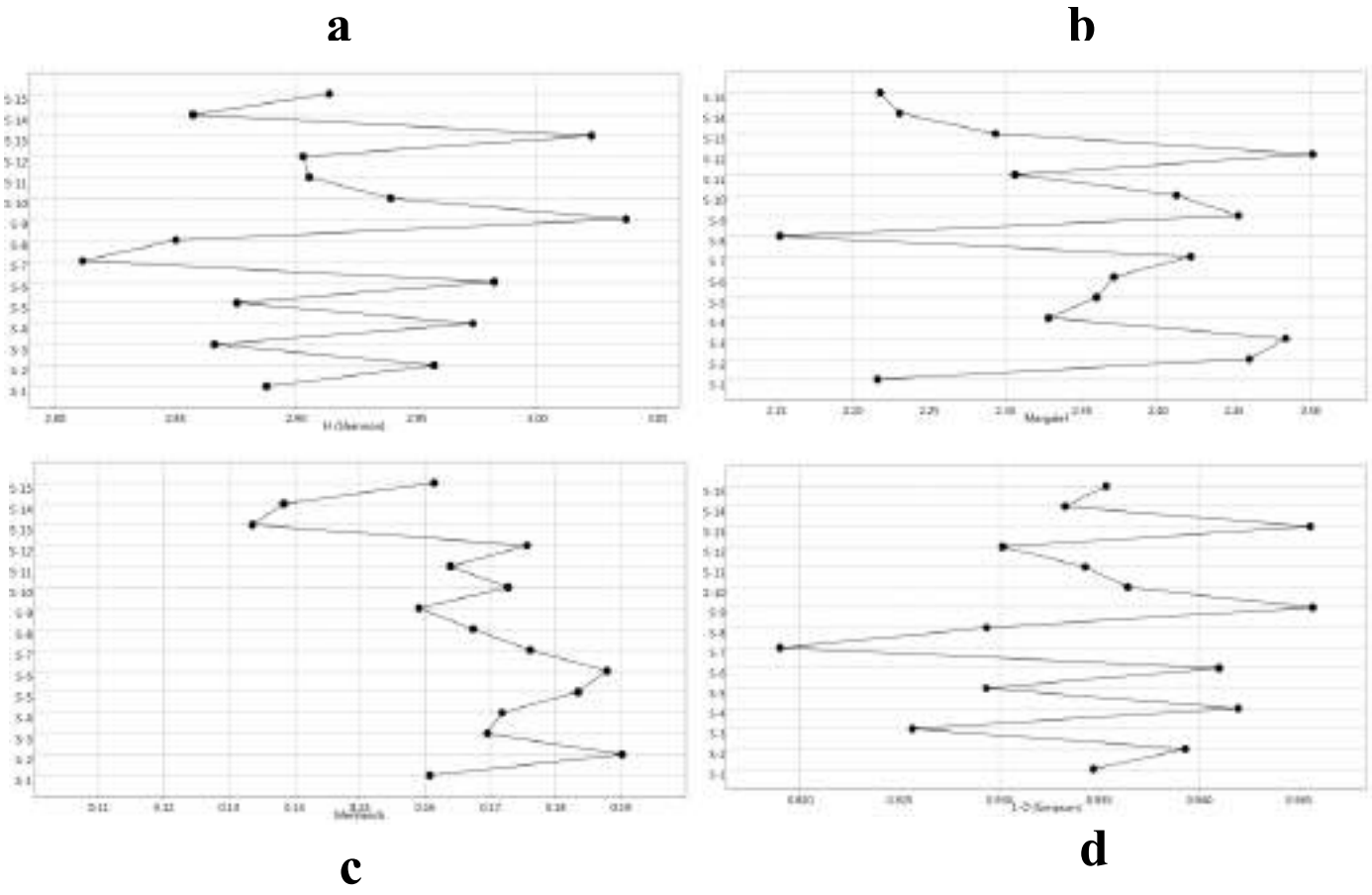

Figure 10: Different diversity indices of Phytoplankton

a. Shannon Index b. Menhinick Index c. Margalef Index d. Simpson Index

Table 3: Phytoplankton density, percentage composition and occurrence during Post-monsoon 2022-2023 in DPA

Grpou	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	PC	PO
Pennales	*Amphora*	320	160	320	320	640	800	160	480	1120	800	320	1280	320	160	1440	2.6	100
	Bacillaria	960	960	640	320	160	480	640	960	1120	800	480	640	1440	800	1280	3.6	100
	Ditylum	960	1280	1760	1440	800	320	640	960	2240	960	2080	1760	2240	1760	640	6.0	100
	Nitzschia	1760	1440	800	320	640	960	2240	960	2080	1760	1440	1280	2240	1600	1120	6.3	100
	Pseudonitzschia	480	640	320	800	640	480	1120	800	320	160	640	160	160	160	320	2.2	100
	Pleurosigma	320	320	640	160	160	320	160	480	1120	640	160	320	960	1280	640	2.3	100
	Rhizosolenia	640	960	960	1280	800	480	640	160	800	640	640	800	1440	1600	480	3.8	100
	Synedra	1760	1440	1120	1280	2240	1280	1120	1920	1600	1440	960	1760	2720	2400	1760	7.6	100
	Navicula	1120	640	640	1280	800	640	320	480	1440	160	1120	480	1760	0	0	3.3	87
Centrales	*Cheatoceros*	1600	1440	2720	2080	1760	1600	3360	960	1280	2720	2560	1760	3200	3040	1600	9.7	100
	Coscinodiscus	1760	1600	3360	960	1280	1600	1440	2720	2080	1760	1600	3360	2400	3040	2720	9.7	100
	Cyclotella	160	160	160	480	320	160	320	160	480	480	640	320	800	1440	960	2.1	100
	Eucampia	480	320	320	320	160	160	640	320	800	480	160	320	320	160	800	1.8	100
	Lauderia	160	160	0	0	0	0	0	0	160	0	160	0	0	0	0	0.2	33
	Leptocylindricus	480	160	160	160	320	320	0	0	160	160	0	320	1280	640	320	1.4	73
	Melosira	160	320	320	160	160	320	0	0	160	320	160	0	320	0	160	0.8	73
	Odontella	1120	1440	1760	1440	800	480	640	960	2400	960	2400	1760	2400	3040	800	6.8	100
	Planktoniella	0	0	160	640	320	480	640	800	0	320	640	480	800	160	320	1.8	80
	Triceratium	0	0	160	320	0	0	160	0	320	0	0	160	480	160	0	0.5	47
	Thalassiosira	160	320	800	1120	160	1280	800	960	1120	320	640	160	1120	960	320	3.1	100
	Hemidiscus	0	160	160	0	0	0	160	0	160	160	160	320	320	160	0	0.5	60
	Thalassionema	2560	640	2880	800	2240	480	2720	640	1120	1600	960	1600	2400	2720	1760	7.7	100
	Thalassiothrix	960	1120	800	1120	480	1280	640	1120	960	1440	640	800	1440	1120	800	4.5	100
	Gyrosigma	640	480	1120	960	640	320	160	640	800	1280	1120	960	1440	1120	640	3.8	100
	Bellerochea	800	320	640	480	640	1120	800	160	1120	960	640	320	1280	1120	800	3.4	100
DF	Noctiluca	0	0	0	0	0	0	160	0	0	0	0	160	0	0	0	0.1	13
Cyanophyceae	Trichodesmium	0	160	160	0	160	320	160	160	320	480	0	160	0	160	320	0.8	73

Total Density	**20480**	**17280**	**23520**	**19520**	**17120**	**16320**	**20160**	**17280**	**26720**	**20960**	**21440**	**21920**	**35040**	**30080**	**20320**	
Total Genera	**23**	**25**	**26**	**24**	**24**	**24**	**25**	**22**	**26**	**25**	**24**	**26**	**25**	**24**	**23**	

PC: Percentage of composition

PO: Percentage of Occurrence

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 45 genera belonging to the 15 groups (Table 5). The phylum Arthropoda was the predominant, represented with 30 genera including copepods, crabs, shrimps and their larva. The phylum Arthropoda dominated in the samples with major groups Calanoida, Harpacticoida, Cyclopoida, (Copepoda) Decapoda, Branchiopoda,Thecostraca, Onychopoda ,and the larval forms of crustaceans. There were 19 genera of copepods of Phylum Arthropoda occurred in the samples. Among the copepods 12 gernera, of the Calanoida ranked first in terms of generic representation ,*Acartia Acrocalanus*, *Aetideus Nannocalanus* .*Temora a*nd *Calanus* while the other 2 groups, Harpacticoida ,Cyclopoida were poor in generic status.(figure-11). Besides this 11 genera belonging to Foraminifera(*Tintinnopsis, Codonellopsis*,),Chaetognatha, Nematoda, Polychaeta, Branchiopoda, Thecostraca, Cnidaria and fish were also present in the samples.

Percentage composition

The overall percentage of the various groups of zooplankton varied from 5.4% to 40.4%. The highest percentage was due to the calanoid copepods (40.4%) followed by Decapoda (16.4%) and Gastropoda (6.4%). The group which contributed the least was *Appendicularia* (5.4%) (Fig.12). The minor group of 11 genera constituted 25.8% of population in which contributed by fish larvae, Globigerina and Branchiopoda (Table 4). Among the zooplankton groups calanoid group was the predominant zooplankton at all sites

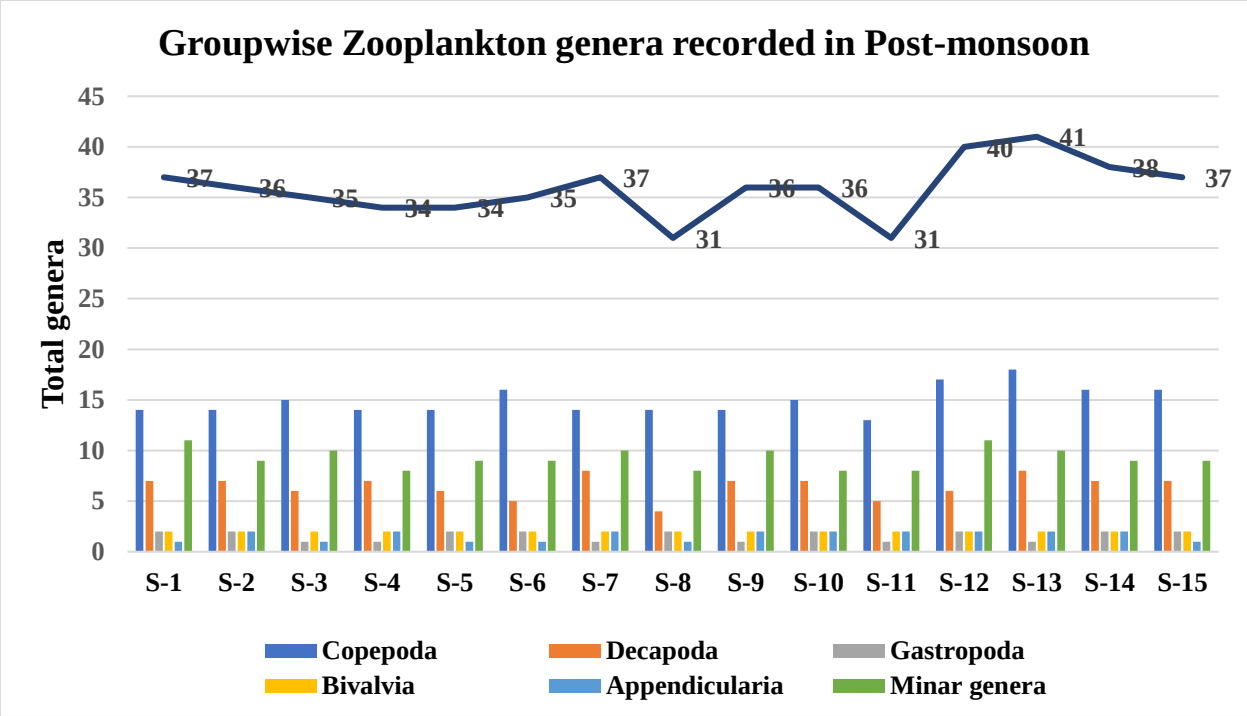

Figure 11: Phylum and generic status of zooplankton during Post-monsoon 2022-2023

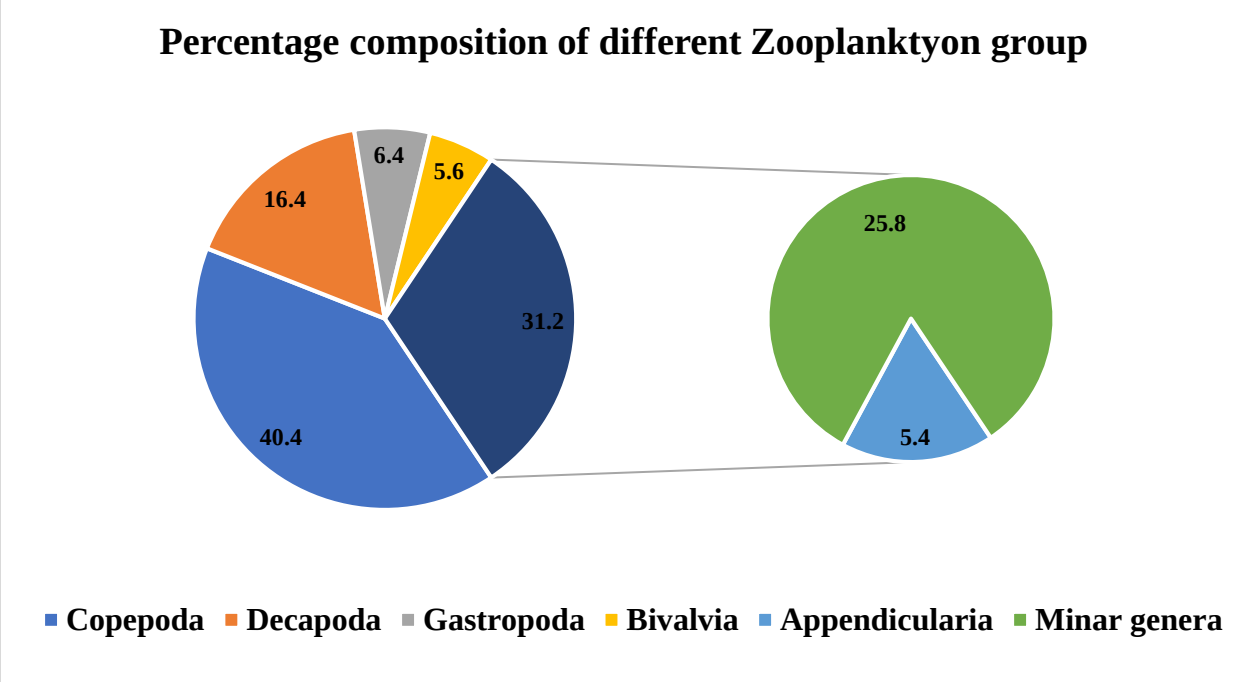

Figure 12: Percentage composition of zooplankton groups during Post-monsoon 2022-2023

Percentage occurrence of zooplankton

The percentage occurrence of zooplankton communities varied from 37% to 100 % (.Figure 13). There were 7 zooplankton genera that exhibited 100% of occurrence (Fig.12) followed by *Branchiopoda Thecostraca* (90%) occurrence. from the study sites (Table4).

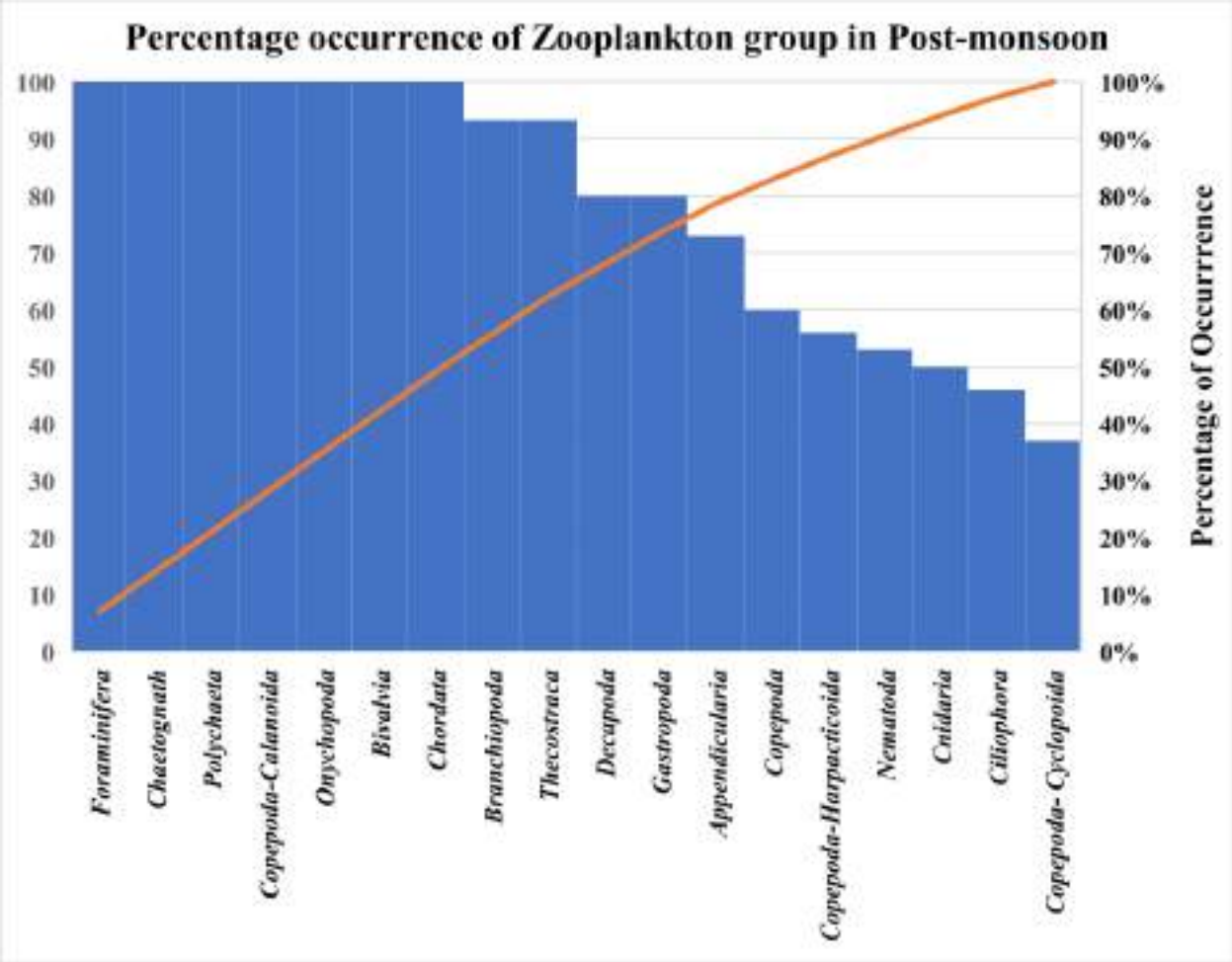

Figure 13: Percentage occurrence of Zooplankton groups during Post-monsoon 2022-2023

Density of zooplankton

Zooplankton population density values during the Post-monsoon 2022 at the 15 sampling sites ranged from 16,840 No/L to37,280 No/L with an overall average of 24,523 No/ L (Table 5). Station-wise, the highest density of 37,280 No/ L was recorded in S-14 and lowest density was reported at S-1 (16,480 No/ L) (Figure 14).

Diversity Index

The Shannon diversity index of the zooplankton ranged between 3.05 to 3.34. Similarly, Margalef and Menhinick species richness index also varied from 2.98 to 3.77, and 0.19 to 0.26 respectively representing the suspended load environment (Figure 15).

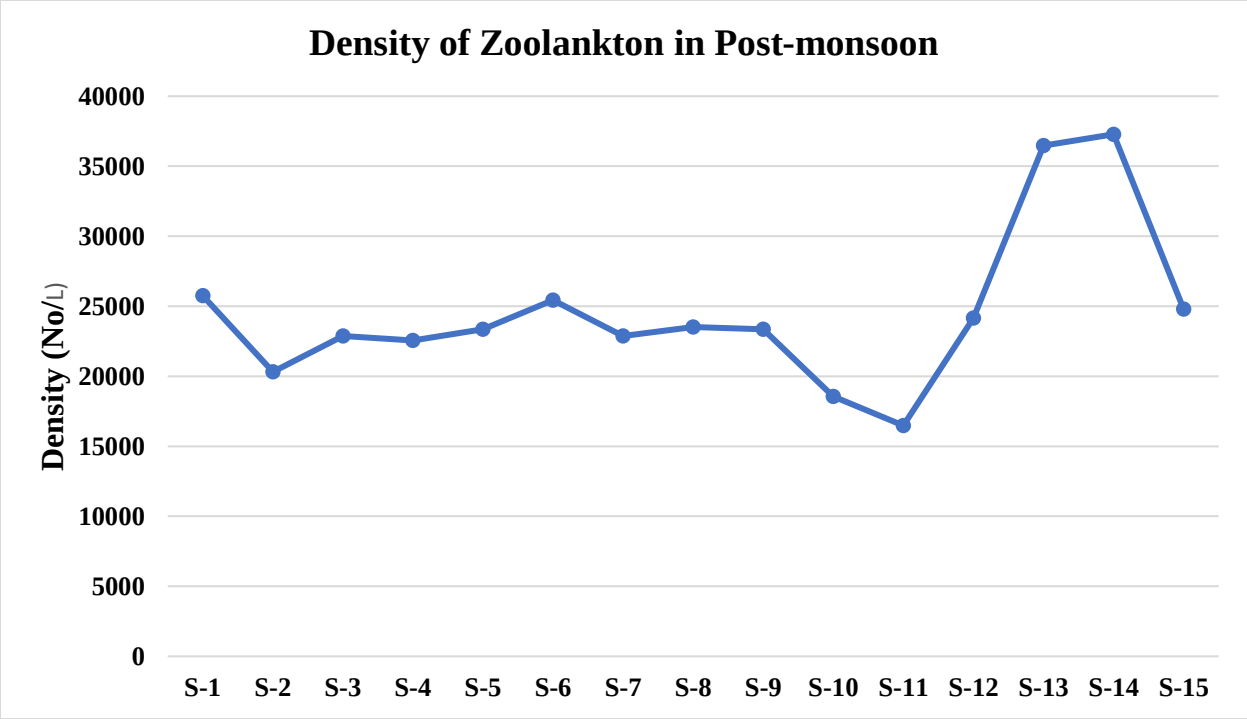

Figure 14: Zooplankton Density in the different stations during Post-monsoon 2022-2023

Table 4: Zooplankton generic status during Post-monsoon 2022-2023 in Deendayal Port Authority area

Phylum	Groups	Genera/ name	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	PC	PO
Protozoa	**Foraminifera**	*Globigerina*	2400	320	1120	2880	160	3680	1920	800	480	640	960	160	1440	480	1760	5.2	100
Colenterate	**Cnidaria**	*Obelia*	160	0	320	0	160	0	0	160	160	0	0	0	160	0	0	0.3	47
		Physalia	0	0	160	0	0	160	160	0	160	0	0	320	160	0	160	0.3	53
Ciliophora		*Tintinnopsis*	160	0	0	0	0	0	160	0	0	0	0	160	0	0	0	0.1	20
		Codonellopsis	320	160	320	0	160	320	160	0	0	160	160	320	320	160	0	0.7	73
	Chaetognath	*Sagitta*	480	320	640	160	160	800	1760	1120	1440	640	800	480	1120	480	320	2.9	100
Annelida	**Nematoda**	*Nematode worm*	480	160	0	160	0	0	160	0	320	0	0	160	0	160	160	0.5	53
	Polychaeta	*Polychaete larvae*	480	2880	640	480	1120	160	320	640	160	640	320	800	480	1120	1760	3.3	100
Arthropoda	**Copepoda Calanoida**	*Acartia*	1440	960	800	800	320	1120	800	1600	1760	1280	480	0	800	2720	480	4.2	
		Acrocalanus	1760	1280	2560	480	2720	960	960	1440	1600	1440	960	800	2720	2080	1760	6.4	100
		Aetideus	640	320	480	1280	800	960	1120	1600	320	480	640	1760	1440	800	480	3.6	
		Calanopia	640	320	160	160	1120	480	800	1120	160	320	480	1120	800	480	640	2.4	
		Calanus	800	800	320	1120	800	1600	1760	1280	480	0	800	2720	480	1440	1120	4.2	
		Centropages	320	160	320	320	160	160	480	800	160	160	320	640	1600	2080	1120	2.4	
		Eucalanus	640	320	160	160	1120	480	800	1120	160	320	480	1120	800	480	640	2.4	
		Labidocera	320	320	160	160	320	480	160	800	640	320	320	160	160	640	160	1.4	
		Nannocalanus	320	1120	800	1600	1760	1280	480	0	800	2720	480	640	800	960	1120	4.0	
		Paracalanus	480	320	160	160	160	320	160	320	320	640	480	480	320	160	320	1.3	
		Pseudodiaptomus	480	480	160	320	320	160	480	480	160	320	320	160	320	160	160	1.2	
		Temora	640	320	480	1280	800	960	1120	1600	320	480	640	1760	2880	1440	480	4.1	
		Tomopteris	0	0	0	0	0	0	0	0	0	0	0	0	160	0	0	0.0	
	Copepoda Harpacticoida	*Corycaeus*	0	0	160	0	0	160	0	320	0	160	0	160	0	0	160	0.3	40
		Clytemnestra	320	160	320	0	160	160	0	0	0	160	0	160	320	160	0	0.5	60
		Euterpina	160	0	160	320	0	320	0	320	480	160	0	160	640	320	160	0.9	73
		Microsetella	0	0	0	160	0	320	0	160	0	160	0	160	160	320	160	0.4	53
	Copepoda-Cyclopoida	*Oithona*	0	160	0	0	0	0	160	0	160	0	320	0	160	0	0	0.3	33
		Oncaea	0	0	0	0	160	0	160	0	0	0	0	160	160	320	160	0.3	40

	Decapoda	*Caridean larvae*	640	320	160	480	640	800	160	320	1120	320	640	160	640	320	800	2.0	100
		Euphausia	1600	320	1440	320	640	1920	640	320	3360	2400	1920	1760	1280	5600	2240	7.0	100
		Lucifer	160	640	0	640	320	0	160	0	160	320	160	0	160	160	1600	1.2	73
		Megalopa larva	160	0	160	0	0	160	160	0	160	0	0	160	320	160	0	0.4	53
		Mysis	480	320	1440	320	160	160	160	0	160	320	0	160	160	160	160	1.1	87
		Nauplius larvae	960	320	640	480	160	0	800	320	160	160	640	160	1440	640	320	2.0	93
		Phyllosoma larva	0	160	0	320	0	0	160	0	0	160	0	0	160	0	160	0.3	40
		Zoea larvae	1120	800	320	640	160	480	160	320	1120	800	160	800	960	320	640	2.4	100
	Branchiopoda	*Cladocera*	480	1280	1600	480	2400	160	0	640	1120	320	160	960	1440	800	1120	3.5	93
	Thecostraca	*Cirriped nauplius*	640	320	160	160	0	320	640	800	320	160	480	160	1120	800	160	1.7	93
	Onychopoda	*Evadne*	800	640	320	640	160	480	160	160	320	160	320	160	640	800	160	1.6	100
Mollusca	**Gastropoda**	*Creseis*	160	160	0	0	160	320	0	160	0	320	0	160	0	320	480	0.6	60
		Gastropod larvae	1920	640	320	3360	2400	1920	1600	320	1440	320	640	1280	2080	1760	1280	5.8	100
	Bivalvia	*Bivalve larvae*	1280	480	1440	960	320	320	1120	640	800	320	160	640	640	1760	160	3.0	100
		Veliger Larva	320	960	640	160	640	160	320	320	1120	320	160	960	1760	1440	160	2.6	100
Chordata		*fish larvae*	160	1280	1760	640	800	2080	1440	1120	800	320	1120	1280	3360	2880	1760	5.7	1000
Appendicularia		*Oikopleura*	1440	640	2080	800	1920	1120	960	2400	640	160	800	640	1920	2400	320	5.0	100
		Copelata	0	160	0	160	0	0	160	0	320	480	160	160	0	0	0	0.4	47
Total Density			25760	20320	22880	22560	23360	25440	22880	23520	23360	18560	16480	24160	36480	37280	24800		
Total genera			37	36	35	34	33	35	37	31	36	36	31	39	40	37	37		

PC: Percentage of composition

PO: Percentage of Occurrence

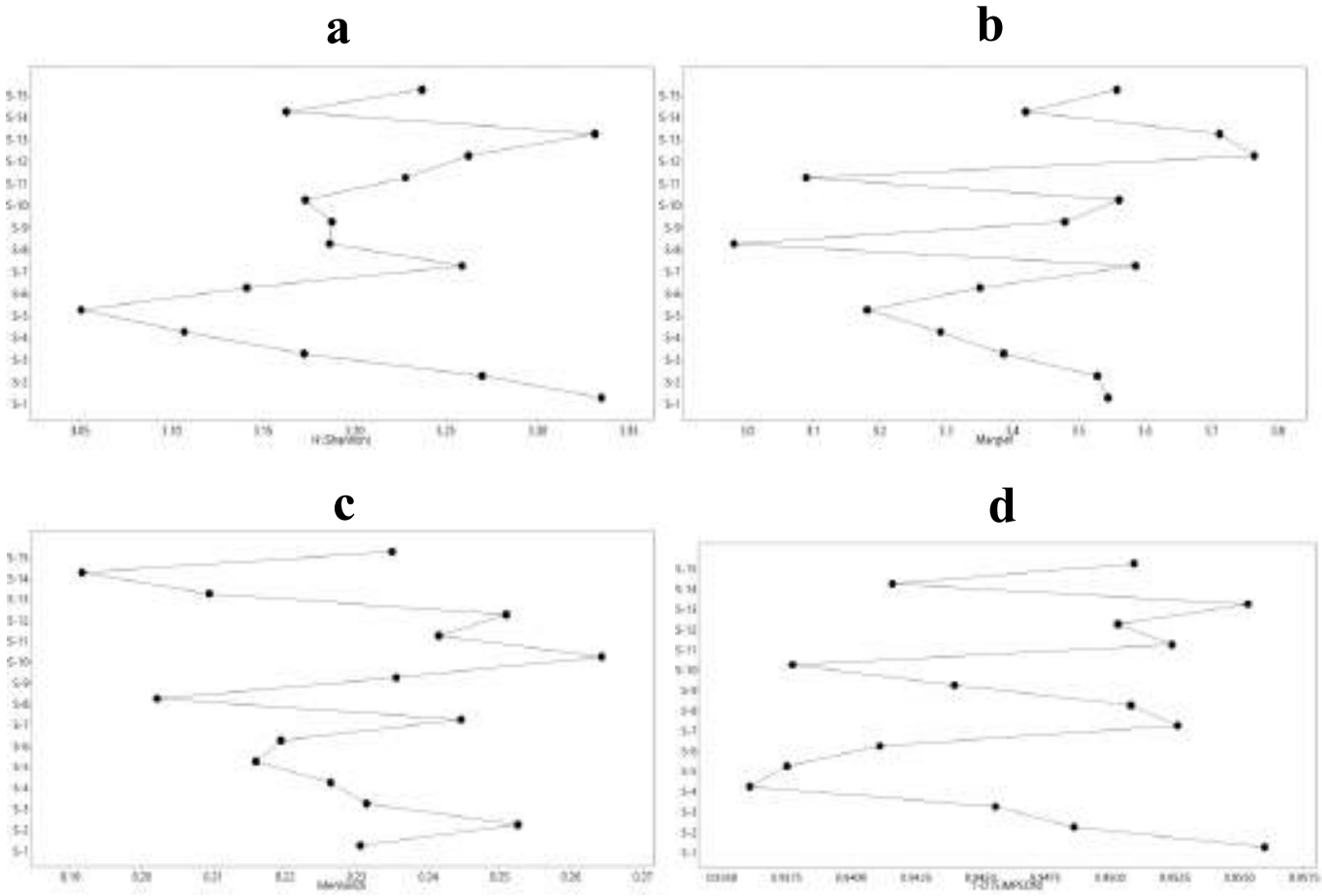

Figure 15: Diversity indices of Zooplankton

a. Shannon Index b. Menhinick Index c. Margalef Index d.Simpson Index

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 Post-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^2 quadrate was placed randomly, and all visible macro-faunal organisms encountered inside the quadrate were identified, counted and recorded. At each site along the transects that run perpendicular to the waterfront, three to six replicate quadrate 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).

Intertidal Fauna

Composition of intertidal Fauna

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 Mollusca (8 species) which is followed by Arthropoda (6 species), Annelida (1species), Nematoda (1 species) and Nemertea (1 species). The phylum Chordata (1) was represented by a single species. The percentage composition of the phyla represented in the samples varied from 5.3% to 42.1%. Among the fauna the highest percentage was contributed by Mollusca (42.1%) followed by Arthropoda (31.6%) and least percentage was due to Nematoda, Nemertea and Chordata (each 5.3%) in the study area during post monsoon (Table 5 & Fig.16).

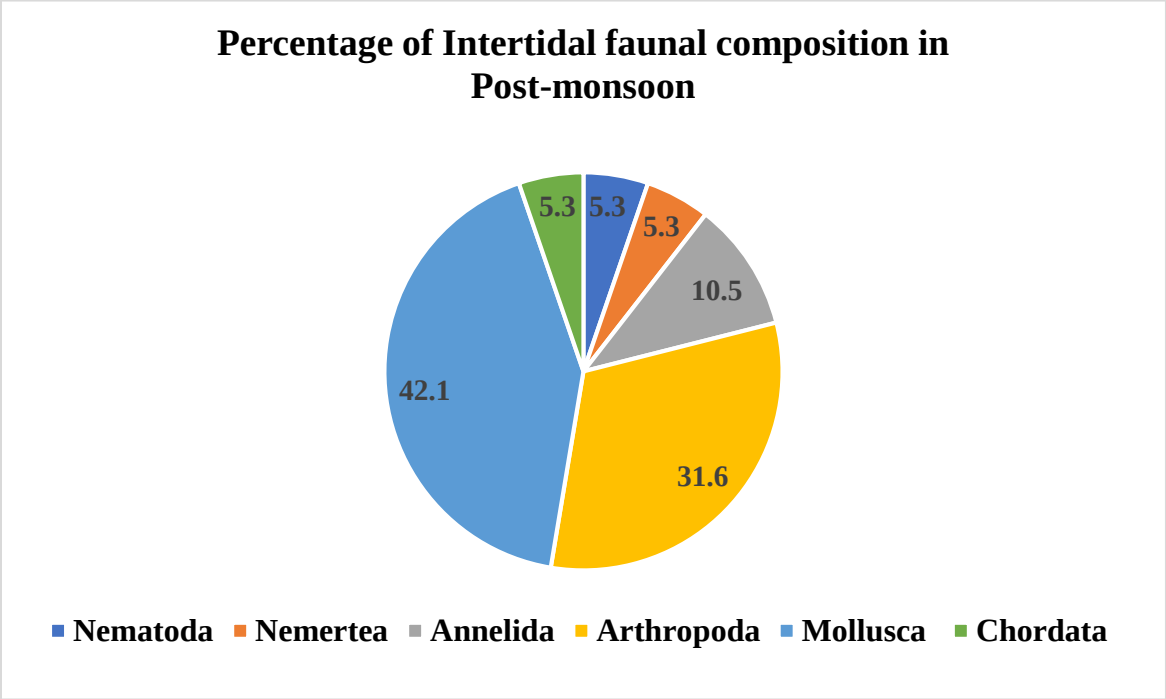

Figure 16: Intertidal Faunal composition (percentage) during post-monsoon 2022-2023

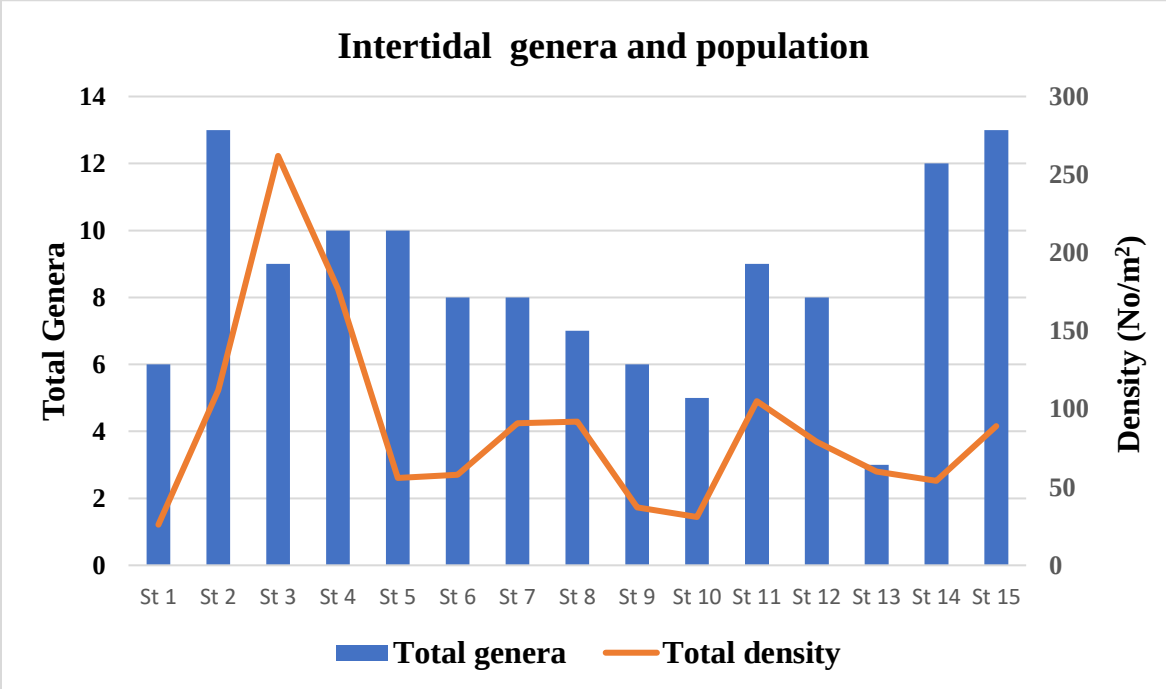

Figure 17 Intertidal genera and population density in Post-monsoon 2022-2023

Intertidal genera and total Population density in (No/m^2)

The population density of intertidal fauna recorded during the post monsoon survey are presented in Fig17. The total genera of intertidal fauna varied from 3 to 13 at the different sampling sites and the average being 8 genera. Highest number of genera was recorded in station S-15 & S-2 followed by S-14,S4 and S-5 (10 each). Least number of genera (3) was recorded at the station S-13. Similarly the density of intertidal fauna varied from 26 No/m2 to 262 No/m2 with average variation of 89 No/m2. The highest population density was recorded at S-3 and lowest population density was recorded at S-1

Percentage composition of species

The percentage composition of intertidal species presented in Fig 18. The overall percentage composition of the four groups of intertidal Fauna at the 15 stations varied from 0.1% to 33.6%. The highest percentage was contributed by the species Pirenella cingulata (33.6%) followed by Optediceros breviculum (13.5%) and Amphibalanus amphitrite (10.9% and the lowest percentage was represented by Metaplax indica (0.1%).

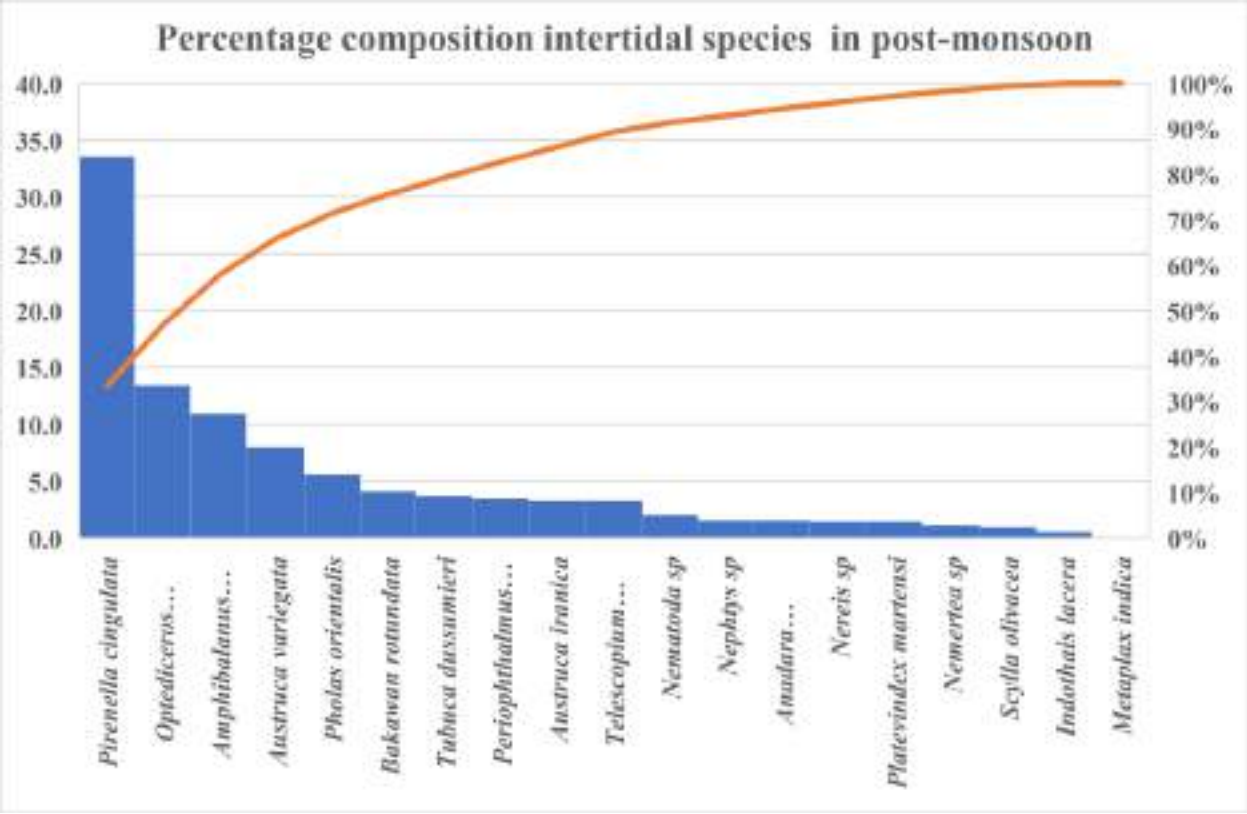

Figure 18: Percentage composition of Intertidal species during post-monsoon 2022-2023

Diversity indices

Figure .19 represents the various intertidal 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 Shannon diversity (H') values varied from 0.67 (S-3) to 2.32 (S-14). The Simpson_1-D varied from 0.28 (S -3) to 0.89 (S-14). The menhinick index varied from 0.39 to 1.63, with the maximum in S-14 and the minimum at S-13. The Margalef index ranged from 0.49 to 2.76, the maximum at S-15 and the minimum at S-13.

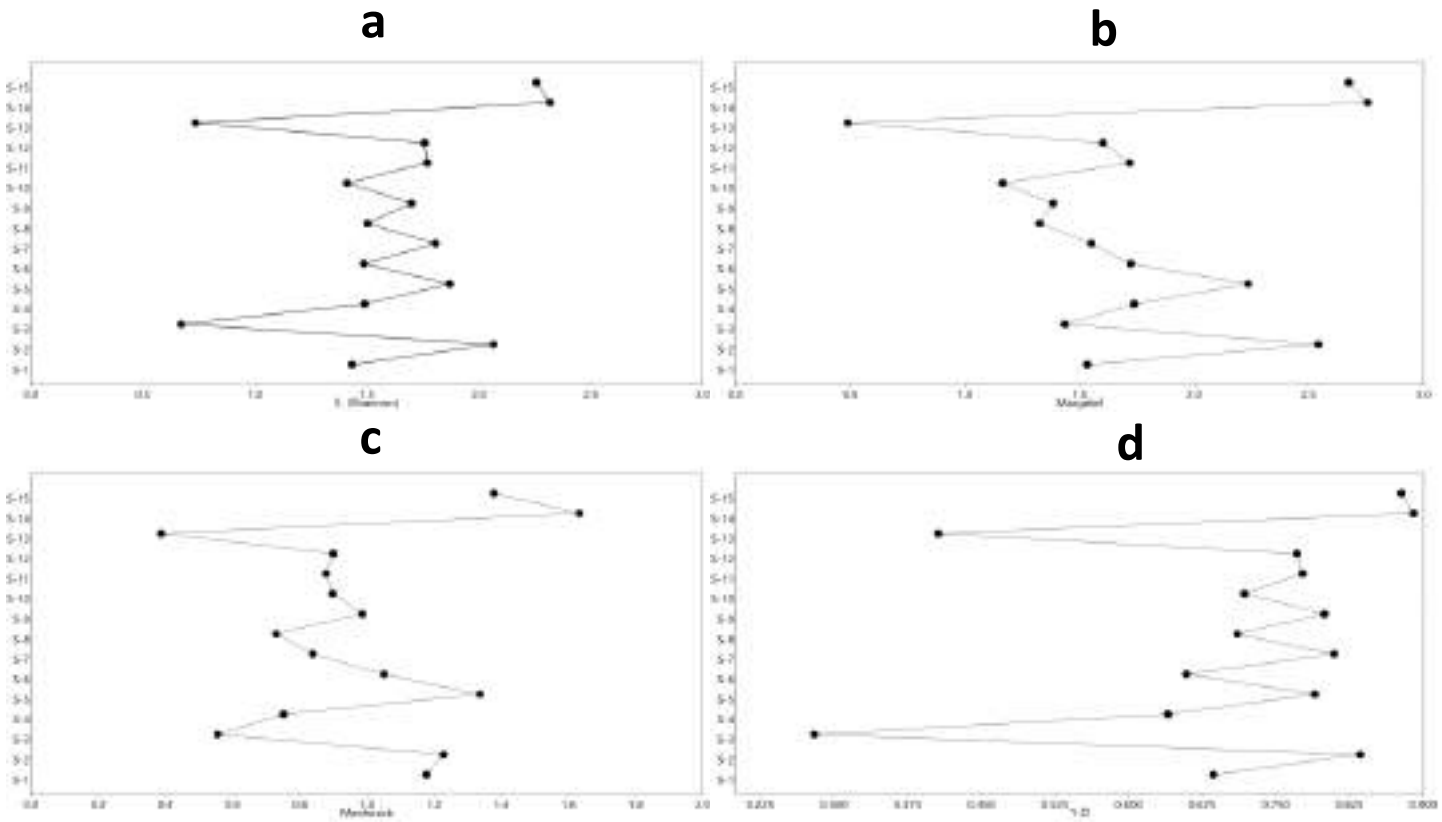

Figure 19: Diversity indices of Intertidal fauna during post-monsoon 2022-2023

a. Shannon Index b. Menhinick Index c. Margalef Index d.Simpson Index

Table 5: Intertidal faunal distribution along Deendayal Port Authority area during Post-monsoon 2022-2023

Phylum	Species	S-1	S-2	S-3	St 4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	St 12	S- 13	S-14	S- 15	PC	PO
Nemertea	*Nemertea* sp	0	0	1	2	0	1	0	0	0	2	0	3	0	3	3	1.1	47
Nematoda	*Nematoda sp*	0	13	0	0	3	1	0	2	0	5	0	0	0	1	2	2.0	47
Annelida	*Nereis* sp	3	0	0	3	2	0	0	6	0	0	0	4	0	0	1	1.4	40
	Nephtys sp	0	4	3	0	0	4	0	0	3	0	3	0	0	3	0	1.5	40
Arthropoda	*Scylla olivacea*	0	1	0	0	4	0	2	0	0	0	3	0	0	3	0	1.0	33
	Austruca variegata	0	10	4	7	1	0	11	21	5	8	11	9	0	3	16	8.0	80
	Austruca iranica	0	32	0	0	0	0	0	0	0	3	0	7	0	1	1	3.3	33
	Metaplax indica	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	7
	Amphibalanus amphitrite	0	23	0	31	21	0	0	42	0	0	0	14	0	0	14	10.9	40
	Tubuca dussumieri	0	1	2	7	11	0	0	13	0	0	0	6	0	0	9	3.7	47
Mollusca	*Pirenella cingulata*	0	0	221	100	0	6	26	3	5	0	34	0	45	6	0	33.6	60
	Telescopium telescopium	2	0	3	5	0	0	11	0	6	0	7	0	7	0	3	3.3	53
	Indothais lacera	1	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0.5	13
	Bakawan rotundata	2	3	2	0	3	3	22	0	0	0	8	0	0	9	3	4.1	60
	Platevindex martensi	0	0	3	0	3	0	2	0	0	0	4	0	0	4	3	1.4	40
	Optediceros breviculum	13	11	23	11	1	32	0	0	12	0	32	32	0	0	12	13.5	67
	Anadara inaequivalvis	0	2	0	4	0	5	0	5	0	0	0	4	0	0	0	1.5	33
	Pholas orientalis	5	9	0	0	7	0	12	0	0	13	0	0	8	7	13	5.6	47
Chordata	*Periophthalmus waltoni*	0	2	0	7	0	6	5	0	6	0	3	0	0	8	9	3.5	53
Density /m2		**26**	**112**	**262**	**177**	**56**	**58**	**91**	**92**	**37**	**31**	**105**	**79**	**60**	**54**	**89**		
Total genera		**6**	**13**	**9**	**10**	**10**	**8**	**8**	**7**	**6**	**5**	**9**	**8**	**3**	**12**	**13**		

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 $0.04m^2$. 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 $/m^2$. 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 a*l., (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).

Subtidal macrobenthos

Phylum composition of subtidal Fauna

The subtidal macrofauna survey was conducted at 15 locations within the vicinity of the Deendayal Port Authority. The species diversity calculated was maximum for phylum Mollusca (13 species) which is followed by Annelida (6species) and Arthropoda (2 species),The Cnidaria was represented by a single species (Table.6). The fanatic composition varied from 5% to 59%. Among the fauna the highest percentage of contribution was contributed by Mollusca (59%) followed by Annelida (27%) and least number of percentage was contributed by Cnidaria (5%) (Fig 20.)

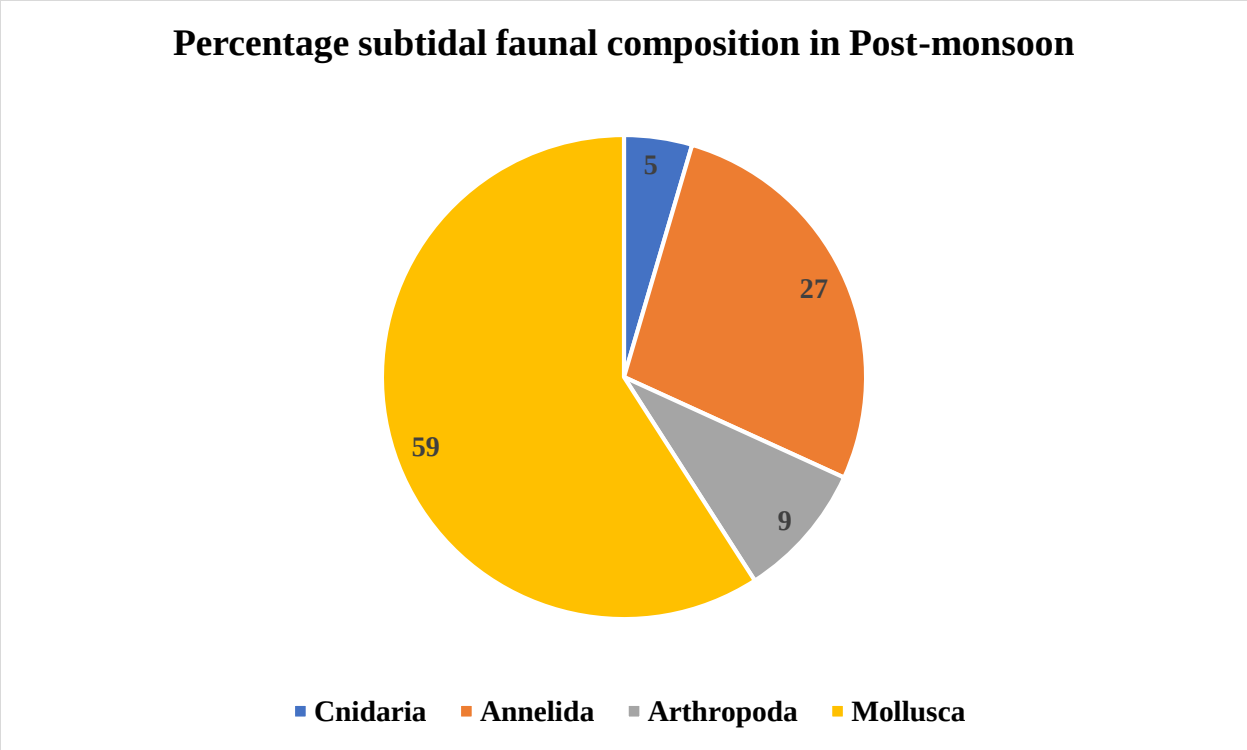

Figure 20. Phylum composition of subtidal macrobenthos during Post-monsoon 2022-2023

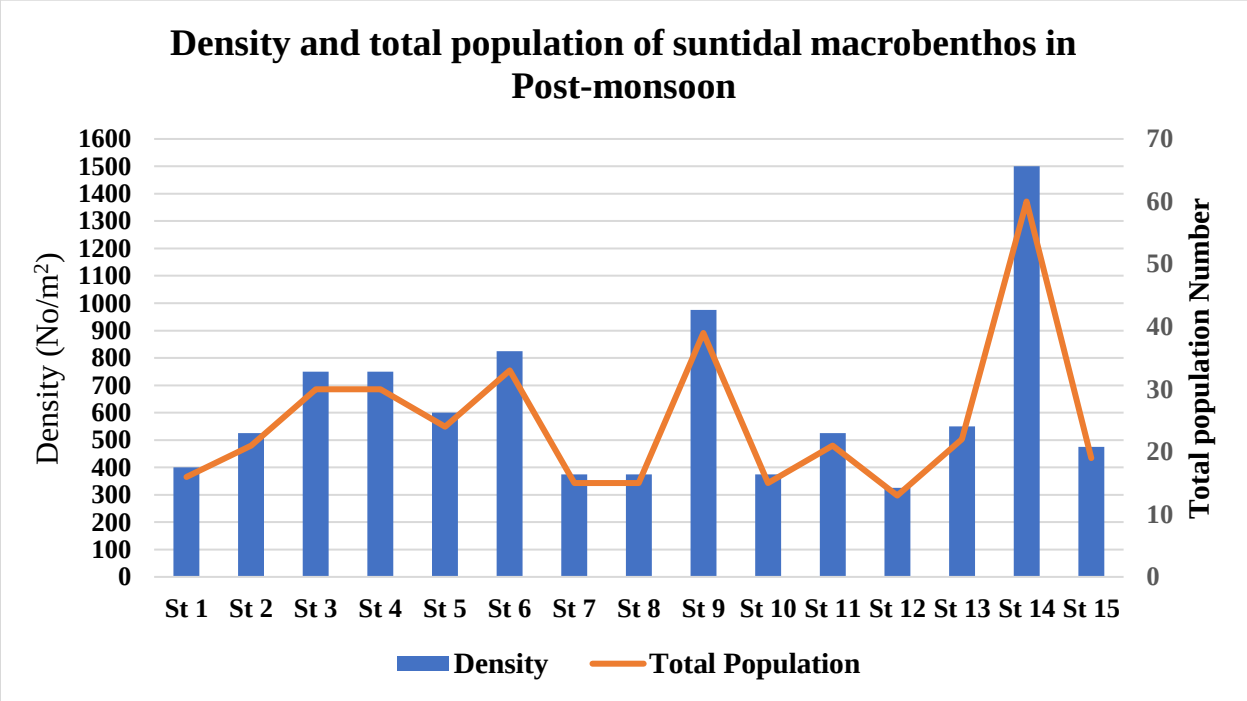

Figure 21: Total genera and population density macrobenthos during Post-monsoon 2022-2023

Total genera &populationa density(No/m^2)

The number of intertidal fauna population collected from the intertidal zone and its density are presented in Fig 21. The total genera of subtidal fauna varied from 6 to 116 with average of 9 number. Highest number of genera was recorded in station S-14 (16) and lowest number of genera was recorded along the station S-7 (3 No). Similarly the total population of subtidal fauna varied from 13-60 number with average variation of 25 number. Highest number of population was recorded at S-14 (60 no) and lowest was recorded at S-12 (13 no). Likewise the subtidal macrobenthos population density varied from 325 No/m^2 to 1500 No/m2 with average 622 No/m^2. The highest population density was recorded at S-14 (1500 No/ m^2) followed by S-9 (975 No/ m^2) and the lowest density was recorded at S-12 throughout the study period.

Percentage composition of species

The overall percentage composition of the four groups of subtidal genera/species at the 15 stations varied between 0.5% to 14% with an average of 4.5% (Fig.22). The highest percentage of species composition was contributed *Glauconome angulata* (13.7%) followed by *Pirenella cingulata* (12.9%) and *Clypeomorus bifasciata*(6.4%) and *Nereis sp.* (6.4%) while the least was (0.5%). represented by *Turritella sp.*

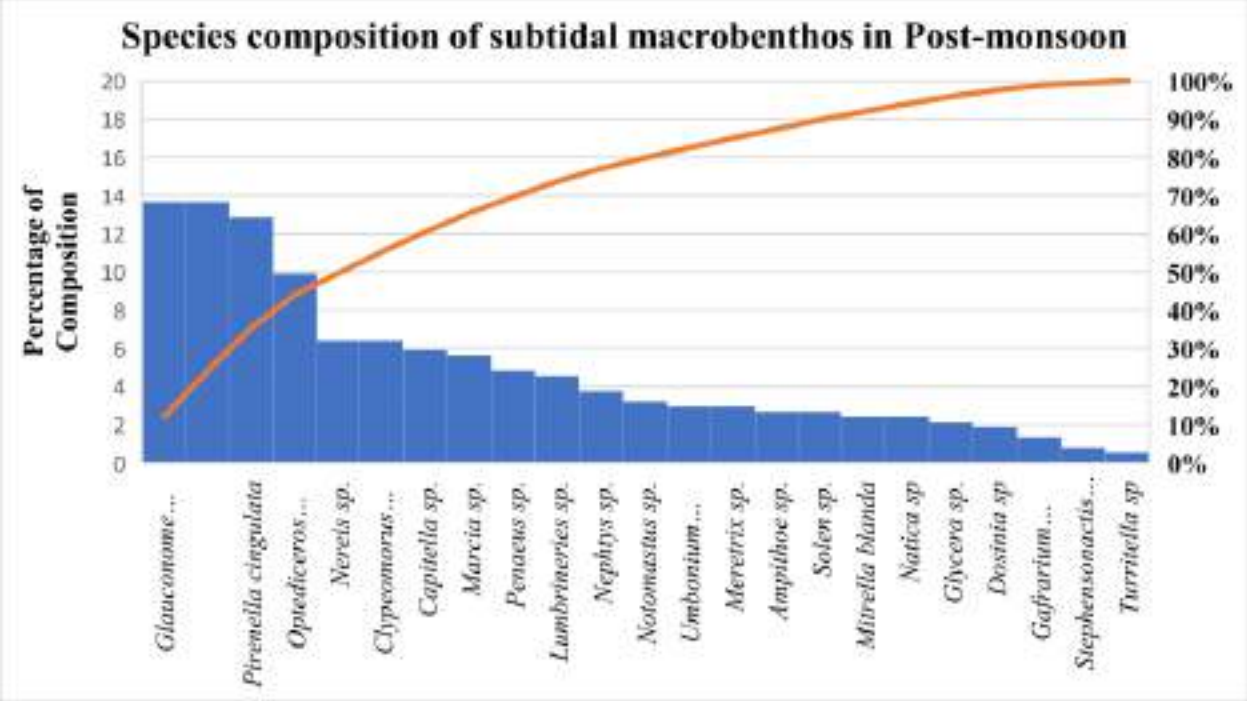

Figure 22. Percentage composition of Subtidal Macrobenthic species in Post-monsoon 2022-2023

Diversity indices

Figure 23 represents the various intertidal 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 Shannon diversity (H') values varied from 1.53 (S-10) to 2.60 (S-14). The Simpson_1-D varied from 0.74 (S -5) to 0.92 (S-14). The menhinick index varied from 1.23 to 2.07, with the maximum in S-14& S-15 and the minimum at S-5. The Margalef index ranged from 1.57 to 3.66, the maximum at S-14and the minimum at S-5.

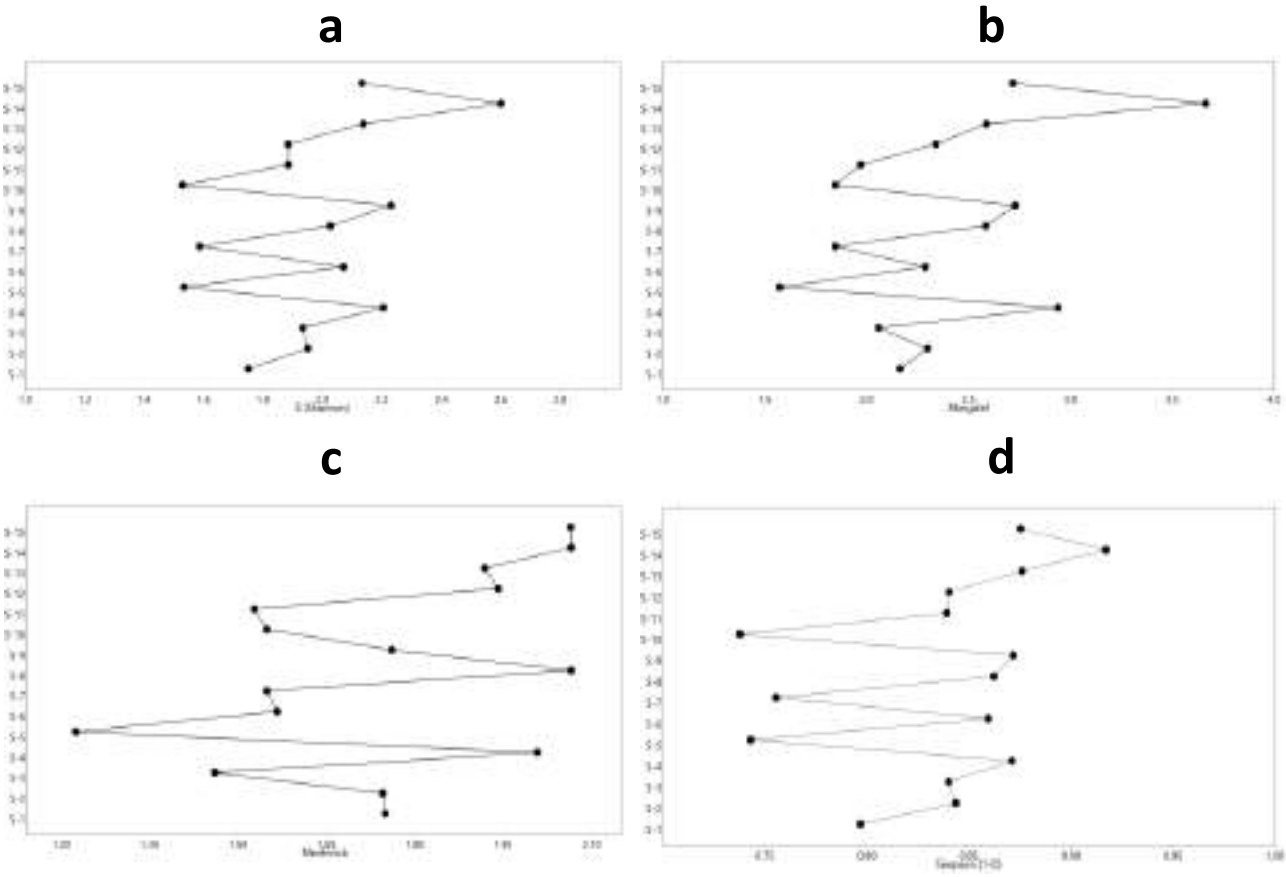

Figure 23: Diversity indices of Subtidal fauna during Post-monsoon 2022-2023

a. Shannon Index b. Menhinick Index c. Margalef Index d. Simpson Index

Table 6: Macro-benthic faunal distribution during Post-monsoon 2022 -2023in Deendayal Port Area

Phylum	Genera/Species	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	PC
Cnidaria	*Stephensonactis* sp.	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0.8
Annelida	*Capitella* sp.	0	3	0	0	3	0	0	0	5	4	3	1	0	3	0	5.9
	Glycera sp.	0	1	0	0	0	0	2	0	2	0	0	0	3	0	0	2.1
	Lumbrineries sp.	1	0	4	3	0	0	1	0	0	2	0	2	2	0	2	4.6
	Nephtys sp.	2	0	2	1	0	3	0	2	3	0	0	0	0	1	0	3.8
	Nereis sp.	0	3	1	1	0	4	0	0	3	1	4	0	4	0	3	6.4
	Notomastus sp.	2	0	0	2	0	3	0	0	2	0	0	0	3	0	0	3.2
Arthropoda	Ampithoe sp.	0	0	0	0	2	0	0	1	3	0	0	2	0	2	0	2.7
	Penaeus sp.	0	2	0	0	1	4	0	0	3	0	2	0	2	1	3	4.8
Mollusca	*Umbonium vestiarium*	1	0	0	2	0	3	0	1	0	1	0	0	0	3	0	2.9
	Mitrella blanda	0	0	0	0	0	0	0	0	0	0	2	0	0	7	0	2.4
	Clypeomorus bifasciata	0	0	0	0	0	0	0	2	10	0	2	3	0	6	1	6.4
	Natica sp	0	0	0	1	0	0	0	0	0	0	0	0	1	7	0	2.4
	Optediceros breviculum	4	5	6	4	2	2	3	2	1	0	0	0	0	5	3	9.9
	Pirenella cingulata	5	0	5	6	7	5	1	2	3	1	5	2	3	1	2	12.9
	Turritella sp	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0.5
	Marcia sp.	0	0	3	2	0	1	2	3	0	0	0	1	2	5	2	5.6
	Glauconome angulata	0	2	7	6	9	8	6	2	0	6	3	2	0	0	0	13.7
	Dosinia sp	0	0	2	2	0	0	0	0	0	0	0	0	0	3	0	1.9
	Gafrarium divaricatum	0	1	0	0	0	0	0	0	0	0	0	0	0	2	2	1.3
	Meretrix sp.	0	4	0	0	0	0	0	0	0	0	0	0	0	6	1	2.9
	Solen sp.	0	0	0	0	0	0	0	0	4	0	0	0	0	6	0	2.7
Density No/m^2		**400**	**525**	**750**	**750**	**600**	**825**	**375**	**375**	**975**	**375**	**525**	**325**	**550**	**1500**	**475**	
Total Population		**16**	**21**	**30**	**30**	**24**	**33**	**15**	**15**	**39**	**15**	**21**	**13**	**22**	**60**	**19**	
Total genera		**7**	**8**	**8**	**11**	**6**	**9**	**6**	**8**	**11**	**6**	**7**	**7**	**9**	**16**	**9**	

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 Chaetomprpha* 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 32200 to 45700 mg/L and suspended solids value between 140-640 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 holophytes 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 Post-monsoon sampling, were *Salicornia brachiata, Aeluropus lagopoides, Salvadora persica* and *Sesuvium portulacastrum*. Among the halophyte species recorded, *Salicornia brachiata* alone was found in the 8 sampling locations. (Table-7 and Plate-12). The percentage of *Salicornia brachiata* was found to be the highest at station S-9 and the lowest in S-11(100%), followed by *Salvadora persica* 20% (S-10) and *Sesuvium portulacastrum* (15%) at S-12. The halophytes grass *Aeluropus lagopoides* reported at S-11 as 33% from Deedayal Port Authority periphery environment.

Table 7: Percentage of Halophytes cover in the DPA during Post-monsoon 2022-2-23

Halophytes	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
Aeluropus lagopoides		0	0	0	0	0	0	0	0	0	33	0	0	0	0
Salicornia brachiata		0	10%	52%	81%	0	0	64%	100%	35	100%	0	0	0	66%
Salvadora persica		0	0	0	0	0	0	0	0	20%	0	0	0	0	0
Sesuvium portulacastrum		0	60%	0	0	0	0	0	0	0	0	15%	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, mangroves are distributed over nine states and three union territories; among those, the state of Gujarat has a longest coastline. With this, two (Gulf of Kachchh and Gulf of Khambhat) out of the three major gulfs of India are located in Gujarat. This makes Gujarat coastal area as one of the most important area in terms of ecology and environment for providing the suitable habitats for various plants and animal species living in coastal environment. Mangroves are found in intertidal areas which protect the coastal areas against various problems such as erosion caused by wind and water currents. With this, mangroves are capable to protect the coast from various natural disasters such as cyclones and tsunamis. They are also play important role as carbon sinks in coastal and intertidal zones. Gujarat shows the second largest mangrove cover of India after the state of West Bengal. This is the success of conservation and development activities had been priorities in the Gujarat for mangroves. Mangrove cover in Gujarat is distributed over a few parts such as Kachchh and Gulf of Kachchh, Saurashtra, and South Gujarat particularly Gulf of Khambhat. Gulf of Kachchh hosts one of the major mangrove formations of India spreading to an area of 980 km2. The vegetation characteristics of mangroves of Gulf of Kachchh have been thoroughly studied and documented by GUIDE.

Tree Density

During the post-monsoon 2022-23, total 12 mangrove sites were surveyed for the recoding the plant growth parameters such as height, girth, canopy cover etc and the density of plants. Among the 12 sampling sites, the mean plant density was maximum at Tuna creek (4371/ ha), followed by Jangi creek (3210/ Ha). Considering the sampling sites individually the highest tree density was reported at S12 in the Tuna creek area (6515/Ha). The lowest average tree density of individual sites was reported in S-5 (1491 trees/ Ha) sampling site located at Phang creek. In terms of creeks, the lowest average density was recorded at Kharo creek in which only one sampling site is located S-7 (2291/ha). All these results show that inconsistency in mangroves was with respect to local geomorphology and various ecological and environmental characteristics. (Fig.24 & Table 8).

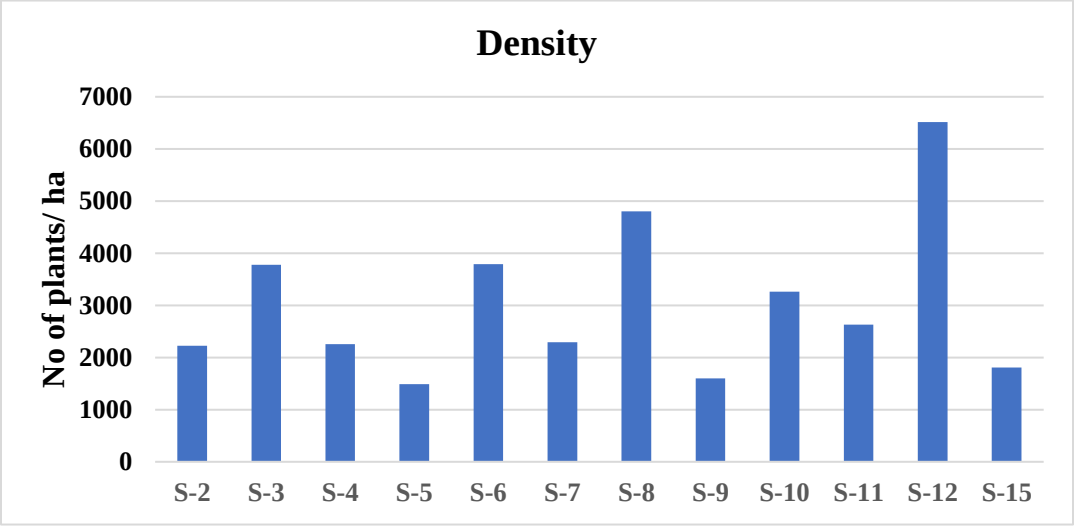

Figure 24. Mangrove Plant density during Post-monsoon 2022-2023

Height

The overall mean height of the mangroves from study sites along the DPT port environment was 1.8 m during post-monsoon season of 2022 (Fig.25). The highest average tree height was recorded at Phang creek area (2.1 m), followed by at Tuna creek (1.9 m). In terms of individual sites, the average highest tree height was recorded at the site S-2 located at Tuna creek, followed by site S-10 located at Phang creek. The average tree heights of the various sites varied between 1.2 m and 2.6 m during the post-monsoon period.

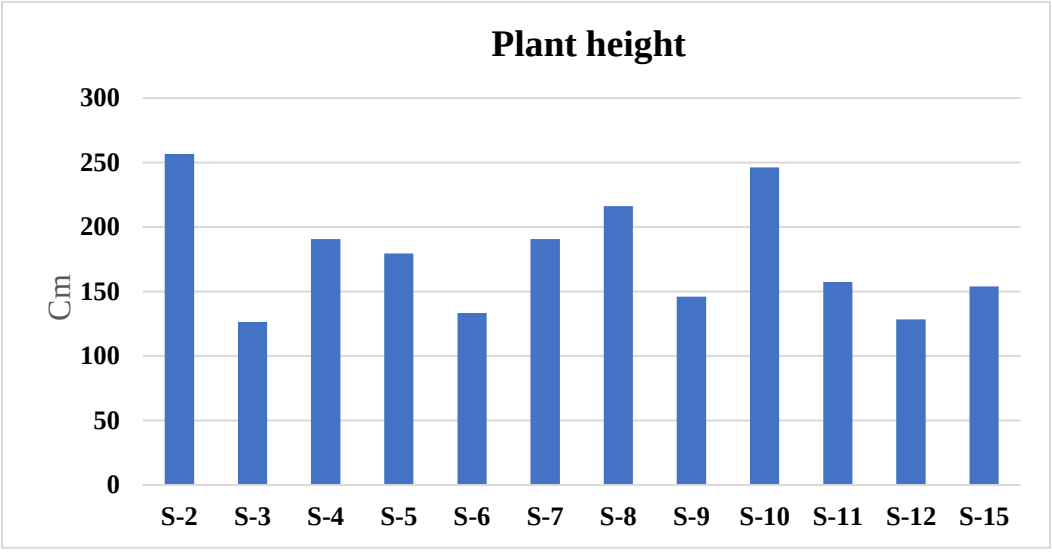

Figure 25. Plant height during Post-monsoon 2022-2023

Canopy Crown Cover

In DPA Kandla sampling area, the canopy cover of mangroves show variations in wide extends. The overall average canopy cover was reported 4.8 m2 during the post-monsoon 2022. The sites S-12 at Tuna creek, S-3 at Kandla creek and S-6 at Jangi creek showed relatively lower average canopy cover compared to others. The highest average canopy cover was reported at S-2 (Tuna creek) which was ranging from 0.48 m to 22.5 m. The second largest average canopy cover was reported at S-15 site of Kandla creek which was ranging from 4 m to 8.4 m (Fig.26).

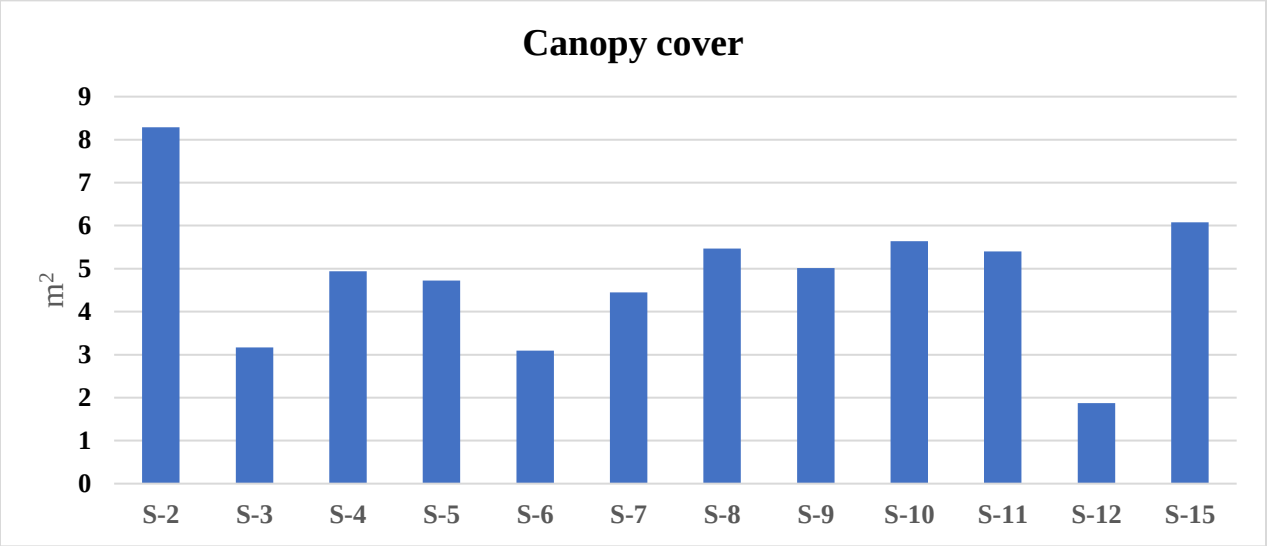

Figure 26. Mangrove canopy cover during Post-monsoon 2022-2023

Basal area

The overall average basal girth of the mangroves of the DPA sampling sites was reported 21.7 cm. In case of individual sampling sites, the highest average basal area (40 cm) was at site S-5 followed by site S-10 (39.7 cm), located in the Phang creek. The lowest average basal girth was reported in the site S-12 (8.7 cm) of Tuna creek. The mangrove plants have multiple stems pattern which is general characteristics of a few mangrove species particularly *Avicennia marina* which is generally found in the DPA Kandla area (Fig.27).

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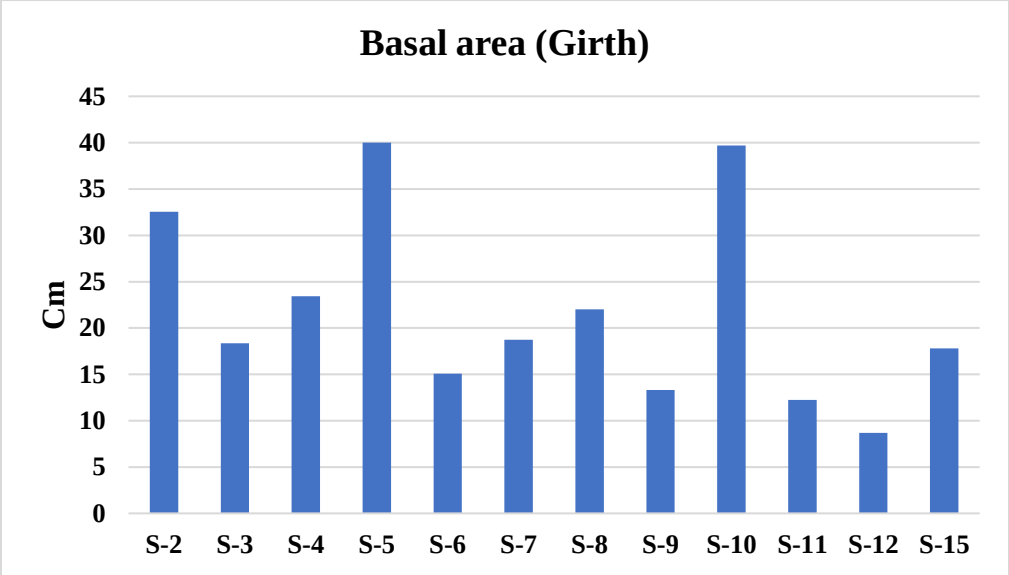


Figure 27. Mangrove basal area during Post-monsoon 2022-2023

Regeneration and Recruitment class

The overall average regeneration class density was 67829 plants/ha and that of recruitment class 13483 plants/ha. The highest average regeneration class plants were recorded (141000 plants/ha) at S-8 site located in Navlakhi creek and for recruitment class, the highest average plants were recorded at site S-3 (28625 plants/ha) located in the Kandla creek during this post-monsoon season. The highest ratio for tree density to recruitment class was observed at S-3 site while the lowest ratio was observed at S-11 site. The complex hydro-edaphic conditions in the DPA Kandla premises can influence the mangrove stature and are substantiated with infrequent tidal coverage and high evapotranspiration. The availability of regeneration and recruitment class plants in the sampling sites can assure that there are plants to take position of trees in case of any harm to mature plants (Table 9).

Plate 8: Mangrove species recorded along the Deendayal Port area

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

Table 8: Density of mangroves in the DPA vicinity during Post-monsoon 2022-2023

Sampling stations	Density (Tree/Ha)	Tree height (m)			Canopy cover (m^2)			Basal Area (cm)		
		Min	Max	Avg.	Min	Max	Avg.	Min	Max	Avg.
Tuna creek										
S2	2226.55	130.00	450.00	256.67	0.48	22.50	8.29	7.00	120.00	32.56
S12	6515.31	110.00	180.00	128.33	0.12	5.46	1.87	7.00	12.00	8.67
Mean	4370.93	120.00	315.00	192.50	0.30	13.98	5.08	7.00	66.00	20.62
Phang creek										
S5	1490.74	110.00	310.00	179.50	1.54	10.54	4.72	12.00	110.00	40.00
S10	3265.31	100.00	420.00	246.25	0.56	16.40	5.64	7.00	120.00	39.69
Mean	2378.03	105.00	365.00	212.88	1.05	13.47	5.18	9.50	115.00	39.85
Kandla creek										
S3	3780.86	105.00	210.00	126.32	0.42	15.58	3.17	7.00	80.00	18.37
S4	2256.25	110.00	380.00	190.53	0.40	12.24	4.94	7.00	80.00	23.42
S15	1810.77	110.00	230.00	154.00	3.99	8.40	6.08	10.00	40.00	17.80
Mean	2615.96	108.33	273.33	156.95	1.60	12.07	4.73	8.00	66.67	19.86
Kharo creek										
S7	2290.89	110.00	400.00	190.71	0.54	20.00	4.45	7.00	100.00	18.75
Jangi creek										
S6	3790.74	110.00	290.00	133.39	0.12	9.30	3.09	7.00	45.00	15.09
S11	2629.85	100.00	200.00	157.50	2.04	8.70	5.40	9.00	17.00	12.25
Mean	3210.30	105.00	245.00	145.45	1.08	9.00	4.25	8.00	31.00	13.67
Navlakhi creek										
S8	4805.21	110.00	400.00	216.29	0.72	21.60	5.47	7.00	80.00	22.00
S9	1600.00	105.00	200.00	146.00	2.21	9.60	5.01	9.00	18.00	13.30
Mean	3202.61	107.50	300.00	181.15	1.47	15.60	5.24	8.00	49.00	17.65
Overall average	3011.45	109.31	316.39	179.94	1.01	14.02	4.82	7.92	71.28	21.73

Table 9: Regeneration and Recruitment class plants during Post-monsoon 2022-2023

Station	Tree density- No/ha (1)	Regeneration density- No/ha (2)	Recruitment density- No/ha (3)	Ratio of 1:3	Ratio of 2:3
Tuna creek					
S-2	2226.55	140000	11775	1 : 5.29	11.89 : 1
S-12	6515.31	70000	11750	1 : 1.80	5.96 : 1
Mean	4370.93	105000	11763	1 : 2.69	8.93 : 1
Phang creek					
S-5	1490.74	80000	6562	1 : 4.40	12.19 : 1
S-10	3265.31	43000	11250	1 : 3.45	3.82 : 1
Mean	2378.03	61500	8906	1 : 3.75	6.91 : 1
Kandla creek					
S-3	3780.86	46500	28625	1 : 7.57	1.62 : 1
S-4	2256.25	84000	7000	1 : 3.10	12.00 : 1
S-15	1810.77	48000	8750	1 : 4.83	5.49 : 1
Mean	2615.96	59500	14792	1 : 5.65	4.02 : 1
Kharo creek					
S-7	2290.89	45000	22250	1 : 9.71	2.02 : 1
Jangi creek					
S-6	3790.74	54444	12500	1 : 3.30	4.36 : 1
S-11	2629.85	34500	4375	1 : 1.66	7.89 : 1
Mean	3210.30	44472	8438	1 : 2.63	5.27 : 1
Navlakhi creek					
S-8	4805.21	141000	16000	1 : 3.33	8.81 : 1
S-9	1600.00	42000	13500	1 : 8.44	3.11 : 1
Mean	3202.61	91500	14750	1 : 4.61	6.20 : 1
Overall average	3011.45	67828.67	13482.94	1 : 4.48	5.03 : 1

3.12. Marine Reptiles

During the field surveys, one reptilian species, the saw-scaled *viper Echis carinatus sochureki* was recorded at site S-10 located in the western part of Sat Saida bet opposite to Phang creek during Post-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.

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 klunzinger*i, *Planiliza planiceps*, *Planiliza macrolepis* (Plate 9) were observed of which *Mugil cephalus* catch was the maximum during Post-monsoon season of (100 kg) followed by Lobester(30 kg) and shrimp 30 kg.from the Deendayal port periphery environment by local fishermen (Personal communication)

Plate 10: Fishery catch along the Deendayal Port Authority in Post-monsoon 2022-2023

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-15 and S-5 in phang creek during Post-monsoon season of total 3 number . 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). Besides this common dolphin also sighed in our observation.

Plate 11. Indian Ocean humpback dolphin *Sousa plumbea*

4. Mud flat

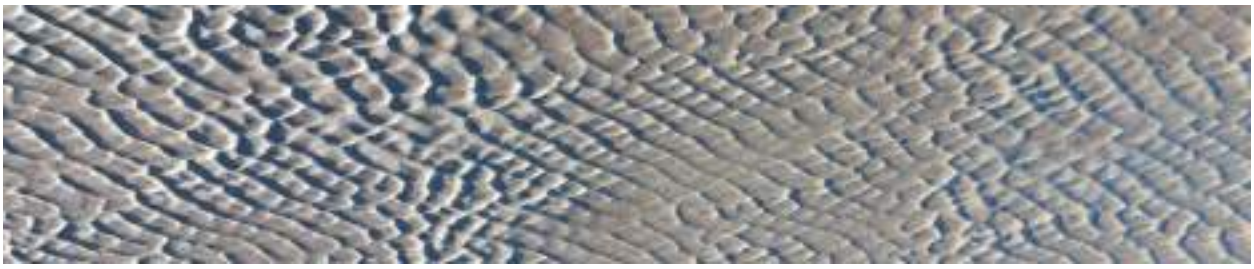
Mudflats and mangroves establish a major ecosystem of the DPA coastal region and the significance of ecosystem services rendered by mudflat is endorsed in Coastal Regulation Zone (CRZ, 2011) as it accords special status to highly productive zone. Mudflat has an assemblage of plant-animal-geomorphological 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.28). The bulk density of mangrove soil at Deendayal Port Authority coastal region in post-monsoon ranged from 1.23g/cm^3 to 1.52 g/cm^3. The highest bulk density was recorded at S-13 and the lowest bulk density was recorded at site S-1 located at Tuna creeek.

Total Organic Carbon (TOC)

The highest TOC value (0.87%) was recorded at station S-6 followed by S-10 . Lowest TOC value was reported at site S-1 (Fig.29). 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 Post-monsoon samplings revealed that the different sampling sites of Deendayal Port Authority jurisdiction have considerable variations with respect to organic carbon.



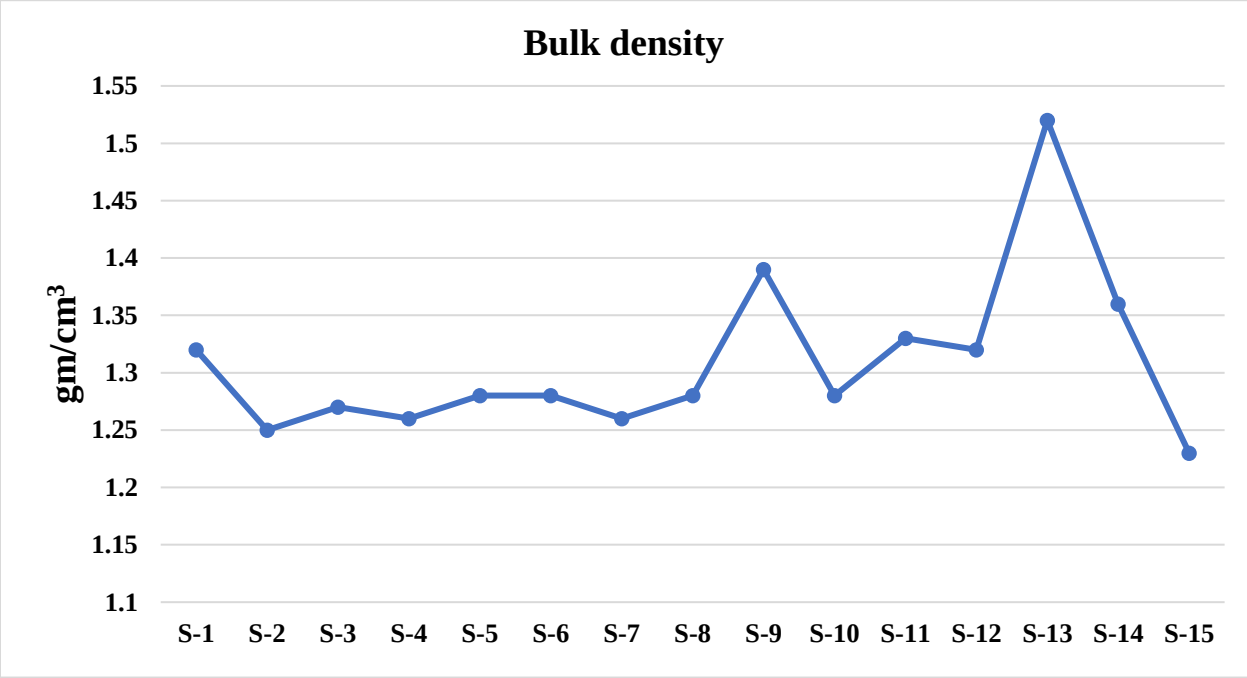


Figure 28: Bulk density of mudflat sediment during Post-monsoon 2022-2023

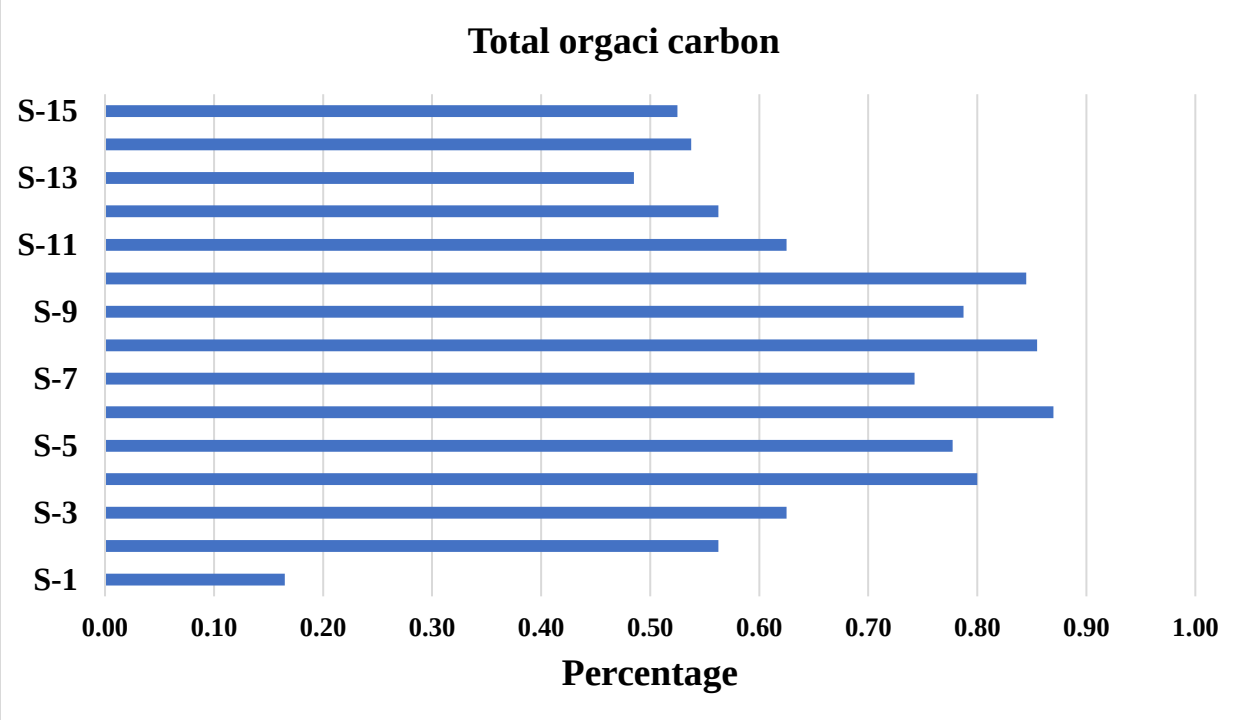


Figure 29: Percentage of Total Organic Carbon in the mudflat in Post-monsoon 2022

5. Avifauna

A total of 79 species belonging to 9 orders, 32 families and 59 genera were recorded from the coastal area of Deendayal Port during this study (Annexure 1). Among these, 49 species were aquatic and 30 species were terrestrial, which included 6 species listed as Near Threatened in the IUCN 2023, Red List. Order Charadriiformes i.e. aquatic birds (including raptors and most water birds) constituted the predominant groups representing 35% of all species recorded from the study area followed by order Passeriformes (24%), Pelecaniformes (19%) and other six orders formed 22% of the recorded species. The families with a greater number of species were Scolopacidae (12 spp.), Ardeidae (8 spp.), Laridae (6 spp.), Charadriidae (5 spp.), Alcedinidae, Hirundinidae, Threskiornithidae each family having (three spp.), six families each having 2 species and eight families each having one species. From the recorded species, 26 species were migrants, 13 species were local migrants or resident migrants, 40 species were breeding resident.

Thirteen (13) kinds of feeding guilds, viz., aquatic invertebrate-feeder, piscivore, insectivore, granivore, frugivore, reptile-feeder, amphibian feeder, nectarivore, weedivore, plankton-feeder, herbivore, carrion-feeder and predatory were identified; among the bird species observed (Ali & Ripley 1987). Here, the aquatic invertebrate guild is the most frequent one with thirty six percent incidence and 31 species occurring under this shared category. Whereas, omnivore, frugivore, granivore, and plankton-feeder guilds are the least frequent with only one species observed in each.Overall mean bird species is 79 calculated from the study area. The overall Shannon diversity (H') is 4.04 with overall species richness index for study area is 9.80. The overall species evenness index value for study area is 0.72 with overall Equitability is 0.92. (Table 10).

Status, distribution and diversity of avifauna in different stations:

Total fifteen sites were surveyed and the results shows that the maximum number of species found from the Site Site 1 (57 spp.) followed by Site 2 (55 spp.), Site 9 (46 spp.), 7 (45 spp.), and. Sites 5 have found lowest avifaunal species (31 spp.) (Fig. 30).

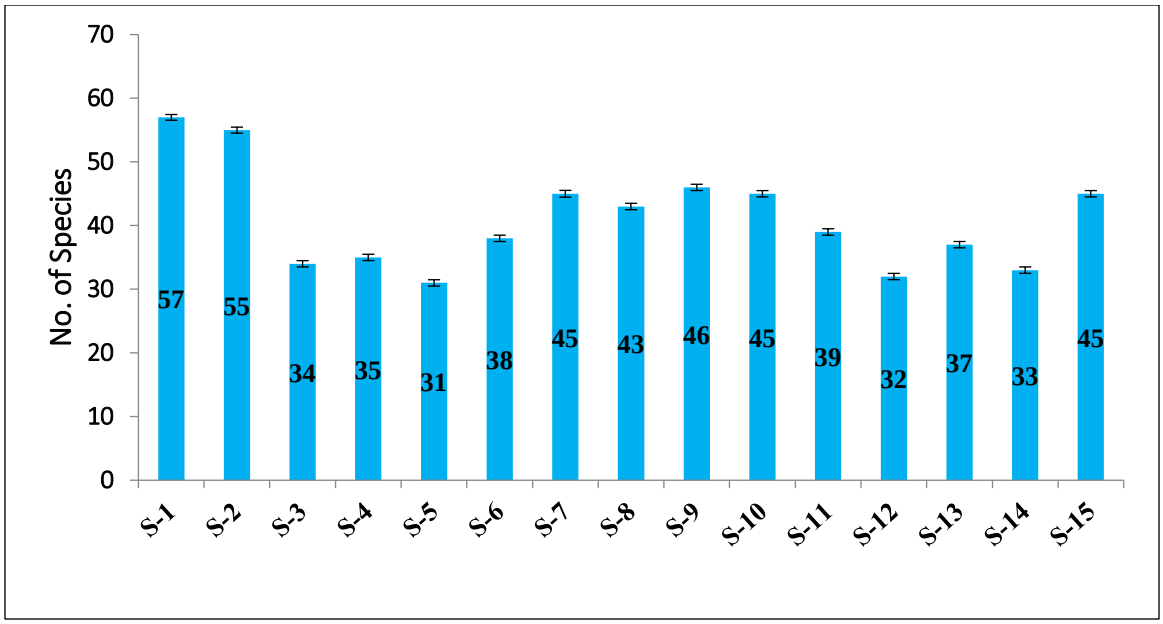


Figure 30. Number of Avian species recorded from the DPA in Post-monsoon2022-2023

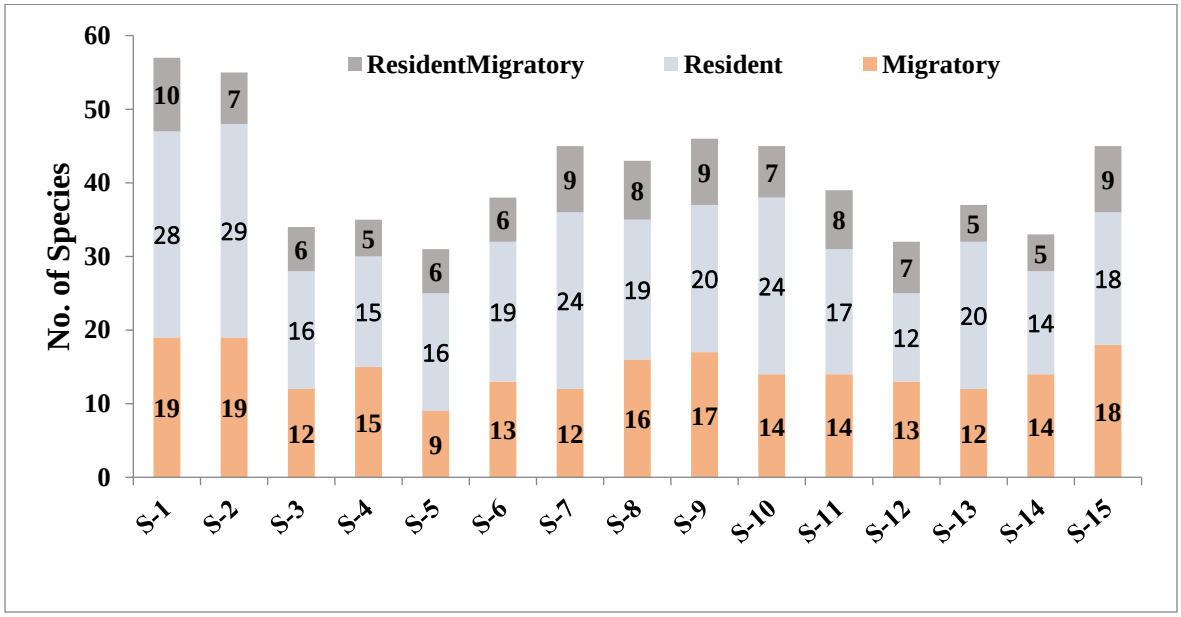


Figure 31. Behavioral status of Avian species from the DPA in Post-monsoon 2022-2023

Each site's wise migratory status was also calculated and the results shows that the maximum migratory species found from the site Site 1&2 (19 spp.) followed by Site 15 (18 spp.), Site 9 (17 spp.) and site 5 (9 spp.) (Fig. 31)..

During the survey we have surveyed both terrestrial habitat like Mangrove plantation adjoining to the Mudflats and waste land, and aquatic habitats like creek area, rivers and wetland. From the study site wise all the species categorised into two habitats i.e. terrestrial and aquatic and the results shows that the maximum terrestrial avifaunal species recorded from the site 1 (23 spp.) and site 2 (21 spp.) followed by site 7,9,15 (17 spp.) and site 6,8,10 (16 spp.). Whereas aquatic avifaunal species recorded more from Site 1 & 2 (34 spp.) followed by site 9,10 (29 spp.), site 7,15 (28 spp.) and site 8 (27 spp.)(Fig. 32)

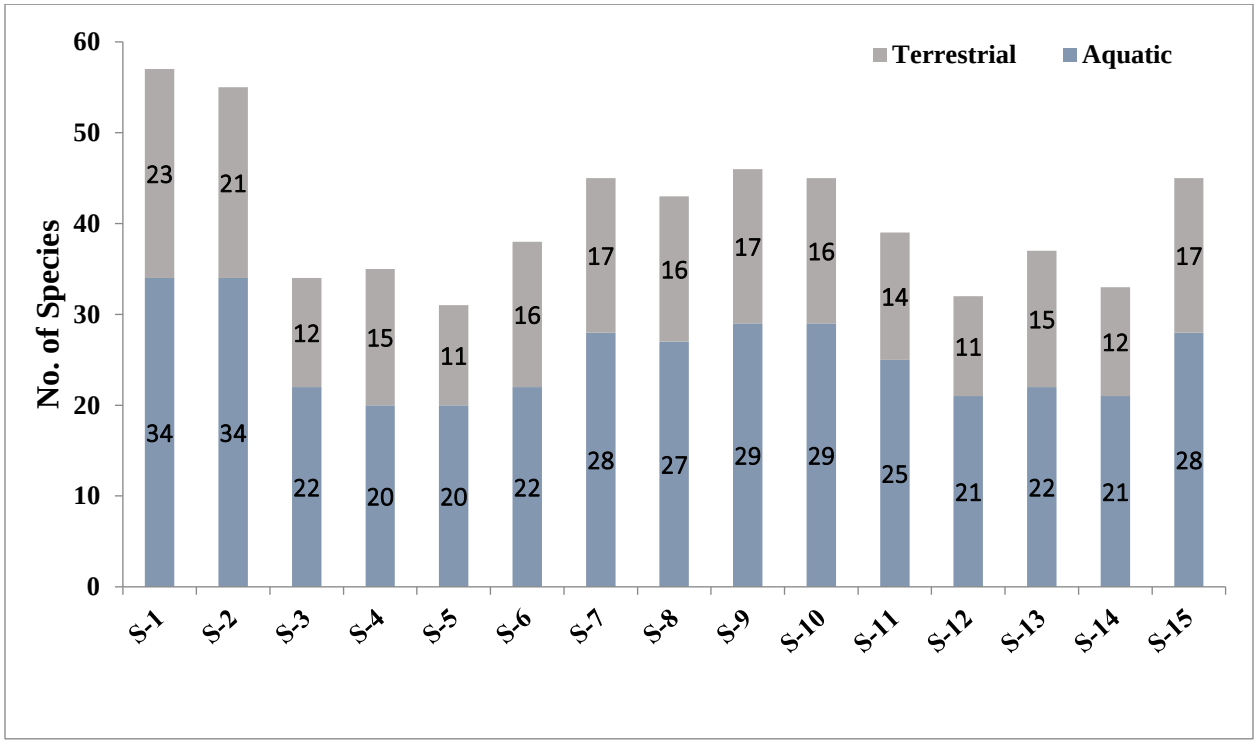


Figure 32. Habitat wise distribution of Bird species in Post-monsoon 2022-2023 from DPA

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 species of aquatic plant/insect feeder birds species (maximum 35 species recorded from Site 1&2) followed by Insectivores (Maximum 8 species recorded from Site 1&2), granivore (maximum 8 species recorded from Site 2) and piscivores (maximum 4 species recoded from Site 3,6,8&11) and least species found of frugivores, omnivores and nectorivores.

Data collected from point counts allows us to calculate species diversity, richness and species composition. The results shows that the maximum diversity found from the Site 1 (H' 3.8) followed by Site 2 (H' 3.7) and the minimum diversity recorded from site 7 (H' 2.7) and Site 5 (H' 2.9). The results of species richness shows that maximum species richness recorded from Site 1 (10.38 spp.) and minimum species richness recorded from Site 5 (6.11 spp.). Other diversity indices details were given in the table 10.

Table 10. Stationwise Diversity Indices recorded from the Deendayal port Area

Diversity Indices	No. of Species	Individuals	Dominance_D	Shannon_H	Evenness_e^H/S	Margalef	Equitability_J
S-1	57	220	0.03	3.83	0.81	10.38	0.95
S-2	55	269	0.03	3.72	0.75	9.65	0.93
S-3	34	157	0.06	3.18	0.70	6.53	0.90
S-4	35	116	0.04	3.40	0.86	7.15	0.96
S-5	31	135	0.08	2.91	0.59	6.12	0.85
S-6	38	161	0.03	3.49	0.86	7.28	0.96
S-7	45	305	0.17	2.78	0.36	7.69	0.73
S-8	43	204	0.04	3.48	0.75	7.90	0.93
S-9	46	261	0.06	3.28	0.58	8.09	0.86
S-10	45	193	0.04	3.56	0.78	8.36	0.93
S-11	39	174	0.05	3.40	0.77	7.37	0.93
S-12	32	155	0.07	3.09	0.68	6.15	0.89
S-13	37	137	0.03	3.47	0.87	7.32	0.96
S-14	33	155	0.05	3.22	0.76	6.35	0.92
S-15	45	212	0.04	3.53	0.76	8.21	0.93
Total	**79**	**2854**	**0.02**	**4.05**	**0.73**	**9.80**	**0.93**

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ANNEXURE – III

Monitoring Report

Environmental Monitoring Report (EMP) prepared under "Preparing and monitoring of environmental monitoring and management plan for Deendayal Port Authority at Kandla and Vadinar for a period of 3 years"

Monitoring period (17th April-16th May, 2023)

Document Ref No.: GEMI/DPA/782(2)/2023-24/18

Submitted to:

Deendayal Port Authority (DPA), Kandla

Gujarat Environment Management Institute (GEMI)

(An Autonomous Institute of Government of Gujarat)

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"AN ISO 9001:2015, ISO 14001:2015 AND ISO 45001:2018 Certified Institute"

About this Document

Gujarat Environment Management Institute (GEMI) has been assigned with the work of "Preparing and monitoring of Environmental monitoring and Management plan for Deendayal Port Authority at Kandla and Vadinar for a period of 3 years" by Deendayal Port Authority, Kandla. Under the said project the report titled *"Environment Monitoring Report (17April-16May 2023)"* is prepared.

- **Name of the Report:** *Environment Monitoring Report (April-May 2023)*
- **Date of Issue:** 21/08/2023
- **Version:** 2.0
- **Report Ref.:** GEMI/DPA/782(2)/2023-24/18

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List of Abbreviations

A	Acceptable Limits as per IS: 10500:2012
AAQ	Ambient Air Quality
AWS	Automatic Weather monitoring stations
BIS	Bureau of Indian Standards
BOD	Biochemical Oxygen Demand
BQL	Below Quantification Limit
CCA	Consolidated Consent & Authorization
CO	Carbon Monoxide
COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
DO	Dissolved Oxygen
DPA	Deendayal Port Authority
EC	Electrical Conductivity
EMMP	Environmental monitoring and Management Plan
EMP	Environment Management Plan
FPS	Fine Particulate Sampler
FY	Financial Year
GEMI	Gujarat Environment Management Institute
IFFCO	Indian Farmers Fertiliser Cooperative Limited
IMD	India Meteorological Department
IOCL	Indian Oil Corporation Limited
LNG	Liquefied Natural Gas
MGO	Marine Gas Oil
MMTPA	Million Metric Tonnes Per Annum
MoEF	Ministry of Environment & Forests
MoEF&CC	Ministry of Environment, Forest and Climate Change
NAAQS	National Ambient Air Quality Standards
NO_x	Nitrogen oxides
NTU	Nephelometric Turbidity Unit
OOT	Off Shore Oil Terminal
OSR	Oil Spill Response
P	Permissible Limits as per IS: 10500:2012
PAH	Poly Aromatic Hydrocarbons
PM	Particulate Matter
PTFE	Polytetrafluoroethylene
RCC	Reinforced Concrete Cement
RDS	Respirable Dust Sampler
SAR	Sodium Adsorption Ratio
SBM	Single Bouy Mooring
SO_x	Sulfur oxides
STP	Sewage Treatment Plant
TC	Total Coliforms
TDS	Total Dissolved Solids
TOC	Total organic Carbon
TSS	Total Suspended Solids
VOC	Volatile Organic Compounds

CHAPTER 1: INTRODUCTION

1.1 Introduction

Kandla Port, also known as the Deendayal Port is a seaport in Kachchh District of Gujarat state in the western India, near the city of Gandhidham. Located on the Gulf of Kachchh, it is one of major ports on the western coast. The Port is located on the Gulf of Kachchh on the north-western coast of India, 256 nautical miles southeast of the Port of Karachi in Pakistan and over 430 nautical miles north-northwest of the Port of Mumbai (Bombay). It is the largest port of India by volume of cargo handled. Deendayal Port's journey began in 1931 with the construction of RCC Jetty by Maharao Khengarji. Kandla was constructed in the 1950s as the chief seaport serving western India, after the independence of India. In the year 2007-08 and has retained the top position for the 14th consecutive year since then. On 31st March 2016, Deendayal Port created history by handling 100 MMT cargo in a year and became the first Major Port to achieve this milestone. It is the largest port of India by volume of cargo handled. Deendayal Port Authority, India's busiest major port in recent years, is gearing up to add substantial cargo handling capacity with private sector participation. Deendayal port Authority creates a new record by handling 137 MMTPA (at Kandla and Vadinar) during the financial year 2022-23. The Deendayal Port Authority (DPA) had commissioned the Off-shore Oil Terminal facilities at Vadinar in the year 1978, for which M/s. Indian Oil Corporation Limited (IOCL) provided Single Bouy Mooring (SBM) system, having a capacity of 54 MMTPA, which was first of its kind in India. Further, significant Quantum of infrastructural upgradation has been carried out & excellent maritime infrastructure has been created at Vadinar for the 32MMTPA Essar Oil Refinery in Jamnagar District. DPA, Kandla crossed the landmark 100 MMT in cargo throughput for FY 2022-23 on December 28, 2022, thereby becoming the first Major Port to reach three figures in cargo handling, that too in only 3 quarters of a fiscal year.

1.2 Green Ports Initiative

Deendayal Port Authority 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 equipment required for monitoring environmental pollution, acquiring dust suppression system, setting up of sewage/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 Authority had also appointed Gujarat Environment Management Institute (GEMI) as an Advisor for "Making Deendayal Port a Green Port - Intended Sustainable Development under the Green Port Initiatives.

Deendayal Port Authority 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 Authority. The plantation is being carried out by the Social Forestry division of Kachchh.

1.3 Importance of EMP

Port activities can cause deterioration of air and marine water quality in the surrounding areas due to multifarious activities. The pollution problems usually caused by port and harbour activities can be categorized as follows:

1. Air pollutant emissions due to ship emissions, loading and unloading activities, construction emission and emissions due to vehicular movement.
2. Coastal habitats may be destroyed and navigational channels silted due to causeway construction and land reclamation.
3. Deterioration of surface water quality may occur during both the construction and operation phases.
4. Harbour operations may produce sewage, bilge wastes, solid waste and leakage of harmful materials both from shore and ships.
5. Human and fish health may be affected by contamination of coastal water due to urban effluent discharge.
6. Oil pollution is one of the major environmental hazards resulting from port/harbour and shipping operations. This includes bilge oil released from commercial ships handling non-oil cargo as well as the more common threat from oil tankers.
7. Unregulated mariculture activities in the port and harbour areas may threaten navigation safety.

Hence, for the determination of levels of pollution, identification of pollution sources, control and disposal of waste from various point and non-point sources and for prediction of pollution levels for future, regular monitoring and assessment are required during the entire construction and operation phase of a major port. As per the Ministry of Environment, Forest and Climate Change **(MoEF&CC)**, The Environmental Management Plan (EMP) is required to ensure sustainable development in the area surrounding the project. Hence, it needs to be an all encompasses plan consist of all mitigation measures for each item wise activity to be undertaken during the construction, operation and the entire life cycle to minimize adverse environmental impacts resulting from the activities of the project. for formulation, implementation and monitoring of environmental protection measures during and after commissioning of projects. The plan indicates the details of various measures and proposed to be taken for appropriate management of the environment of Deendayal Port Authority.

It identifies the principles, approach, procedures and methods that will be used to control and minimize the environmental and social impacts of operational activities associated

with the port. An EMP is a required part of environmental impact assessment of a new port project but could also be evolved for existing ports. It is useful both during the construction and operational phases of the new port but only for operation of existing ports to ensure the effectiveness of the mitigation measures and to give guidance as to the most appropriate way of dealing with any unforeseen effects.

It is extremely essential that port and harbour projects should have an Environmental monitoring and Management Plan (EMMP), which incorporates monitoring of Ambient Air, Drinking Water, Noise, Soil, Marine (water, sediment, ecology) quality along with the collection of online meteorological data throughout the duration of the project.

To ensure the effective implementation of the EMP and weigh the efficiency of the mitigation measures, it is proposed to undertake environmental monitoring both during construction and operation period. In view of the above, Gujarat Environment Management Institute (GEMI) has been awarded with the work "**Preparing and Monitoring of Environmental Monitoring and Management Plan for Deendayal Port Authority at Kandla and Vadinar for a period of 3 years**" vide letter No. EG/WK/EMC/1023/2011/III/239 dated: 15/02/2023 by DPA.

This document presents the environmental monitoring report (EMR) for Kandla and Vadinar for the month of April -May 2023.

1.4 Objectives and scope of the Study

In line with the work order, the key objective of the study is Environmental Monitoring and preparation the Management Plan at Kandla and Vadinar for a period of 3 years". Environmental monitoring refers to systematic sampling of air, water, soil, noise and ecology in order to monitor the performance/ compliance of a project compliance with Environmental quality standards, and any applicable Statutory Compliance and the effectiveness of mitigation measure in EMP.

The scope of work includes not limited to following:

1. To review the locations of Ambient Air, Ambient Noise, drinking water, and Marine Water, Soil and Sediments monitoring stations within the impacted region in and around DPA establishment, in view of the developmental projects.
2. To assess the Ambient Air quality, quality at 6 stations at Kandla and 2 at Vadinar in terms of gases and particulate matter.
3. To assess the DG stack emissions (gases and particulate matter).
4. To assess Drinking water quality at twenty stations in terms of Physical, Chemical and Biological parameters viz., Color, Odor, turbidity, conductivity, pH, Total Dissolved Solids, chlorides, Hardness, total iron, sulfate, NH_4, PO_4, and bacterial count on a monthly basis.
5. To assess the Marine water quality in terms of aquatic Flora and Fauna and Sediment quality in terms of benthic flora and fauna.
6. To assess Marine Water Quality and sediment in term of physical and chemical parameter.

7. To assess the trends of water quality in terms of Marine ecology by comparing the data collected over a specified time period.
8. Every week a sample (Treated wastewater) of the Sewage Treatment Plant (STP) shall be analyzed to see the water quality being discharged by DPA.
9. Noise monitoring will be carried out twice a day at the representative stations for a period of 24 hours.
10. Meteorological parameters are very important from air pollution point of view and precise and continuous data collection is of utmost importance. The data collected is analyzed as per the standards. Meteorological data on wind speed, wind direction, temperature, relative humidity, solar radiation and rainfall will be collected from one permanent station at DPA and one permanent station at Vadinar.
11. To suggest incorporates, mitigation measures, based on the findings of this study and also check compliance with Environmental quality standards, green port initiatives, MIV 2030, and any applicable Statutory Compliance.
12. To recommend Environment management plans on Monitoring programme based on findings of study.

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CHAPTER 2: METHODOLOGY

2.1 Study Area:

Under the study, the locations specified by Deendayal Port Authority for the areas of Kandla and Vadinar would be monitored. The details of the study area as follows:

a. Kandla:

Deendayal Port (Erstwhile Kandla Port) is one of the twelve major ports in India and is located on the West Coast of India, in the Gulf of Kutch at 23001'N and 70013'E in the state of Gujarat in India. Deendayal port primarily services the Northern India hinterland, including the land locked states of Jammu & Kashmir, Uttar Pradesh, Madhya Pradesh and Gujarat. Now, the Major Port Authorities Act 2021 is the governing statute for Administration of Major Ports. Now, on 18 February 2021, Major Port Authorities, (MPA) Act 2021 notified in the Gazette of India same has come into force from 3 November 2021. Under, MPA 2021, Deendayal Port Trust (DPT) have become Deendayal Port Authority (DPA). At Kandla, Deendayal Port has sixteen (16) cargo berths for handling various types of Dry Bulk Cargo viz, fertilizer, food grains, Coal, sulphur, timber, salt, ores etc. and Containers. Apart from dry bulk, DPA has seven (7) oil for handling all types of Liquid Cargo viz. POL, Chemicals etc. at Kandla. Deendayal Port Authority has handled total 135 MMTPA cargo (at Kandla & Vadinar) during the financial year 2022-23.

- **Climatic conditions of Kandla**

Kandla has a semi-desert climate. Temperature varies from 25°C to 44°C during summer and from 10°C to 25°C during winter. The average annual temperature is 24.8 °C. The average rainfall is 410 mm, most of which occurs during the monsoon from the months of June to September.

b. Vadinar:

Vadinar is a small coastal town located in Devbhumi Dwarka district of the state of Gujarat, India at coordinates 22° 27' 16.20" N - 069° 40' 30.01". The offshore oil terminal of the Deendayal Port Authority (DPA) is located in Vadinar and contributes in a large way to the total earnings of this major port. Vadinar is now notable due to the presence of two refineries-one promoted by Reliance Industries and the other by Essar Oil Ltd. The Deendayal Port Authority had commissioned the Off Shore Oil Terminal (OOT) facilities at Vadinar in the year 1978, for which M/s. Indian Oil Corporation Limited (IOCL) provided Single Bouy Mooring (SBM) system, which has a capacity of 54 MMTPA.

It also handled 43.30 MMT at Vadinar (which includes transhipment), the containerized cargo crossed 4.50 lakh TEU during this period, grossing a total of 100 MMT overall. Major commodities handled by the Deendayal Port are Crude Oil, Petroleum product, Coal, Salt, Edible Oil, Fertilizer, Sugar, Timber, Soya bean, Wheat, etc.

- **Climatic conditions of Vadinar**

Vadinar has a hot semi-arid climate, there are three defined seasons. The summer season lasts from March to May and is extremely hot, humid, but dry. The climatic conditions in Vadinar are quite similar to that recorded in its district head quarter in Jamnagar. The yearly mean temperature is 26.7 °C. Rainy season with extremely erratic monsoonal rainfall that averages around 630 millimetres. Tropical cyclones sometimes affect the region during this period. The winter season is from October to February remains hot during the day but has negligible rainfall, low humidity and cool nights to be by far the most comfortable time of year.

The locations of Kandla Port and Vadinar port have been depicted in the **Figure 1** as follows:

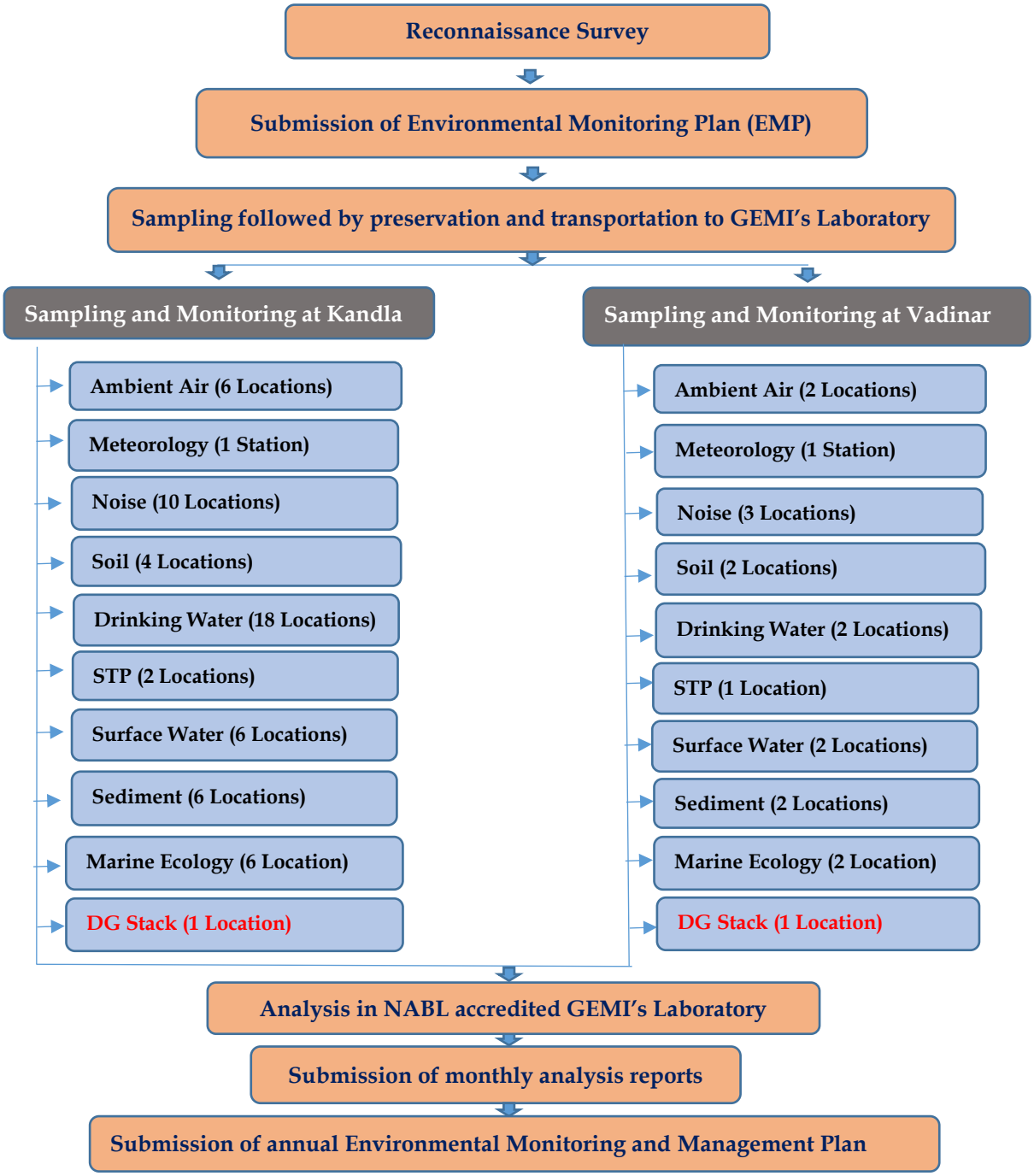
Figure 1: Locations Map of Kandla and Vadinar

Figure 2: Map of Kandla Port

Figure 3: Map of Vadinar Port

2.2 Methodology adopted for the study

Methodology is a strictly defined combination of practices, methods and processes to plan, develop and control a project along the continuous process of its implementation and successful completion. The aim of the project management methodology is to allow the control of the whole process of management through effective decision-making and problem solving. The methodology adopted for the present study is as follows:



2.3 Environmental Monitoring at Kandla and Vadinar

Regular monitoring of environmental parameters is of immense importance to assess the status of environment during project operation. With the knowledge of baseline conditions, the monitoring programme will serve as an indicator for any deterioration in environmental conditions due to operation of the project, to enable taking up suitable mitigatory steps in time to safeguard the environment. Monitoring is as important as that of control of pollution since the efficiency of control measures can only be determined by monitoring.

Environmental Monitoring Plan (EMP) is very important for monitoring the environmental status of the port for sustainable development. The list of main elements for which Environmental monitoring is to be carried out is mentioned below:

- Meteorology
- Ambient Air
- Noise
- Drinking Water
- DG Stack
- Soil
- Sewage
- Marine (Surface) water
- Marine Sediments
- Marine Ecology

Gujarat Environment Management Institute (GEMI) has been entrusted by Deendayal Port Authority to carry out the monitoring of the various aforementioned environmental aspects of the port, so as to verify effectiveness of Environment management plan; confirm statutory and legal compliance; and identify any unexpected changes. Standard methods and procedures have been strictly adhered to in the course of this study. QA/QC procedures were strictly followed which covers all aspects of the study, and includes sample collection, handling, laboratory analyses, data coding, statistical analyses, presentation and communication of results. All analysis was carried out in GEMI's NABL/MoEF accredited/recognized laboratory.

Under the present study, the details of various sectors of Environment monitoring are described in subsequent chapters.

CHAPTER 3: METEOROLOGY MONITORING

3.1 Meteorology Monitoring

Meteorological conditions play a crucial role in dispersion of air pollutants. 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. In order to determine the prevailing micro-meteorological conditions at the project site an Automatic Weather Monitoring Stations (AWS) of Envirotech WM280 were installed at both the sites of Kandla and Vadinar at 10 m above the ground. The details of the AWS have been mentioned in **Table 1** as follows:

Table 1: Details of Automatic Weather Station

Sr. No.	Site	Location Code	Location Name	Latitude Longitude
1.	Kandla	AWS-1	Environment Laboratory (DPA)	23.00996N 70.22175E
2.	Vadinar	AWS-2	Canteen Area	22.39994N 69.716608E

3.2 Methodology

During the study, a continuous automatic weather monitoring station was installed at both the sites to record climatological parameters such as Wind speed, Wind Direction, Relative Humidity, Solar Radiation, Rainfall and Temperature to establish general meteorological regime of the study area. The stations (observatory) were installed at Kandla and Vadinar on 19/04/2023. The methodology adopted for monitoring meteorological data shall be as per the standard norms laid down by Bureau of Indian Standards (BIS) and the India Meteorological Department (IMD).

The details of Automatic Weather Monitoring Station have been mentioned in **Table 2**.

Table 2: Automatic Weather Monitoring Station details

Sr. No.	Details of Meteorological Data	Unit of Measurement	Instrument	Frequency
1.	Wind Direction	degree	Automatic Weather Monitoring Station (Envirotech WM280)	Hourly Average
2.	Wind Speed	Km/hr		
3.	Rainfall	mm/hr		
4.	Relative Humidity	% RH		
5.	Temperature	^{o}C		
6.	Solar Radiation	W/m^2		

The Meteorological parameters were recorded at an interval of 1 hour in a day and the average value for all the Meteorological parameters were summarized for the period of April and May 2023 at both the observatory site.

3.3 Results:

The summary of hourly climatological observations recorded at observatory, Kandla during 19th April – 16st May 2023, with respect to significant parameters has been mentioned in **Table 2**. Monthly average of maximum and minimum daily observed values summarized in **Table 3** have been discussed as follows:

Table 3: Meteorological data for Kandla and Vadinar

Details of micro-meteorological data at Kandla Observatory												
Date	**Wind Speed (Km/h)**			**Temperature (°C)**			**Relative humidity (%)**			**Solar Radiation (W/m²)**	**Wind Direction (°)**	**Rainfall (mm)**
Stat.	**Mean**	**Max.**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**			
April-May 23	8.78	27.02	1.54	31.31	32.21	30.40	61.07	64.12	57.76	105.42	South-south East	0.05
Details of micro-meteorological data at Vadinar Observatory												
Date	**Wind Speed (Km/h)**			**Temperature (°C)**			**Relative humidity (%)**			**Solar Radiation (W/m²)**	**Wind Direction (°)**	**Rainfall (mm)**
Stat.	**Mean**	**Max.**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max.**	**Min**			
April-May 23	13.24	26.33	7.78	28.17	28.74	28.04	71.08	73.47	70.00	110.76	west and south	0.02

- **Temperature**
  a. Kandla: The ambient Temperature from April to May varies between the range of 26.75-35.23°C for Kandla, with average temperature of 31.31°C.
  b. Vadinar: The ambient temperature for the month of April varies between the range of 25.04-30.62°C for Vadinar, with average temperature of 28.17°C.
- **Relative Humidity**
  a. Kandla: The Relative Humidity recorded between the range of 43.77-69.65%, with average Humidity of 61.07%.
  b. Vadinar: During the study period, the Relative Humidity varies between 64.53-76.05%, with average Humidity of 71.08%.
- **Rainfall**
  a. Kandla: It is observed that, the average Rainfall in the monitoring period was found to be 0.05 mm
  b. Vadinar: The average Rainfall was recorded as 0.02 mm,
- **Wind Speed**

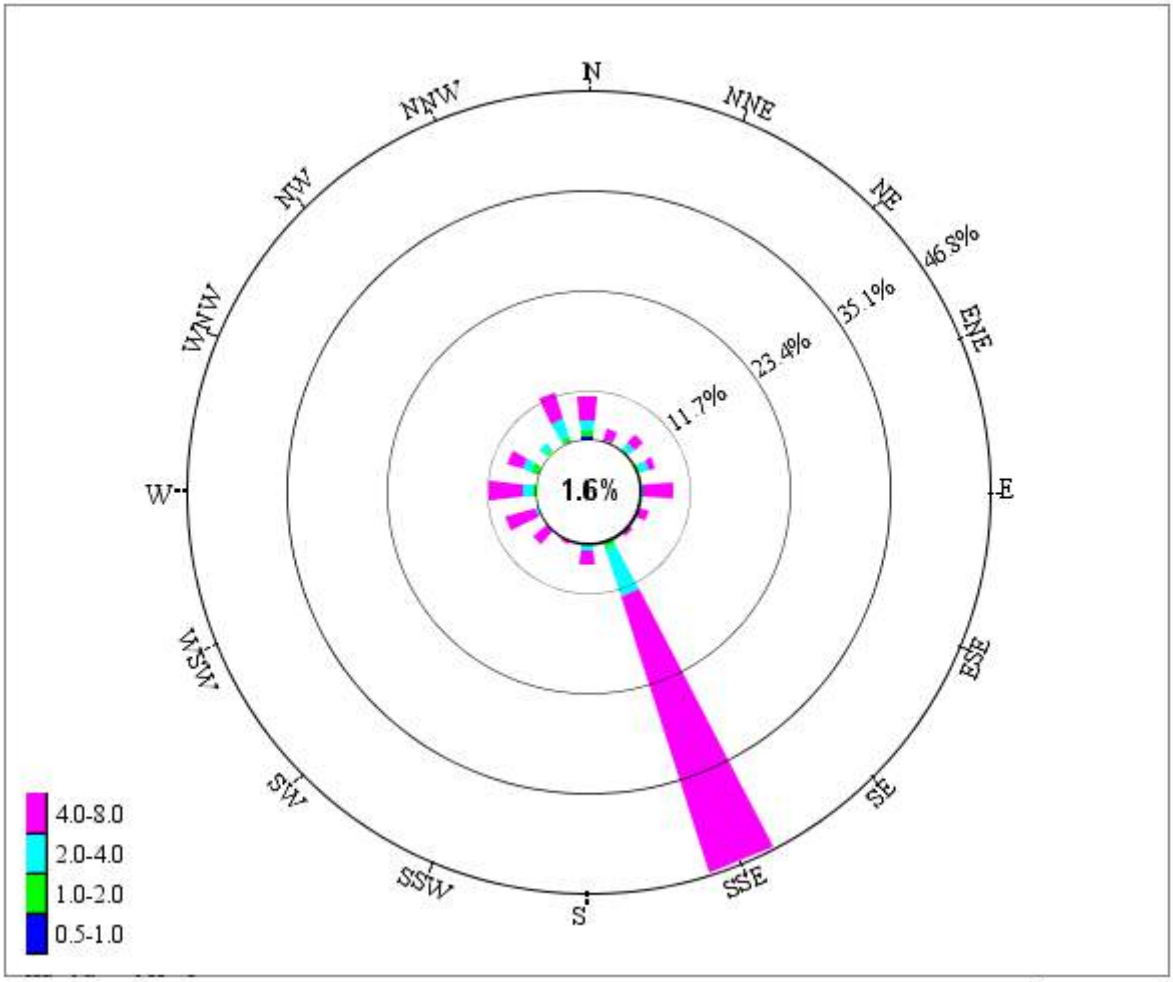
  Wind speed and Direction play a significant role in transporting the pollutants and thus decides the air quality.

  a. Kandla: Wind speed recorded ranges between 3.98-18.42 Km/hr
  b. Vadinar: During the study period, the Wind speed recorded, ranges between 6.23-18.08 Km/hr.
- **Solar Radiation:**
  a. Kandla: The average Solar Radiation for the monitoring period was recorded as 105.42 W/m^2.
  b. Vadinar: The average Solar Radiation was recorded as 110.76 W/m^2
- **Wind rose diagram -**

  The wind-rose diagram for the Monitoring period has been drawn on the basis of hourly wind speed and direction data.

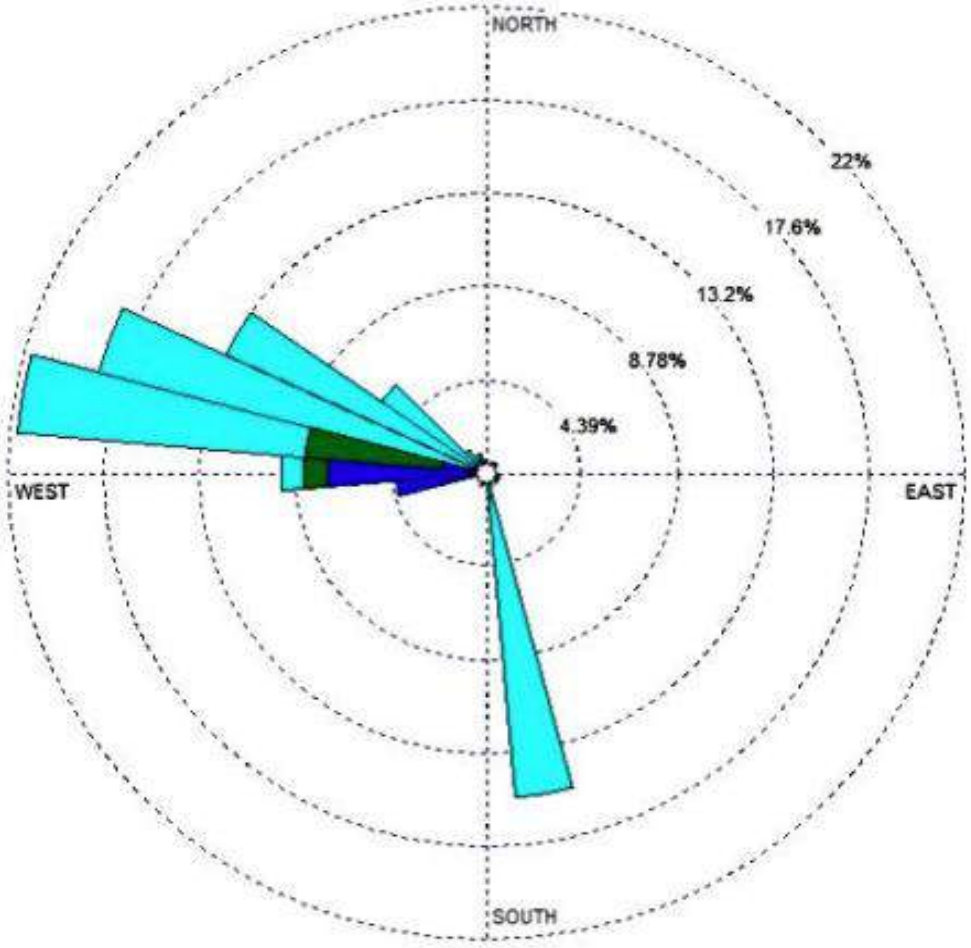
This wind rose reveals that the prevailing winds in Kandla during the given period predominantly blow from the northwest direction. The wind rose diagram represents that the wind flow at Kandla for the monitoring month towards South-South east. Whereas the winds at Vadinar were observed to flow from west directions.

Wind Rose Plot (April) M/s Deendayal Port Authority Site: Kandla Port (Environment Laboratory)	Display: Wind Direction Wind Speed



Data Period: 21/04/2023 to 16/05/2023	Modeler: Envirotech Instruments Pvt. Ltd. Delhi.

Wind Rose Plot (17 April- 16 May 2023) M/s Deendayal Port Authority Site: Vadinar Port (Canteen Area)	Display: Wind Direction Wind Speed



Data Period: 20/04/2023 to 16/05/2023	Modeler: Envirotech Instruments Pvt. Ltd. Delhi.

CHAPTER 4: AMBIENT AIR QUALITY MONITORING

4.1 Ambient Air Quality

To determine the impact of the shipping activities and port operations on the ambient air quality, it is necessary to monitor the ambient air quality of the study area The prime objective of ambient air quality monitoring with respect to is to assess the present air quality and its conformity to ambient air quality standards (NAAQS, 2009). Ambient air quality in terms of (parameters) are monitored from 17th April- 15th May 2023 covering 6 weeks.

4.2 Methodology adopted for the Study

The study area represents the area occupied by Deendayal port authority and its associated Port area, facilities, as well as the surrounding area comprising of few villages. The sources of air pollution in the region are mainly vehicular traffic, fuel burning, loading & unloading of dry cargo, fugitive emissions from storage area and dust arising from unpaved village roads, eight locations within the study area were scientifically selected and are based on the following considerations:

- Meteorological conditions;
- Topography of the study area;
- The direction of the wind;
- Representation of the region for establishing current air quality status; and
- Representation with respect to likely impact areas.

The description of various stations monitored at Kandla and Vadinar are given in **Table 4**.

Table 4: Details of Ambient Air monitoring locations

Sr. No.	Location Code		Location Name	Latitude Longitude	Significance
1.	Kandla	A-1	Oil Jetty No. 1	23.029361N 70.22003E	Loading of materials, dry cargo handling, liquid containers, emission from ship
2.		A-2	Oil Jetty No. 7	23.043538N 70.218617E	
3.		A-3	Kandla Port Colony	23.019797N 70.213536E	Vehicular activity, dust emission, Traffic
4.		A-4	Marine Bhavan	23.007653N 70.222197E	Construction activity, road dust emission
5.		A-5	Coal Storage Area	23.000190N 70.219757E	Coal Dust, Vehicular activity
6.		A-6	Gopalpuri Hospital	23.081506N 70.135258E	Residential area, dust emission, vehicular activity
7.	Vadinar	A-7	Admin Building	22.441806N 69.677056E	Vehicular activity
8.		A-8	Vadinar Colony	22.401939N 69.716306E	Residential Area, burning waste, vehicular activity

The monitoring locations at Kandla and Vadinar have been depicted in **Figure 4 and 5** respectively follows:

Figure 4: Location Map for Ambient Air Monitoring at Kandla

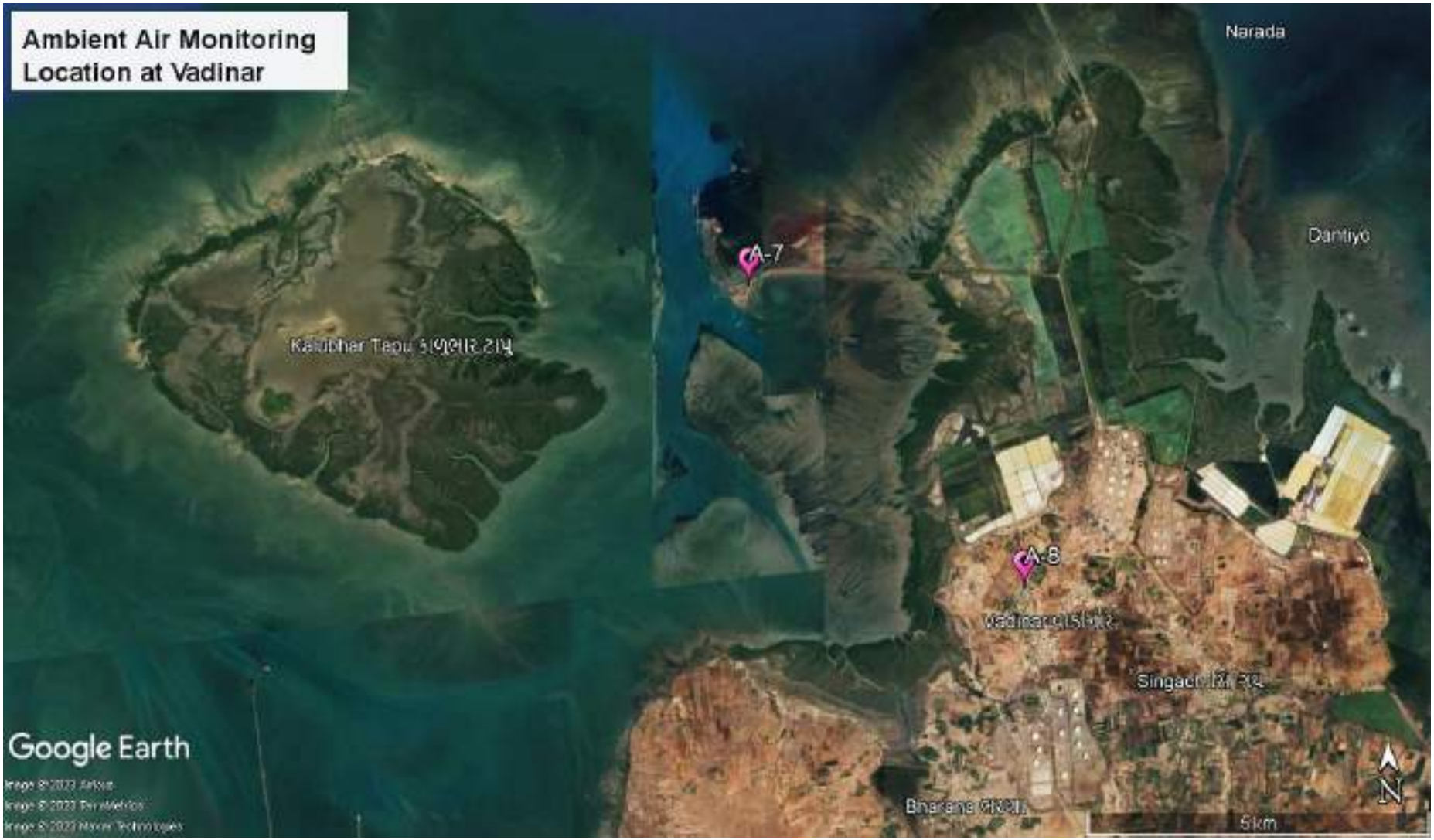


Figure 5: Location Map for Ambient Air Monitoring at Vadinar

Frequency of AAQ Monitoring

The sampling for Particulate matter (PM_{10}, $PM_{2.5}$) and gaseous like SO_x, NO_x, CO and Total VOCs were monitored twice in a week for a duration of 24 hours a day. Whereas, the samples of PAH, Benzene and non-Methane VOCs were collected on monthly basis.

Method of sampling and analysis:

The Sampling of the Ambient Air Quality parameters and analysis is done as per CPCB guidelines of National Ambient Air Quality monitoring. The sampling was performed at a height of 3.5 m (approximately) from the ground level.

For the sampling of PM_{10}, calibrated 'Respirable Dust Samplers' were used, where Whatman GF/A microfiber filter paper (size: 8" X 10") was used for the collection of PM_{10}. APM- air sampler of the make Envirotech instrument was attached with Respirable Dust Sampler $PM_{2.5}$ sampler for monitoring particulate matter of size <2.5 microns. A known volume of ambient air is passed through the cyclone to the initially pre-processed filter paper. The centrifugal force in cyclone acts on particulate matter to separate them into two parts and collected as following: -

Particles <10 µ size (Respirable): GF/A Filter Paper

Particles <2.5 µ size (Respirable): Polytetrafluoroethylene (PTFE)

Sampling and analysis of ambient SO_2 was performed by adopting the 'Improved West and Gaeke Method'. The ambient air, drawn through the draft created by the RDS, is passed through an impinger, containing a known volume of absorbing solution of sodium tetrachloromercurate, at a pre-determined and measured flow rate of 1 liter/minute (L/min). Similarly, NOx was performed by adopting the 'Jacob Hochheister Modified' (Na arsenite) method. The impinger contains known volume of absorbing solution of sodium arsenite and sodium hydroxide.

Data has been compiled for PM_{10}, $PM_{2.5}$, SO_x and NO_x samples of 24-hour duration on two days a week (i.es., 8 samples were collected at each location). In case of CO, one hourly sample were taken on selected monitoring days using the sensor-based CO Meter. For the parameters Benzene, Methane & Non-methane and Volatile Organic Carbons (VOCs) the Low Volume Sampler is used, where the charcoal tubes are used as sampling media. The sampling in the Low Volume Sampler is carried out as per IS 5182 (Part 11): 2006 RA: 2017, where the ambient air flow rate is maintained at 200 cc/min, the volume of air that passes through the low volume sampler during two hours monitoring is approx. 24 L. Whereas the sampling of PAHs is carried out as per IS: 5182 (Part 12): 2004. Where, the EPM 2000 Filter papers are utilized in the Respirable Dust Sampler (RDS). For the parameters, PAH & Non-methane VOC's, monthly monitoring is carried out. The details of the parameters with their frequency monitored are mentioned in **Table 5:**

Table 5: Parameters for Ambient Air Quality Monitoring

Sr. No.	Parameters	Units	Reference method	Instrument	Frequency
1.	PM_{10}	µg/m³	IS 5182 (Part 23): 2006	Respirable Dust Sampler (RDS) conforming to IS:5182 (Part-23): 2006	Twice in a week
2.	$PM_{2.5}$	µg/m³	IS:5182 (Part:24):2019	Fine Particulate Sampler (FPS) conforming to IS:5182 (Part-24): 2019	
3.	Sulphur Dioxide (SO_x)	µg/m³	IS 5182 (Part:2): 2001	Gaseous Attachment conforming to IS:5182 Part-2	
4.	Oxides of Nitrogen (NO_x)	µg/m³	IS:5182 (Part-6): 2006	Gaseous Attachment conforming to IS:5182 Part-6	
5.	Carbon Monoxide	mg/m³	GEMI/SOP/AAQM/11; Issue no 01, Issue date 17.01.2019: 2019	Sensor based Instrument (Make: Vaibhav Instruments)	
6.	VOC	µg/m³	IS 5182 (Part 17): 2004	Low Flow Air Sampler	
7.	Benzene	µg/m³	IS 5182 (Part 11): 2006 RA: 2017	Low Flow Air Sampler	
8.	PAH	µg/m³	IS: 5182 (Part 12): 2004	Respirable Dust Sampler (RDS) conforming to IS:5182 (Part-12): 2004	Monthly
9.	Non-methane VOC	µg/m³	IS 5182 (Part 11): 2006	Low Volume Sampler	

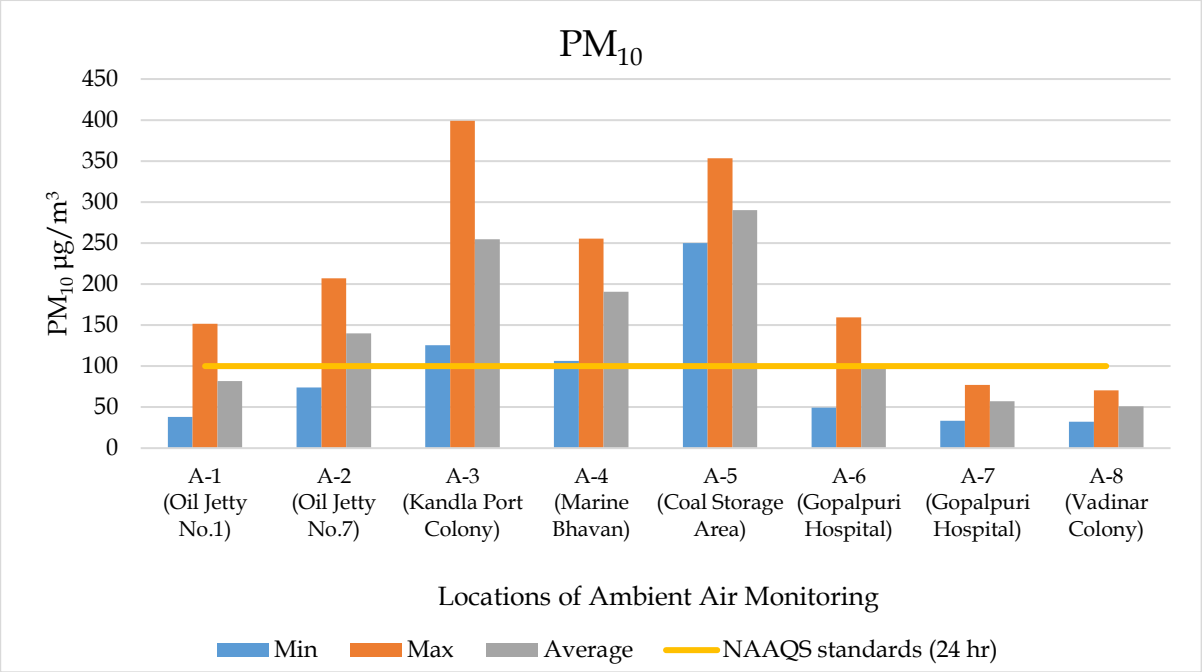
4.3 Result and Discussion:

The summarized results of ambient air quality monitoring for the period from 17th April to 15th May 2023 are presented in **Table-6 to 15** along with the graphical representation depicted in **Graph 1 to Graph 6.** Various parameters monitored during the study have been presented by their maximum, minimum, average and standard deviation.

Table 6: Summarized results of PM_{10} for Ambient Air quality monitoring

PM_{10} (µg/m³)										
Sr No	Location / Sampling Date	Kandla						Vadinar		
		A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8	NAAQS standards (24 hr)
1	17-Apr-2023	86.35	144.87	341.95	255.59	211.81	89.13	56.62	42.63	100 µg/m³
2	19-Apr-2023	69.35	135.52	349.89	106.41	305.36	115.90	59.78	56.55	
3	24-Apr-2023	72.27	121.69	399.25	155.37	260.08	159.38	74.25	56.50	
4	26-Apr-2023	151.72	149.37	271.07	185.15	216.88	73.34	76.96	70.37	
5	1-May-2023	81.83	124.52	182.54	156.01	219.18	56.78	33.42	43.40	
6	3-May-2023	58.16	74.14	125.42	252.46	323.61	124.93	33.97	32.10	
7	8-May-2023	72.81	207.10	287.49	207.14	249.87	109.62	56.42	59.48	

PM_{10} (µg/m³)										
Sr No	Location / Sampling Date	Kandla						Vadinar		NAAQS standards (24 hr)
		A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8	
8	10-May-2023	104.33	154.22	204.48	207.03	267.24	128.82	63.83	49.15	
9	15-May-2023	37.94	149.14	128.12	189.98	353.42	49.35	57.77	46.17	
	Minimum	37.94	74.14	125.42	106.41	249.87	49.35	33.42	32.10	
	Maximum	151.72	207.10	399.25	255.59	353.42	159.38	76.96	70.37	
	Average	81.64	140.06	254.47	190.57	290.18	100.81	57.00	51.02	
	Std Dev	32.07	35.06	99.61	47.63	55.45	36.37	15.16	12.38	



Graph 1: Spatial trend in PM_{10} Concentration at Monitoring locations

Interpretation:

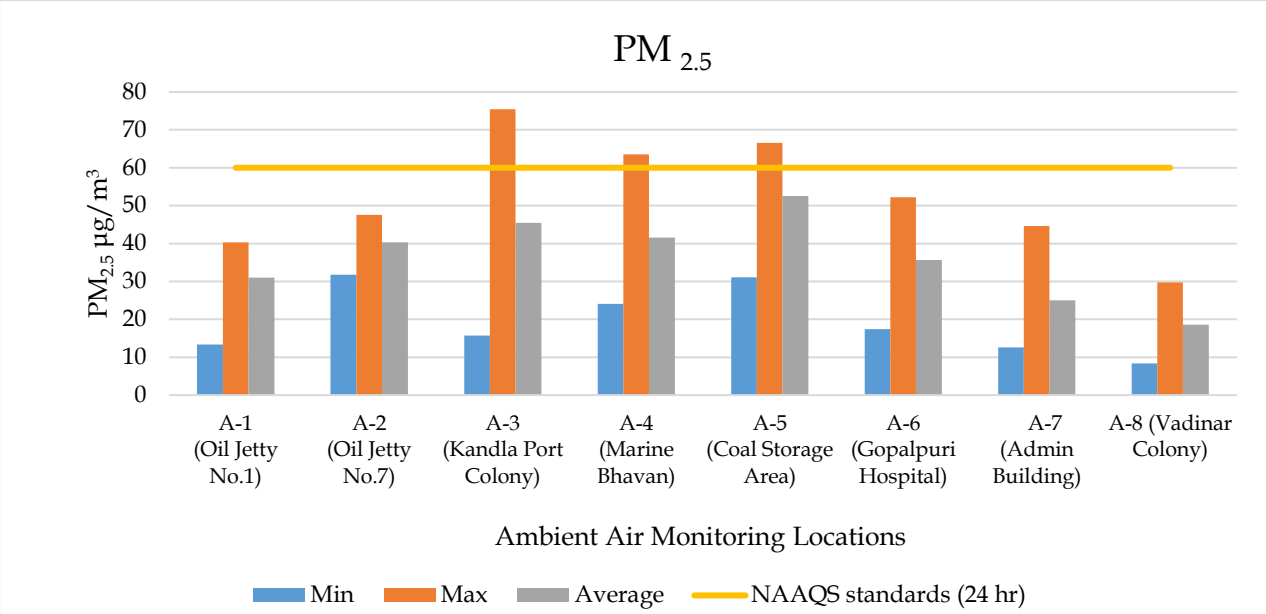
The results were compared with National Ambient Air Quality Standards (NAAQS), 2009 of Central Pollution Control Board (CPCB). Particulate Matter (PM_{10}) exceeded the norms at locations (Oil jetty 1, KPT colony, Marine Bhavan, Coal storage area). The highest concentration of PM_{10} was observed at location A-3 i.e., Kandla Port Colony (399.25 µg/m³), whereas the lowest was observed at A-1 i.e., Oil Jetty No.1 (37.94 µg/m³). All the monitored values of PM_{10} at station A-2, A-3, A-4 and A5 are exceeding the specified limit of 100 µg/m³.

The higher reporting of PM_{10} could be due to heavy vehicular traffic, loading and unloading of cargo, dust from construction activities. Emissions and dispersion from construction equipment, work vessels, trucks and other vehicles used in construction work could be a source of Particulate matter. The unloading of coal directly in the truck, using grabs cause coal to disperse in air as well as coal dust to fall and settle 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 increased

suspension of coal from trucks/dumpers during its transit from vessel to yard or storage site. This also increases the PM values around marine Bhavan & Coal storage area. Whereas for the Ambient Air locations of Vadinar, the concentration of PM_{10} falls within the stipulated norm of 100 µg/m³. Kandla Port is a coastal area with extensive salt pans on the western side. Some of these salt pans are temporarily not in use and the hence this barren area is source of fugitive dust. Wind speeds also contribute to increased dispersion of pollutants in the area. Apart from this, dust storms are also common.

Table 7: Summarized results of $PM_{2.5}$ for Ambient Air quality monitoring

$PM_{2.5}$ (µg/m³)									
Sr. No	Location / Sampling date	Kandla						Vadinar		NAAQS standards (24 hr)
		A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8	
1	17-Apr-2023	40.32	31.73	60.77	49.96	68.52	35.99	40.63	35.08	60 µg/m³
2	19-Apr-2023	28.39	38.62	41.03	45.23	88.51	35.27	42.74	30.15	
3	24-Apr-2023	31.31	47.55	67.13	47.27	56.75	35.27	44.65	28.31	
4	26-Apr-2023	39.87	42.70	32.14	31.82	71.62	36.21	32.58	29.76	
5	1-May-2023	22.23	34.23	28.33	24.06	38.84	34.46	12.61	11.05	
6	3-May-2023	38.73	47.58	38.22	36.51	89.04	25.32	14.52	8.35	
7	8-May-2023	26.60	42.51	75.44	39.65	66.58	48.62	26.09	19.25	
8	10-May-2023	38.44	37.28	50.47	63.55	60.03	52.18	25.99	22.94	
9	15-May-2023	13.32	40.22	15.73	35.86	31.09	17.39	18.87	10.49	
	Minimum	13.32	31.73	15.73	24.06	31.09	17.39	12.61	8.35	
	Maximum	40.32	47.58	75.44	63.55	66.58	52.18	44.65	29.76	
	Average	31.02	40.27	45.47	41.55	52.57	35.63	25.04	18.59	
	Std Dev	9.33	5.46	19.54	11.53	18.89	10.51	11.16	8.81	



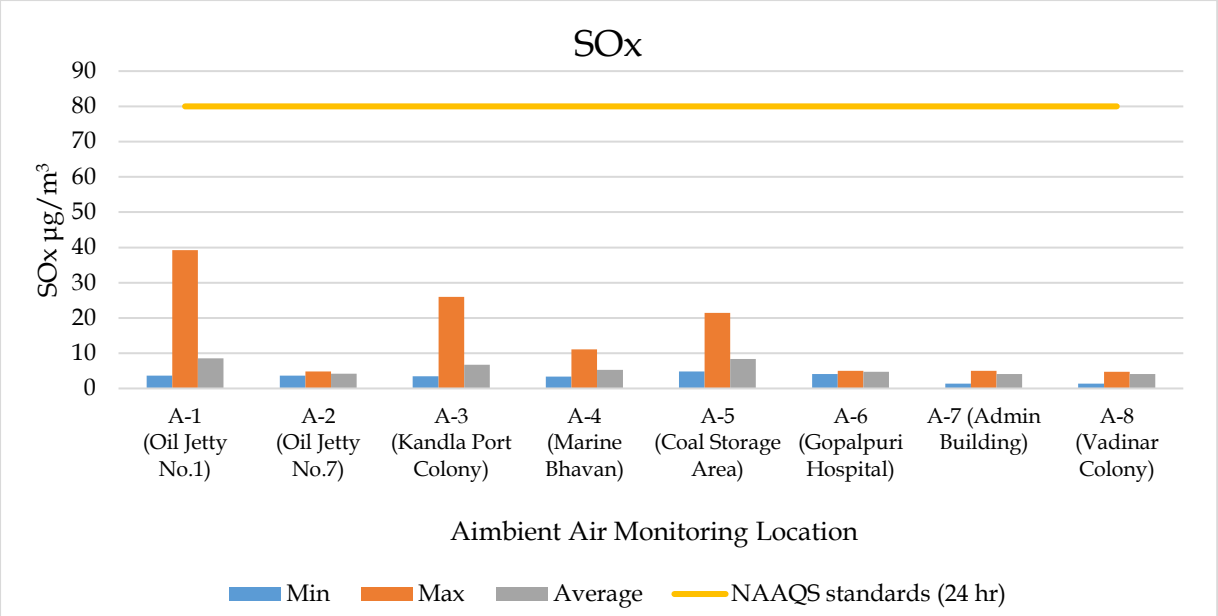
Graph 2: Spatial trend in $PM_{2.5}$ Concentration at Monitoring locations

The highest $PM_{2.5}$ concentration (75.44 µg/m³) was recorded at station A-3, Kandla Port Colony which is above the limit prescribed by NAAQS. Whereas majority of the monitored values of $PM_{2.5}$ at Kandla were reported well below the specified limit of 60 µg/m³. While for Vadinar monitoring station the maximum value for $PM_{2.5}$ observed is,

44.65 µg/m³ at Admin Building (A-7). Similar to values detected for the Respirable Dust i.e., PM_{10}, higher concentration of $PM_{2.5}$ was also observed at the Locations A-3 to A-5. This may be attributed to emissions from combustion of gasoline, oil, diesel fuel or wood produce.

Table 8: Summarized results of SO_x for Ambient Air quality

SO_x (µg/m³)									
Sr. No	Location / Sampling date	Kandla						Vadinar		
		A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8	NAAQS standards (24 hr)
1	17-Apr-2023	5.98	4.8	4.1	3.6	5.33	4.9	4.6	4.6	80 µg/m³
2	19-Apr-2023	4.3	4.2	4.9	3.8	7.53	4.6	4.3	4.2	
3	24-Apr-2023	3.9	4.5	4.6	3.7	9.21	4.1	4.51	4.58	
4	26-Apr-2023	7.44	3.6	3.6	3.4	4.8	4.9	1.39	4.69	
5	1-May-2023	39.19	3.8	5.16	3.9	8.65	4.98	3.12	1.4	
6	3-May-2023	4.2	3.9	3.5	8.27	5.15	4.85	4.99	4.67	
7	8-May-2023	3.6	4.6	26.01	11.13	21.47	4.67	4.6	4.25	
8	10-May-2023	4.1	4.0	4.6	4.9	7.97	4.58	4.2	4.36	
9	15-May-2023	3.6	3.6	3.5	3.4	4.8	4.1	1.39	1.4	
	Minimum	3.6	3.6	3.5	3.4	4.8	4.1	1.39	1.4	
	Maximum	39.19	4.8	26.01	11.13	21.47	4.98	4.99	4.69	
	Average	8.57	4.18	6.74	5.28	8.34	4.72	4.06	4.11	
	Std Dev	11.55	0.40	7.25	2.66	5.21	0.27	1.13	1.04	



Graph 3: Spatial trend in SOx Concentration at Monitoring locations

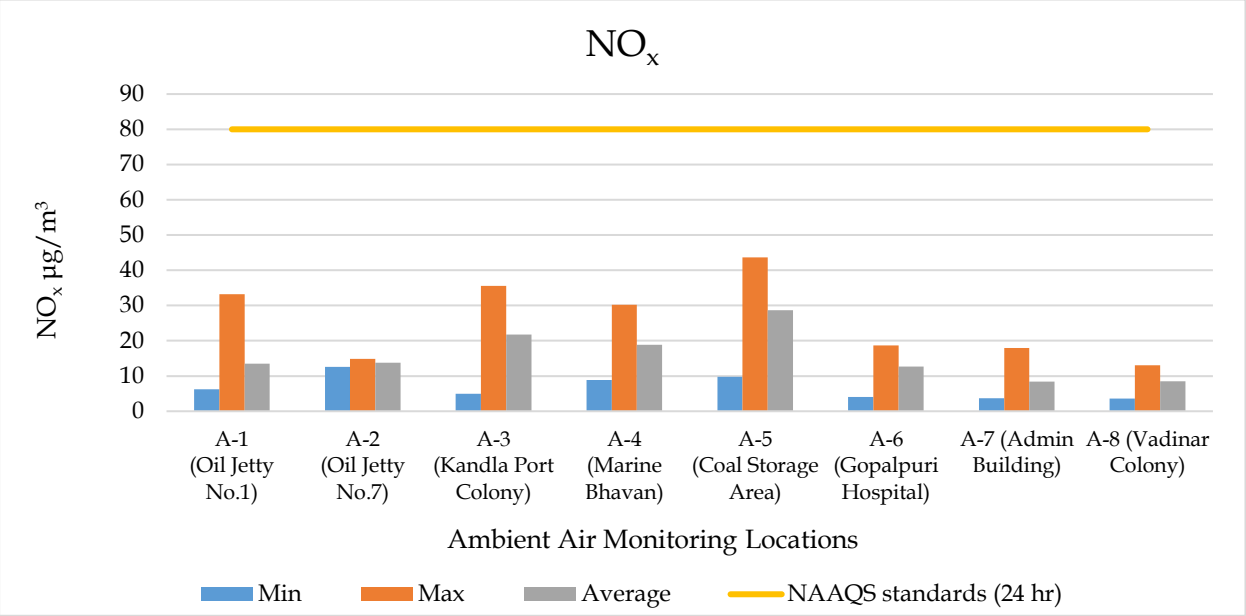
The highest SO_x concentration (39.19 µg/m³) was recorded at station A-1, Oil Jetty No.1 area while the lowest SO_x concentration was found to be 3.4 µg/m³ at A-4, Marine Bhavan. From the observed value it is seen that the concentration of SO_x falls within the limit prescribed by NAAQS.

Whereas for Vadinar monitoring station the maximum and minimum value for SO_x observed is, 4.99 µg/m³ and 1.39 µg/m³ at Admin Building (A-7) at different month. The

majority of the monitored values of SO_x at Vadinar were reported well below the specified limit of 80 µg/m³.

Table 9: Summarized results of NOx for Ambient Air quality monitoring

NO_x (µg/m³)									
Sr No	Location / Sampling date	Kandla						Vadinar		
		A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8	NAAQS standards (24 hr)
1	17-Apr-2023	9.20	12.85	21.94	19.41	27.76	8.70	8.14	9.72	80 µg/m³
2	19-Apr-2023	10.02	12.55	19.88	8.90	31.22	10.24	7.64	11.25	
3	24-Apr-2023	6.20	14.87	35.54	18.80	32.57	17.38	17.94	12.81	
4	26-Apr-2023	33.24	13.40	30.12	25.04	20.64	13.24	10.00	10.58	
5	1-May-2023	18.72	14.89	21.27	19.81	21.84	18.68	7.47	13.06	
6	3-May-2023	7.52	14.33	5.00	13.18	25.84	4.08	6.43	6.48	
7	8-May-2023	12.28	13.37	23.49	21.98	32.60	14.12	7.85	7.77	
8	10-May-2023	13.99	13.55	27.64	30.18	43.64	12.00	5.45	5.12	
9	15-May-2023	10.65	14.36	11.05	12.57	9.78	15.61	3.66	3.61	
	Minimum	6.20	12.55	5.00	8.90	9.78	4.08	3.66	3.61	
	Maximum	33.24	14.89	35.54	30.18	43.64	18.68	17.94	13.06	
	Average	13.54	13.80	21.77	18.87	28.67	12.67	8.40	8.49	
	Std Dev	8.26	0.85	9.33	6.60	17.27	4.55	4.65	3.73	

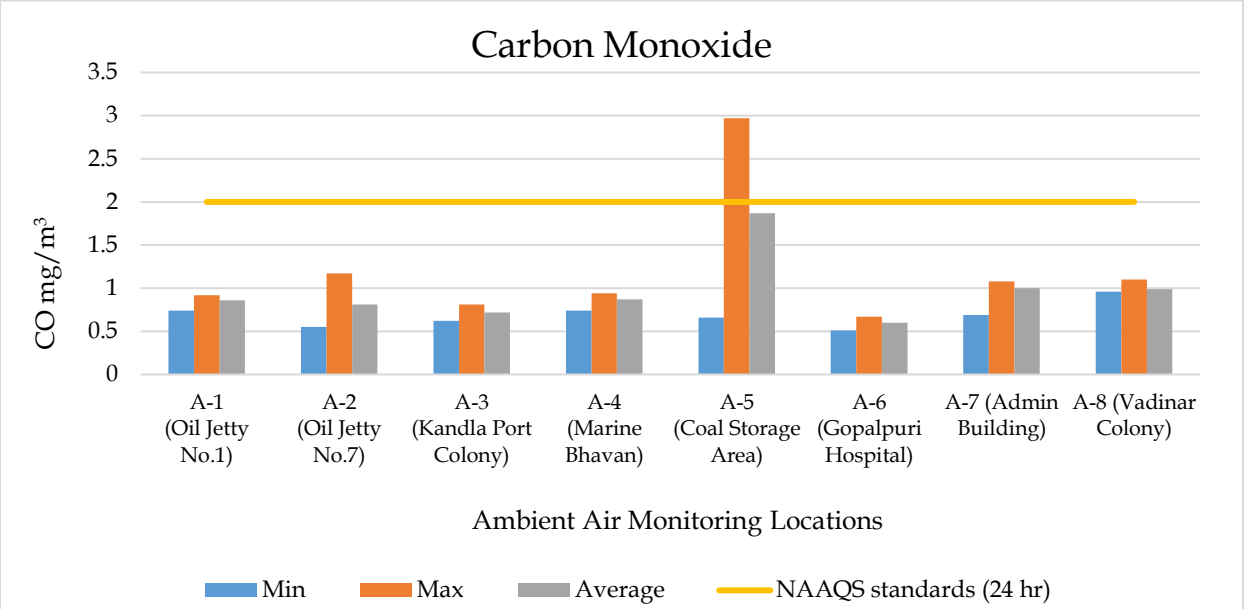


Graph 4: Spatial trend in NOx Concentration at Monitoring locations

The highest NO_x concentration 43.64 µg/m³ was recorded at station A-5, Coal Storage Area. All the monitored values of NO_x are found well below the specified limit of 80 µg/m³. At Vadinar, the concentration of NO_x was found to be below the NAAQS limit for both the monitoring stations.

Table 10: Summarized results of Carbon Monoxide for Ambient Air quality monitoring

Carbon Monoxide (mg/m³)									
Sr No	Location / Sampling date	Kandla						Vadinar		
		A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8	NAAQS standards (8 hr)
1	17-Apr-2023	0.90	0.76	0.62	0.89	1.13	0.66	0.88	0.97	2 mg/m³
2	19-Apr-2023	0.86	1.06	0.65	0.86	1.16	0.64	0.94	0.89	
3	24-Apr-2023	0.89	1.17	0.63	0.87	1.98	0.65	1.08	1.10	
4	26-Apr-2023	0.91	0.55	0.71	0.92	2.01	0.67	0.69	0.99	
5	1-May-2023	0.91	0.77	0.67	0.91	0.54	0.66	1.01	0.96	
6	3-May-2023	0.74	0.71	0.79	0.94	1.68	0.52	1.03	0.98	
7	8-May-2023	0.92	0.76	0.80	0.83	1.97	0.51	1.04	0.99	
8	10-May-2023	0.75	0.56	0.79	0.87	2.97	0.58	1.08	0.97	
9	15-May-2023	0.84	0.92	0.81	0.74	0.66	0.54	1.04	0.96	
	Minimum	0.74	0.55	0.62	0.74	0.66	0.51	0.69	0.96	
	Maximum	0.92	1.17	0.81	0.94	2.97	0.67	1.08	1.10	
	Average	0.86	0.81	0.72	0.87	1.87	0.60	1.00	0.99	
	Std Dev	0.07	0.21	0.08	0.06	1.16	0.07	0.14	0.05	



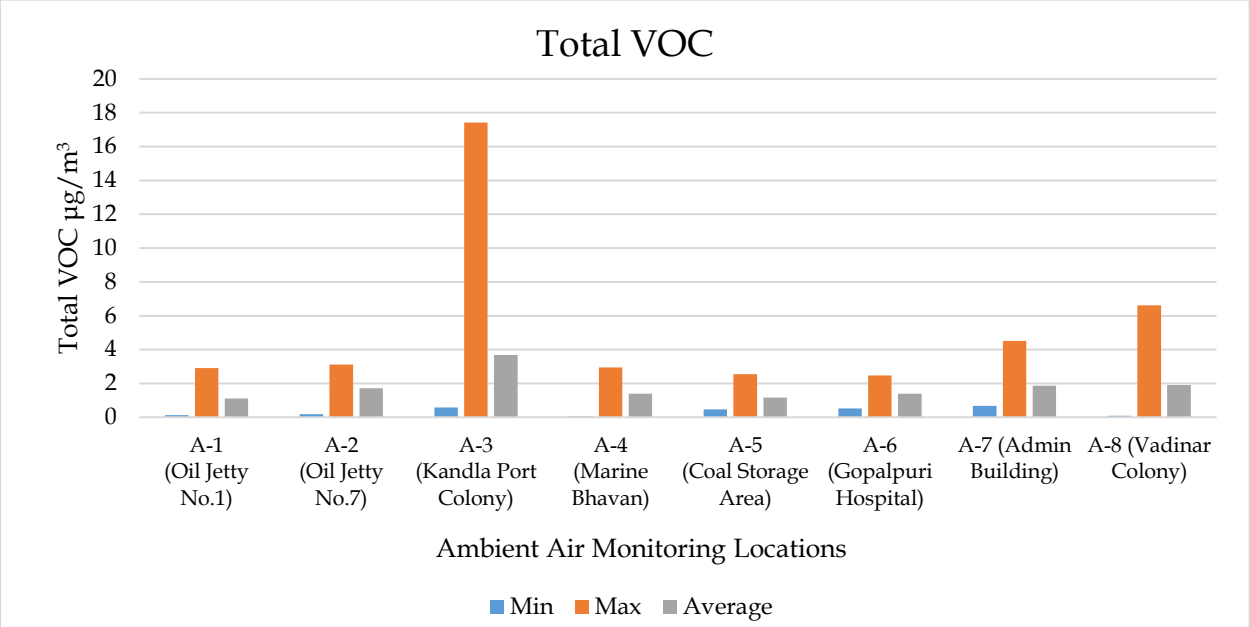
Graph 5: Spatial trend in CO Concentration at Monitoring locations

During the monitoring period, the highest CO concentration i.e., 2.97 mg/m³ was recorded at A-5, Coal Storage Area with mean value 1.87 mg/m³. Whereas other monitoring station were recorded the CO concentration well below the specified limit of 2 mg/m³.

The levels of CO at monitoring station of Vadinar were found well within the permissible limit. The mean concentration of CO was found 1.00 and 0.99 mg/m³, in A-7 (Admin building) and A-8 (Vadinar Colony) respectively. In the coal storage area, as the moisture in the coal is liberated and the coal oxidizes, both heat and carbon monoxide are created. This might be attributed to the higher concentration of Carbon Monoxide in the Coal Storage Area as compared to the other monitored locations.

Table 11: Summarized results of Total VOC for Ambient Air quality monitoring

Total VOCs (µg/m³)									
Sr. No	Locations / Sampling date	Kandla						Vadinar	
		A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8
1	17-Apr-2023	0.13	2.54	17.43	2.36	2.54	2.48	4.52	6.62
2	19-Apr-2023	1.32	0.67	2.21	0.04	1.14	2.06	2.6	2.4
3	24-Apr-2023	0.69	2.45	1.97	0.94	0.47	1.84	2.76	2.98
4	26-Apr-2023	2.91	1.99	2.85	1.58	1.85	0.81	0.87	2.45
5	1-May-2023	1.08	2.07	1.83	2.95	0.49	0.52	1.28	0.25
6	3-May-2023	0.97	3.11	2.92	1.74	1.52	2.10	2.09	1.08
7	8-May-2023	1.04	0.19	1.91	0.99	0.58	1.00	1.06	0.08
8	10-May-2023	1.05	2.11	1.47	0.85	0.96	0.85	0.95	0.27
9	15-May-2023	0.65	0.28	0.57	1.09	1.02	0.87	0.68	1.09
	Minimum	0.13	0.19	0.57	0.04	0.47	0.52	0.68	0.08
	Maximum	2.91	3.11	17.43	2.95	2.54	2.48	4.52	6.62
	Average	1.10	1.71	3.68	1.39	1.17	1.39	1.87	1.91
	Std Dev	0.76	1.06	5.20	0.87	0.69	0.72	1.26	2.06



Graph 6: Spatial trend in Total VOCs Concentration at Monitoring locations

During the monitoring period, the highest total VOC concentration was observed (17.43 µg/m³) at A-3, Kandla Port Colony. While at Vadinar monitoring station the highest total VOC concentration was observed 6.62 µg/m³ at A-8 with mean value 1.91 µg/m³. VOCs emitted from an urban source to the atmosphere may cause pollution on a local scale. VOCs are present mainly due to motor vehicles emissions. Gasoline and natural gas are a major source of VOCs that impact outdoor air quality. Vehicle exhaust and burning fossil fuels, wood, and garbage all release VOCs into the atmosphere.

Table 12: Summarized results of Benzene for Ambient Air quality monitoring

Benzene (µg/m³)										
Sr. No	Location / Sampling date	Kandla						Vadinar		
		A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8	NAAQS standards (24 hr)
1	17-Apr-2023	3.5	1.01	1.43	0.04	1.08	1.08	0.48	0.37	5 µg/m³

The Ambient air Monitoring location of Kandla recorded the highest Benzene concentration i.e., 1.43 µg/m³ at A-3, Kandla Port Colony. While at Vadinar monitoring station the highest Benzene concentration was found to be 0.77 µg/m³ at A-7, Admin Building. Thus, all monitoring station at Kandla and Vadinar recorded the Benzene concentration well below the specified limit of 5 µg/m³.

Table 13: Summarized results of Polycyclic Aromatic Hydrocarbon

Sr No		Kandla						Vadinar	
	Location / Components	A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8
		26-Apr-2023		24-Apr-2023				24-Apr-2023	
1	Napthalene	0.41	17.31	0.49	0.32	1.92	39.82	0.39	0.32
2	Acenaphthylene	0.03	0.48	0.34	0.53	0.03	0.05	0.005	0.005
3	Acenaphthene	0.01	0.45	15.10	119.08	0.02	11.80	0.14	0.12
4	Fluorene	0.04	0.33	22.99	178.72	0.07	27.22	0.05	0.03
5	Anthracene	0.23	0.47	0.88	5.05	0.35	3.78	0.32	0.27
6	Phenanthrene	0.34	0.13	0.08	0.55	0.51	0.78	0.29	0.22
7	Fluoranthene	0.34	0.26	1.43	15.67	0.26	20.36	0.36	0.30
8	Pyrene	0.40	0.26	2.40	42.23	0.33	51.22	0.21	0.01
9	Chrycene	0.39	0.15	0.58	6.27	0.36	5.82	0.22	0.25
10	Banz(a)anthracene	1.17	0.38	1.64	15.42	0.92	16.73	0.32	0.21
11	Benzo[k]fluoranthene	0.98	0.38	0.71	0.64	0.64	4.25	0.31	0.03
12	Benzo[b]fluoranthene	0.89	0.35	0.47	3.97	0.61	6.52	0.25	0.07
13	Benzopyrene	0.75	0.29	0.52	2.85	0.70	3.40	0.32	0.03
14	Indeno[1,2,3-cd] fluoranthene	2.39	0.69	0.80	2.46	1.68	4.61	0.35	0.1
15	Dibenz(ah)anthracene	1.00	0.19	0.21	1.04	0.31	0.46	0.29	0.05
16	Benzo[ghi]perylene	2.34	0.47	0.97	6.07	1.90	6.38	0.27	0.21

Higher concentration of the PAH was observed the period of 17th April to 16th May 2023. Polycyclic aromatic hydrocarbons (PAHs) are ubiquitous pollutants in urban atmospheres. Anthropogenic sources of total PAHs in ambient air emissions are greater than those that come from natural events. Polycyclic aromatic hydrocarbons (PAHs) are a class of chemicals that occur naturally in coal, crude oil, and gasoline. They result from burning coal, oil, gas, etc. Six sources can be identified such as road dust, oil, coal, vehicles, incineration, and road salt. The road dust and emissions from traffic are the main outdoor source for the PAH concentration. Other outdoor sources of PAHs are industrial plants in and around the DPA premises.

Table 14: Summarized results of Non-methane VOCs (µg/m³)

Sr No	Location / Sampling date	Kandla						Vadinar	
		A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8
1	17-Apr-2023	0.12	0.15	0.16	0.17	0.13	0.19	0.15	0.15

The Ambient air Monitoring location of Kandla recorded the highest Non-methane VOC concentration i.e., 0.19 µg/m³ at A-6, Gopalpuri Hospital while the lowest Non-methane VOC concentration was found 0.12 µg/m³ at A-1, Oil Jetty No.1. While at Vadinar monitoring station, the lowest Non-methane VOC concentration was observed 0.09 µg/m³ at A-7, Admin Building. Thus, all monitoring station at Kandla and Vadinar recorded the Benzene concentration well below the specified limit of 5 µg/m³.

4.4 Conclusion:

From the ambient monitoring study conducted for a period (17th April-15th May 2023), it may be concluded that the particulate matter (PM_{10}), were reported in higher concentrated and apparently were exceeding the NAAQS particularly at 4 locations in Kandla (Oil Jetty No 7, Coal storage area, Kandla port colony and Marine bhavan) while gaseous pollutants (NO_x, SO_x, CO, VOCs etc.) falls within the permissible limit. The probable reason contributing to these emissions of pollutants into the atmosphere in and around the port area are summarized as follows-

1. **Ship Emissions:** Ships primarily emit air pollutants through their exhaust stacks. These emissions include sulfur oxides (SO_x), nitrogen oxides (NO_x), particulate matter (PM), carbon monoxide (CO), volatile organic compounds (VOCs), and greenhouse gases (GHGs) such as carbon dioxide (CO_2). The type of fuel used by ships greatly influences the amount and type of emissions produced.
2. **Port Machinery:** Port activities involve the use of various machinery and equipment, including cranes, forklifts, tugboats, and cargo handling equipment. These machines often rely on diesel engines, which can emit pollutants such as NO_x, PM, and CO. Older or poorly maintained equipment tends to generate higher emissions.
3. **Port Vehicles:** Trucks and other vehicles operating within port and port area contributes to air pollution. Similar to port machinery, diesel-powered vehicles can emit NO_x, PM, CO, and other pollutants such as (PAH), VOCs etc. Vehicle traffic and congestion in and around port areas can exacerbate the air quality issues.
4. While docked or at anchor, ships may use auxiliary engines to power onboard systems such as lighting, heating, and refrigeration. These engines can emit pollutants and contribute to air pollution, particularly in port areas with significant vessel traffic.

4.5 Suggestive Measures to control the air pollution:

Efficient mitigation strategies need to be implementation for substantial environmental and health co-benefits. To improve air quality the port has adopted a 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. To address air pollution from port shipping activities, various measures can be implemented including:

- Practice should be initiated for using mask as preventative measure, to avoid Inhalation of dust particle-Mask advised in sensitive areas.
- Covering vehicles with tarpaulin during transportation of construction material to site.
- Ensuring that contractors are maintaining engines and that machinery deployed during construction are complying with emission standards.
- Ensuring frequent water sprinkling on roads to reduce dust vehicular movement on land. 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.
- Use of proper transport methods, such as a conveyor belt, for excavated material and screens around the construction site.
- Temporary pavement of roads in a construction site could considerably reduce dust emission.
- Prohibition of the use of heavy diesel oil as fuel could be a possible means to reduce pollutants Use of Cleaner Fuels: Encouraging or mandating the use of low-sulfur fuels, such as marine gas oil (MGO) or liquefied natural gas (LNG), can significantly reduce sulfur and particulate matter emissions from ships.
- Retrofitting and Engine Upgrades: Retrofitting ships with exhaust gas cleaning systems, also known as scrubbers, can help reduce sulfur emissions. Engine upgrades, such as optimizing fuel combustion and improving engine efficiency, can reduce overall emissions.
- Shore Power Infrastructure: Investing in infrastructure for cold ironing allows ships to connect to the electrical grid while docked, reducing the need for auxiliary engines and associated emissions.
- Improved Port Operations: Implementing efficient cargo-handling processes, optimizing logistics to reduce congestion and idling times, and encouraging use of cleaner port machinery and vehicles can all contribute to reducing air pollution in port areas.
- Inspection of condition of contractor's barges and equipment before start of work and ensuring a maintenance schedule is followed for the equipment used.
- Minimization of movement of project vehicles at night and especially during peak hour traffic (9-11am, 2-3 pm and 5-6pm).
- Regular maintenance of diesel generators engines However, continued efforts are needed to improve air quality and mitigate the impact of port shipping activities on the environment and public health.

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CHAPTER 5: NOISE MONITORING

5.1 Noise Monitoring

Noise can be defined as an unwanted sound. It is, therefore, necessary to measure both the quality as well as the quantity of environmental noise in and around the study area. Noise produced during operation stage and thereafter activities may affect surrounding environment impacting the fauna and also the human population working and residing not only at site but also in the nearby areas. Under the scope, the noise monitoring is required to be carried out at 10 locations in Kandla and 3 locations in Vadinar. The sampling locations for noise are confined to commercial areas of DPA. The details of the noise monitoring stations are mentioned in **Table 15** and locations have been depicted in the **Figure 6 and 7** as follow:

Table 15: Details of noise monitoring locations

Sr. No.	Location Code		Location Name	Latitude/ Longitude
1.	Kandla	N-1	Oil Jetty 7	23.043527N 70.218456E
2.		N-2	West Gate No.1	23.006771N 70.217340E
3.		N-3	Canteen Area	23.003707N 70.221331E
4.		N-4	Main Gate	23.007980N 70.222525E
5.		N-5	Main Road	23.005194N 70.219944E
6.		N-6	Marin Bhavan	23.007618N 70.222087E
7.		N-7	Port & Custom Building	23.009033N 70.222047E
8.		N-8	Nirman Building	23.009642N 70.220623E
9.		N-9	ATM Building	23.009985N 70.221715E
10.		N-10	Wharf Area/ Jetty	22.997833N 70.223042E
11.	Vadinar	N-11	Near Main Gate	22.441544N 69.674495E
12.		N-12	Near Vadinar Jetty	22.441002N 69.673147E
13.		N-13	Port Colony Vadinar	22.399948N 69.716608E

Figure 6: Location Map for Noise Monitoring at Kandla

Figure 7: Location Map for Noise Monitoring at Vadinar

Frequency of Noise Monitoring

Monitoring was carried out at each noise monitoring station for Leq. noise level (Day and Night), which was recorded for 24 hours continuously for once in a month with the help of Class-1 Sound/Noise Level Meter.

5.2 Method of sampling and analysis:

The intensity of sound energy in the environment is measured in a logarithmic scale and is expressed in a decibel (dB(A)) scale. Ordinary sound level meter measures the sound energy that reaches the microphone by converting it into electrical energy and then measures the magnitude in dB(A). In a sophisticated type of sound level meter, an additional circuit (filters) is provided, which modifies the received signal in such a way that it replicates the sound signal as received by the human ear and the magnitude of sound level in this scale is denoted as dB(A). The sound levels are expressed in dB(A) scale for the purpose of comparison of noise levels, which is universally accepted by the international community.

Noise levels were measured using an integrated sound level meter of the make Casella Sound Level Meter (Class-I). It has an indicating mode of Lp and Leq. Keeping the mode in Lp for few minutes and setting the corresponding range and the weighting network in "A" weighting set the sound level meter was run for one-hour time and Leq was measured at all locations.

The day noise levels have been monitored during 6.00am to 10.00pm and night noise levels, during 10.00pm to 6.00am at all the thirteen locations monthly.

Table 16: Details of the Noise Monitoring that carried out at Kandla and Vadinar

Sr. No.	Parameters	Units	Reference Method	Instrument
1.	Leq (Day)	dB(A)	IS 9989: 2014	Noise Level Meter (Class-I)
2.	Leq (Night)	dB(A)		

Standard for Noise

Ministry of Environment & Forests (MoEF) has notified the noise standards vide gazette notification dated February 14, 2000 for different zones under the Environment Protection Act (1986). The specified standards are as mentioned in **Table 17** as follows:

Table 17: Ambient Air Quality norms in respect of Noise

Area Code	Category of Area	Noise dB(A) Leq	
		Daytime	Night time
A	Industrial Area	75	70
B	Commercial Area	65	55
C	Residential Area	55	45
D	Silence Zone	50	40

Note:

1 Day time shall mean from 6.00 am to 10.00 pm.
2 Night time shall mean from 10.00 pm to 6.00 am.
3 Silence zone is defined as area comprising not less than 100 meters around hospitals, educational institutions, courts, religious places or any other area, which is declared as such by the competent authority.

5.3 Result and Discussion

The details of the Noise monitoring conducted for the months of April-May 2023 have been summarized in the **Table 18** as below. The day noise levels have been monitored during 6.00am to 10.00pm and night noise levels, during 10.00pm to 6.00am at all the thirteen locations monthly.

Table 18: The results of Ambient Noise Quality

Sr. No.	Station Code	Station Name	Category of Area	Standard	Day Time			Standard	Night Time		
					Max.	Min.	Leq dB(A) Total		Max	Min	Leq dB(A) Total
1	N-1	Oil Jetty 7	A	75	64.5	38.4	53.7	70	56.3	36.9	48.4
2	N-2	West Gate No.1	A	75	66.3	46.1	57.2	70	51.3	39.6	46.6
3	N-3	Canteen Area	B	65	66.2	38.0	54.8	55	51.2	38.6	46.4
4	N-4	Main Gate	A	75	60.8	37.1	52.2	70	50.8	38.6	46.3
5	N-5	Main Road	A	75	64.9	41.4	54.9	70	51.0	33.6	43.5
6	N-6	Marin Bhavan	B	65	60.7	39.0	52.1	55	52.3	44.3	48.5
7	N-7	Port & Custom Building	B	65	66.3	37.6	54.5	55	53.2	37.9	45.7
8	N-8	Nirman Building	B	65	58.7	42.1	51.3	55	58.9	38.5	50.8
9	N-9	ATM Building	B	65	64.5	35.1	54.2	55	53.4	37.3	49.0
10	N-10	Wharf Area/ Jetty	A	75	74.5	42.1	63.1	70	52.7	38.7	48.9
11	N-11	Near Main Gate	A	75	67.7	35.7	56.7	70	54.3	34.3	46.8
12	N-12	Near Vadinar Jetty	A	75	65.3	39.2	54.5	70	54.1	34.7	46.2
13	N-13	Port Colony Vadinar	C	55	58.7	41.8	50.7	45	55.7	36.3	47.8

5.4 Data Interpretation:

With reference to the Table 18, during the monitoring period at Kandla highest day time noise was observed at N-10 i.e., Wharf Area/Jetty (74.5 dB(A)). The day time noise levels were observed to be within the prescribed limit of 75 dB(A).

While considering the Night time, highest noise was observed at N-8 i.e., Nirman Building (58.9 dB(A)), whereas lowest noise was observed at N-5 i.e., Main Road area (33.6 dB(A). The night time noise levels were observed to be within the prescribed limit of 70 dB(A).

For the locations of Vadinar highest and lowest day time noise was observed at N-11 i.e., Near Main Gate as 67.7 dB(A) and 35.7 dB(A) respectively. The day time noise levels were observed to be within the prescribed limit of 75 dB(A).

While considering the Night time, highest noise was observed at N-13 i.e., Port Colony Vadinar (55.7 dB(A)), whereas lowest noise was observed at N-11 i.e., Near Main Gate (34.3 dB(A)). The night time noise levels were observed to be within the prescribed limit of 70dB(A).

5.5 Conclusion

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 in all 10 locations at Deendayal Port Authority ranged from 51.3 dB(A) to 63.1 dB(A) while at Vadinar port 3 location ranged from 50.7 dB(A) to 56.7 dB(A) and for The Night Time Average Noise Level in all locations of Deendayal Port Authority ranged from 43.5 dB(A) to 50.8 dB(A) while at Vadinar port ranged from 46.2 dB(A) to 47.8 dB(A) which falls within the permissible limits set for the industrial, commercial and residential area for the daytime.

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. Construction activities may create a problem of noise generated by construction equipment, truck traffic, work vessels and other similar sources. Sources of noise can be individuated in port areas in the following three main areas:

- Passenger car and heavy vehicle (trucks) road traffic (the most important one);
- Goods movement (from machinery such as quay-crane, pumps, etc.);
- Rail traffic noise: rail movement in port and in surrounding areas are prevalent to low speed and of consequence the noise level is not so high, however in highly trafficked areas the problem can be relevant.

5.6 Measures against adverse effects

Transmission of noise may reduce with the distance from their sources. Noise could be considerably reduced by adoption of low noise equipment or installation of sound insulation fences. Green belt of plants can be a good barrier. Limitation of working hours may be a possible means to mitigate the nuisances of construction activities.

CHAPTER 6: DRINKING WATER MONITORING

6.1 Drinking Water Monitoring

It is necessary to check with the drinking water sources regularly so as to know whether water quality meets the prescribed standards for drinking. Monitoring the drinking water quality is essential to protect human health and the environment. A total of 20 locations (18 at Kandla and 2 at Vadinar) were monitored for Drinking Water. The location map has been depicted in the **Figure 8 and 9** and the details of the drinking water monitoring locations within the premises of DPA have been mentioned in **Table 19**.

Table 19: Details of Drinking Water Sampling Locations

Sr. No.	Location Code		Location Name	Latitude/ Longitude
1.	Kandla	DW-1	Oil Jetty 7	23.043527N 70.218456E
2.		DW-2	Port & Custom Building	23.009033N 70.222047E
3.		DW-3	North Gate	23.007938N 70.222411E
4.		DW-4	Workshop	23.009372N 70.222236E
5.		DW-5	Canteen Area	23.003707N 70.221331E
6.		DW-6	West Gate 1	23.006771N 70.217340E
7.		DW-7	Sewa Sadan -3	23.009779N 70.221838E
8.		DW-8	Nirman Building	23.009642N 70.220623E
9.		DW-9	Custom Building	23.018930N 70.214478E
10.		DW-10	Port Colony Kandla	23.019392N 70.212619E
11.		DW-11	Wharf Area/ Jetty	22.997833N 70.223042E
12.		DW-12	Hospital Kandla	23.018061N 70.212328E
13.		DW-13	A.O. Building	23.061914N 70.144861E
14.		DW-14	School Gopalpuri	23.083619N 70.132061E
15.		DW-15	Guest House	23.078830N 70.131008E
16.		DW-16	E- Type Quarter	23.083306N 70.132422E
17.		DW-17	F- Type Quarter	23.077347N 70.135731E
18.		DW-18	Hospital Gopalpuri	23.081850N 70.135347E
19.	Vadinar	DW-19	Near Vadinar Jetty	22.440759N 69.675210E
20.		DW-20	Near Port Colony	22.401619N 69.716822E

Figure 8: Location Map for Drinking Water Monitoring for Kandla

Figure 9: Location Map for Drinking Water Monitoring at Vadinar

6.2 Methodology of Monitoring:

The water samples were collected from the finalized sampling locations and analyzed for physico-chemical and microbiological parameter. The analysis of these samples collected was carried out as per APHA, 23rd Edition and Indian Standard method in GEMI's NABL Accredited Laboratory, Gandhinagar. GEMI has followed the CPCB guideline as well as framed its own guidelines for the collection of water/wastewater samples, under the provision of Water (Preservation and Control of Pollution) Act 1974, titled as '**Sampling Protocol for Water & Wastewater'**; approved by the Government of Gujarat vide letter no. ENV-102013-299-E dated 24-04-2014. The samples under the study were collected and preserved as per the said Protocol. The samples were analyzed for selected parameters to establish the existing water quality of the study area. The parameters finalized to assess the drinking water quality have been mentioned in **Table 20** as follows:

Table 20: List of parameters for Drinking Water Quality monitoring

Sr. No.	Parameters	Units	Reference method	Instrument
1.	pH	-	APHA, 23rd Edition (Section-4500-H^+B):2017	pH Meter
2.	EC	µS/cm	APHA, 23rd Edition (Section-2510 B):2017	Conductivity Meter
3.	Turbidity	NTU	APHA, 23rd Edition (Section -2130 B):2017	Nephlo Turbidity Meter
4.	TDS	mg/L	APHA, 23rd Edition (Section-2540 C):2017	Vaccum Pump with filtration assembly and Oven
5.	TSS	mg/L	APHA, 23rd Edition, 2540 D: 2017	
6.	Chloride	mg/L	APHA, 23rd Edition (Section-4500-Cl-B):2017	Titration Apparatus
7.	Total Hardness	mg/L	APHA, 23rd Edition (Section-2340 C):2017	
8.	Ca Hardness	mg/L	APHA, 23rd Edition (Section-3500-Ca B):2017	
9.	Mg Hardness	mg/L	APHA, 23rd Edition (Section-3500-Mg B):2017	
10.	Free Residual Chlorine	mg/L	APHA 23rd Edition, 4500	
11.	Fluoride	mg/L	APHA, 23rd Edition (Section-4500-F-D):2017	UV- Visible Spectrophotometer
12.	Sulphate	mg/L	APHA, 23rd Edition (Section 4500-SO4-2-E):2017	
13.	Sodium	mg/L	APHA, 23rd Edition (Section-3500-Na-B):2017	Flame Photometer
14.	Potassium	mg/L	APHA,23rd Edition, 3500 K-B: 2017	
15.	Salinity	mg/L	APHA, 23rd Edition (section 2520 B, E.C. Method)	Salinity /TDS Meter

Sr. No.	Parameters	Units	Reference method	Instrument
16.	Nitrate	mg/L	APHA, 23rd Edition, 4500 NO3- B: 2017	UV- Visible Spectrophotometer
17.	Nitrite	mg/L	APHA, 23rd Edition, 4500 NO2-B: 2017	
18.	Hexavalent Chromium	mg/L	APHA, 23rd Edition, 3500 Cr B: 2017	
19.	Manganese	mg/L	APHA,23rd Edition, ICP Method 3120 B: 2017	ICP-OES
20.	Mercury	mg/L	EPA 200.7	
21.	Lead	mg/L	APHA ICP 23rd Edition (Section-3120 B):2017	
22.	Cadmium	mg/L	APHA ICP 23rd Edition (Section-3120 B):2017	
23.	Iron	mg/L	APHA ICP 23rd Edition (Section-3120 B):2017	
24.	Total Chromium	mg/L	APHA ICP 23rd Edition (Section-3120 B):2017	
25.	Copper	mg/L	APHA,23rd Edition, ICP Method 3120 B: 2017	ICP-OES
26.	Zinc	mg/L	APHA ICP 23rd Edition (Section-3120 B):2017	
27.	Arsenic	mg/L	APHA ICP 23rd Edition (Section-3120 B):2017	
28.	Colour	mg/L	APHA, 23rd Edition, 2120 B:2017	Color Comparator
29.	Total Coliforms	MPN/ 100ml	IS 15185: 2016	LAF/ Incubator

6.3 Conclusion Result and discussion:

The drinking water quality of the locations at Kandla and Vadinar and its comparison with the to the standard (Drinking Water Specifications i.e., IS: 10500:2012) have been summarized in **Table 21**.

Table 21: Summarized Result of Drinking Water quality

Sr. No.	Parameters	Units	Standard values as per IS		Kandla																		Vadinar	
			A	P	DW-1	DW-2	DW-3	DW-4	DW-5	DW-6	DW-7	DW-8	DW-9	DW-10	DW-11	DW-12	DW-13	DW-14	DW-15	DW-16	DW-17	DW-18	DW-19	DW-20
1.	pH	-	6.5-8.5	-	7.35	7.15	7.36	7.26	7.27	7.31	7.45	7.42	7.24	7.23	7.33	7.19	7.62	7.65	7.55	7.53	7.6	7.28	7.46	7.45
2.	Colour	Hazen	5	15	1	1	1	1	1	1	1	1	1	1	1	1	1	5	1	1	1	1	5	20
3.	EC	µS/cm	-	-	198	38	138	36	42	48	36	40	315	138	55	62	24	551	58	146	150	38	115	683
4.	Salinity	mg/L	-	-	0.10	0.02	0.07	0.02	0.02	0.02	0.02	0.02	0.15	0.07	0.02	0.03	0.02	0.27	0.03	0.07	0.07	0.02	0.06	0.33
5.	Turbidity	NTU	1	5	BQL	BQL	0.7	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	5.3
6.	Chloride	mg/L	250	1000	46.9	7.50	30.99	8.5	10.32	12.59	7.5	10.50	72.48	25.99	13.54	12.50	7.50	80.97	12.50	25.99	26.49	11.5	19.99	90.47
7.	Total Hardness	mg/L	200	600	15	10	10	15	10	15	10	15	15	10	15	15	10.0	160	15	20	20	10	20	160
8.	Ca Hardness	mg/L	-	-	5	5	5	5	5	5	5	5	5	5	5	5	5.0	90	5	10	10	5	5	80
9.	Mg Hardness	mg/L	-	-	10	5	5	10	5	10	5	10	10	5	10	10	5.0	70	10	10	10	5	15	80
10.	Free Residual Chlorine	mg/L	0.2	1	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
11.	TDS	mg/L	500	2000	100	20	72	20	22	25	20	22	158	70	29	30	28	278	32	76	78	20	62	346
12.	TSS	mg/L	-	-	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	12
13.	Fluoride	mg/L	1.0	1.5	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
14.	Sulphate	mg/L	200	400	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	25.84	BQL	BQL	BQL	BQL	BQL	40.57

Sr. No.	Parameters	Units	Standard values as per IS		Kandla																Vadinar	
			A	P	DW-1	DW-2	DW-3	DW-4	DW-5	DW-6	DW-7	DW-8	DW-9	DW-10	DW-11	DW-12	DW-13	DW-14	DW-15	DW-16	DW-17	DW-18	DW-19	DW-20
15.	Nitrate	mg/L	45	-	9.59	1.09	3.27	BQL	BQL	BQL	BQL	BQL	3.615	7.458	BQL	BQL	BQL	3.564	1.223	1.097	1.191	BQL	15.79	18.54
16.	Nitrite	mg/L	-	-	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
17.	Sodium	mg/L	-	-	24.1	BQL	13.00	BQL	12	13.6	BQL	BQL	41.55	13	12.8	BQL	BQL	50.93	BQL	16.83	17.51	BQL	7.55	54.55
18.	Potassium	mg/L	-	-	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
19.	Hexavalent Chromium	mg/L	-	-	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	0.041	0.015
20.	Odour	TON	Agreeable		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21.	Arsenic	mg/L	0.01	0.05	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
22.	Cadmium	mg/L	0.003	-	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
23.	Copper	mg/L	0.05	1.5	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	16.25	BQL
24.	Iron	mg/L	0.3	-	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	1.478	BQL
25.	Lead	mg/L	0.01	-	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	10.53	BQL
26.	Manganese	mg/L	0.1	0.3	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	139.03	93.717
27.	Mercury	mg/L	0.001	-	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL

Sr. No.	Parameters	Units	Standard values as per IS		Kandla																		Vadinar	
			A	P	DW-1	DW-2	DW-3	DW-4	DW-5	DW-6	DW-7	DW-8	DW-9	DW-10	DW-11	DW-12	DW-13	DW-14	DW-15	DW-16	DW-17	DW-18	DW-19	DW-20
28.	Total Chromium	mg/L	0.05	-	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
29.	Zinc	mg/L	5	15	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
30.	Total Coliform*	CFU/ 100ml	Shall not be detected		5	390	BQL	25	5	5	BQL	BQL	BQL	BQL	5	5	BQL	135	BQL	7650	2350	5	2850	130000

A: Acceptable, P:Permissible, BQL: Below Quantification limit Turbidity (QL=0.5), Free Residual Chlorine (QL=2), Total Suspended Solids (QL=2), Fluoride (QL=0.3), Sulphate (QL=10), Nitrate as NO3 (QL=1), Nitrite as No2 (QL=0.1), Sodium as Na (QL=5), Potassium as K (QL=5), Hexavalent Chromium (QL=0.01), Arsenic (QL=5), Cadmium (QL=2), Copper (QL=5), Iron (QL=0.1), Lead (QL=2), Manganese (QL=40), Mercury (QL=0.5), Total Chromium (QL=5), Zinc (QL=0.5)

***Note:** For Total Coliform, one MPN is equivalent to one CFU. The use of either methods; MPN or CFU for the detection of bacteria are considered valid measurements for bacteria limits.

6.4 Data Interpretation:

- **pH:** The pH is measure of the intensity of acidity or alkalinity and the concentration of hydrogen ion in water. At Kandla, the pH values for drinking water samples ranged from 7.15-7.65 and mean value was 7.37 while at Vadinar pH ranged from 7.45-7.46 and mean value was 7.45.
- **Turbidity:** Turbidity measurements are used to determine how clear and clean a water sample is. Small particles like clay, silt, algae, and microorganisms can be suspended in water and cause light scattering, giving water a milky or cloudy appearance. At the drinking water locations of Kandla, the turbidity was observed to be "Below the detection Limit" for majority of the locations, except location DW-3 (0.7 NTU). Whereas, for Vadinar the turbidity was observed to be "Below the detection Limit" for DW-19 and 5.3 NTU for DW-20.
- **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. During the study period, TDS values at Kandla varied between 20 to 278 mg/L. The average TDS value was found 114.8 mg/L. The minimum value for TDS was 20 mg/L at DW-2, DW-4, DW-7 and DW-18 and maximum was 278 mg/L at DW-14. The average TDS was 61.11 mg/L. Whereas, at Vadinar TDS ranged from 62-346 mg/L and mean was 204 mg/L.
- **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 ranged from 24-551 µS/cm with the average value as 117.38 µS/cm. While at Vadinar, the value of EC ranged from 115-683 µS/cm with the average value as 399 µS/cm.
- **Chlorides:** Excessive chloride concentration increase rates of corrosion of metals in the distribution system. The Chloride concentration varied from 7.5-80.97 mg/L, with the average value as 23.57 mg/L. The lowest concentration was observed at DW-2, DW-7 and DW-13, while the highest was observed at DW-14. While at Vadinar, the concentration varied from 19.99-90.47 mg/L. With the average chloride concentration as 55.23 mg/L. The lowest concentration was observed at DW-19, while the highest was observed at DW-20.
- **Total Hardness:** Hardness is caused by compounds of calcium and magnesium, and by a variety of other metals. The Total Hardness concentration varied from 10-160 mg/L, with the average value as 21.66 mg/L. The highest was observed at DW-14. While at Vadinar, the concentration varied from 20-160 mg/L. With the average Total Hardness concentration as 90 mg/L. Hardness at all the locations was observed to have concentrations within the norms specified. The hardness of water is according to the IS standards and it is not harmful for local inhabitants.
- The parameters Free Residual Chlorine, Total Suspended Solids, Fluoride, Sulphate, Nitrate, Nitrite, Sodium, Hexavalent Chromium, Potassium, and the metals Arsenic, Cadmium, Copper, Iron, Lead, Manganese, Mercury, Total Chromium and Zinc were all observed to have concentrations "Below the Quantification Limit (BQL)" at majority of the locations for both the monitoring period.

- Bacteriological Analysis of the drinking water at Kandla and Vadinar reveals that the Total Coliforms were detected at majority of the locations of Kandla and Vadinar. This shows that drinking water samples is unfit for human consumption. Reporting such high concentration of Coliforms indicates certain external influx may contaminate the source. Hence, it should be checked at every distribution point.

6.5 Conclusion

- These results were compared with permissible limits as prescribed in IS 10500:2012 – Drinking Water Specification. It may be concluded from the analysis data that amongst the drinking water parameters so monitored, the parameters such as TDS, Total hardness, chloride, fluoride were observed to be well below the acceptable limit of IS standard at all the 20 monitoring locations. Whereas Total Coliforms were found to be present in all the drinking water samples collected from both the locations.
- Low TDS water shall contain lower mineral content, Normal drinking water provides about 20% of your dietary intake of dissolved minerals. So, which means by consuming such water may result in mineral deficiency. Further, it may increase the metal leaching.
- Bacteriological Analysis of the drinking water at Kandla and Vadinar reveals that the drinking water samples is unfit for human consumption.
- Appropriate water treatment processes should be implemented to remove or inactivate coliform bacteria that include disinfection with chlorine, ultraviolet (UV) light, or ozone etc. Filtration systems can also help remove bacteria, sediment, and other impurities.
- Further, a regular monitoring program to test the quality of drinking water at various stages, including the source, purification plants, distribution network, and consumer endpoints would help in early detection of coliform bacteria or other microbial contaminants.

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CHAPTER 7: DG STACK MONITORING

7.1 DG Stack Monitoring

A diesel generator is a mechanical-electrical machine that produces electrical energy (electricity) from diesel fuel. They are used by the residential, commercial, charitable and governmental sectors to provide power in the event of interruption to the main power, or as the main power source. Diesel generating (DG) sets are generally used in places without connection to a power grid, or as an emergency power supply if the grid fails. These DG sets utilize diesel as fuel and generate and emit the air pollutants such as Suspended Particulate Matter, SO_x, NO_x, CO, etc. from the stack during its functioning. The purpose of stack sampling is to determine emission levels from plant processes to ensure they are in compliance with any emission limits set by regulatory authorities to prevent macro environmental pollution. The stack is nothing but chimney which is used to disperse the hot air at a great height, emissions & particulate matters that are emitted. Hence, monitoring of these stacks attached to DG Sets is necessary in order to quantify the emissions generated from it.

As defined in scope by Deendayal Port Authority (DPA), the monitoring of DG Stack shall be carried out at two locations, one at Kandla and one at Vadinar. The details of the DG Sets at Kandla and Vadinar have been mentioned in **Table 22** as follows:

Table 22: Details of DG Set monitoring locations

Sr. No.	Location Code	Location Name	Latitude/ Longitude
1.	DG-1	Kandla	22.98916N 70.22083E
2.	DG-2	Vadinar	22.44155N 69.67419E

The map depicting the locations of DG Stack Monitoring to be monitored in Kandla and Vadinar have been mentioned in **Map 10 and 11** as follows:

Figure 10: Location Map for DG Set monitoring at Kandla

Figure 11: Location Map for DG Set monitoring at Vadinar

Frequency of DG Monitoring

Monitoring is required to be carried out once a month for both the locations of Kandla and Vadinar.

7.2 Method of sampling and analysis:

Under the study, the list of parameters to be monitored under the projects for the Soil Quality Monitoring been mentioned in **Table 23** as follows:

Table 23: Parameters to be monitored under the study

Sr. No.	Parameter	Unit	Instrument
1.	Suspended Particulate Matter	mg/Nm^3	Stack Monitoring Kit
2.	Sulphur Dioxide (SO_2)	mg/Nm^3	Sensor based Flue Gas Analyzer (Make: TESTO, Model 350)
3.	Oxides of Nitrogen (NO_x)	mg/Nm^3	
4.	Carbon Monoxide	mg/Nm^3	
5.	Carbon Dioxide	mg/Nm^3	

The methodology for monitoring of DG Set has been mentioned as follows:

The monitoring of DG Stack is carried out as per the IS:11255 and USEPA Method. The Stack monitoring kit is used for collecting representative samples from the stack to determine the total amount of pollutants emitted into the atmosphere in a given time. Source sampling is carried out from ventilation stack to determine the emission rates/or characteristics of pollutants. Sample collected must be such that it truly represents the conditions prevailing inside the stack. Whereas the parameters Sulphur Dioxide, Oxides of Nitrogen (NOx), Carbon Monoxide and Carbon Dioxide, the monitoring is carried out by using the sensor-based Flue Gas Analyzer.

As per CPCB or Indian standards for Industrial Stack Monitoring the flue gas emission from DG set emissions should not exceed the limit as mentioned in **Table 24.**

Table 24: Standards for stack emission

Sr. No.	Stack Monitoring Parameters for DG Sets	Stack Monitoring Limits / Standards As per CPCB (mg/Nm^3)
1.	Particulate Matter	150
2.	Sulphur Dioxide (SO2)	40
3.	Oxides of Nitrogen (NOx)	25
4.	Carbon Monoxide	1%

During the monitoring period, the DG sets were not utilized, and hence monitoring was not conducted.

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CHAPTER 8: SOIL QUALITY MONITORING

8.1 Soil Quality Monitoring:

The purpose of soil quality monitoring is to track changes in the features and characteristics of the soil, especially the chemical properties of soil occurring at specific time intervals under the influence of human activity. Soil quality assessment helps to determine the status of soil functions and environmental risks associated with various practices prevalent at the location.

As defined in scope by Deendayal Port Authority (DPA), Soil Quality Monitoring shall be carried out at Six locations, four at Kandla and two at Vadinar. The details of the soil monitoring locations within the Port area of DPA are mentioned in **Table 25:**

Table 25: Details of the Soil quality monitoring locations

Sr. No.	Location Name		Location Code	Latitude Longitude
1.	Kandla	Oil Jetty 7	S-1	23.043527N 70.218456E
2.		IFFCO Plant	S-2	23.040962N 70.216570E
3.		Khori Creek	S-3	22.970382N 70.223057E
4.		Nakti Creek	S-4	23.033476N 70.158461E
5.	Vadinar	Near SPM	S-5	22.400026N 69.714308E
6.		Near Vadinar Jetty	S-6	22.440759N 69.675210E

The map depicting the locations of Soil Quality Monitoring to be monitored in Kandla and Vadinar have been mentioned in **Map 12 and 13** as follows:

Figure 12: Location Map for Soil Quality Monitoring at Kandla

Figure 13: Location Map for Soil Quality Monitoring at Vadinar

8.2 Methodology of Monitoring:

As per the defined scope by Deendayal Port Authority (DPA), the sampling and analysis of Soil quality has been carried out on monthly basis.

The samples of soil collected from the locations of Kandla and Vadinar and analyzed for the various physico-chemical parameter. Collection and analysis of these samples was carried out as per established standard methods and procedures. The samples were analyzed for selected parameters to get the present soil quality status and its and environmental risks associated with various practices prevalent at the location. GEMI has framed its own guidelines for collection of soil samples titled as ***'Soil Sampling Manual'***. Soil samples were collected from up to 30 cm depth below the surface using scrapper, filled in polythene bags, labelled on-site with specific location code and name and sent to GEMI's laboratory for further detailed analysis. The samples collected from all locations are homogeneous representative of each location. The list of parameters to be monitored under the projects for the Soil Quality Monitoring been mentioned in **Table 26** as follows:

Table 26: List of parameters to be monitored for Soil Quality

Sr. No.	Parameters	Units	Reference method	Instruments
1.	TOC	%	Methods Manual Soil Testing in India January, 2011, 09. Volumetric method (Walkley and Black, 1934)	Titration Apparatus
2.	Organic Carbon	%		
3.	Inorganic Phosphate	mg/Kg	Practical Manual Chemical Analysis of Soil and Plant Samples, ICAR-Indian Institute of Pulses Research 2017 Determination of Available Phosphorus in Soil	UV-Visible Spectrophotometer
4.	Texture	-	Methods Manual Soil Testing in India January 2011,01	Hydrometer
5.	pH	-	IS 2720 (Part 26): 1987	pH Meter
6.	Conductivity	µS/cm	IS 14767: 2000	Conductivity Meter
7.	Particle size distribution & Silt content	-	Methods Manual Soil Testing in India January 2011	Sieves Apparatus
8.	SAR	meq/L	Procedures for Soil Analysis, International Soil Reference and Information Centre, 6th Edition 2002 13-5.5.3 Sodium Absorption Ratio (SAR), Soluble cations	Flame Photometer

Sr. No.	Parameters	Units	Reference method	Instruments
9	Water Holding Capacity	%	NCERT, Chapter 9, 2022-23 and Water Resources Department Laboratory Testing Procedure for Soil & Water Sample Analysis	Muffle Furnace
10	Aluminium	mg/Kg	EPA Method 3051A	ICP-OES
11	Chromium	mg/Kg		
12	Nickel	mg/Kg		
13	Copper	mg/Kg	Methods Manual Soil Testing in India January, 2011, 17a	
14	Zinc	mg/Kg	Methods Manual Soil Testing in India January, 2011, 17a	
15	Cadmium	mg/Kg	EPA Method 3051A	
16	Lead	mg/Kg		
17	Arsenic	mg/Kg		
18	Mercury	mg/Kg		

8.3 Result and Discussion

The analysis results of physical analysis of the soil samples collected during environmental monitoring mentioned in **Table 27** are shown below:

Table 27: Results of Soil Quality

Sr. No	Location / Parameters	Unit	Kandla				Vadinar	
			S-1 (Oil Jetty 7)	**S-2** (IFFCO Plant)	**S-3** (Khori Creek)	**S-4** (Nakti Creek)	**S-5** (Near SPM)	**S-6** (Near Vadinar Jetty)
1	pH	-	7.69	8.27	7.27	8.04	7.92	8.5
2	Conductivity	µS/cm	8840	6040	39600	11700	111	625
3	Inorganic Phosphate	mg/Kg	11.01	27.6	20.31	11.46	5.64	5.1
4	Organic Carbon	%	0.03	0.38	1.88	0.46	0.85	0.3
5	Organic Matter	%	0.06	0.66	3.23	0.79	1.47	0.52
6	SAR	meq/L	1.05	0.67	1.10	1.65	0.10	0.25
7	Aluminium	mg/Kg	1392.53	1368.22	1569.23	1388.41	1480.53	1425.50
8	Chromium	mg/Kg	69.98	69.92	79.56	70.18	106.00	91.88
9	Nickel	mg/Kg	33.32	27.54	27.16	31.51	40.89	42.68
10	Copper	mg/Kg	25.33	51.65	148.05	50.49	123.18	98.20
11	Zinc	mg/Kg	52.29	155.24	100.20	61.30	83.05	52.89
12	Cadmium	mg/Kg	BQL	1.07	BQL	BQL	BQL	BQL
13	Lead	mg/Kg	9.30	17.33	3.45	7.24	BQL	0.91
14	Arsenic	mg/Kg	4.87	8.4	BQL	4.03	BQL	BQL
15	Mercury	mg/Kg	BQL	BQL	BQL	BQL	BQL	BQL
16	Water Holding Capacity	%	45.54	45.29	25.98	45.84	39.85	54.23
17	Sand	%	70.7	72.28	60.08	76.33	51.84	53.62
18	Silt	%	9.77	13.86	29.74	11.84	12.24	36.08
19	Clay	%	19.53	13.86	10.18	11.84	35.92	10.3
20	Texture		Sandy loam	Loamy Sand	Sandy loam	Sandy loam	Sandy loam	Sandy loam

Under the project, in order to classify the soil quality of Kandla and Vadinar, the "Standard Soil Classification" has been adopted from Hand Book of Agriculture, ICAR, New Delhi. The classification is mentioned in the **Table 28** as follows for the parameters pH, Electrical Conductivity, Organic Carbon.

Table 28: Classification of soil parameters as mentioned in Hand Book of Agriculture

Sr. No.	Soil Parameters	Classification
1.	pH	**<4.5** Extremely acidic **4.51-5.50** Very strongly acidic **5.51-6.00** moderately acidic **6.01-6.50** slightly acidic **6.51-7.30** Neutral **7.31-7.80** slightly alkaline **7.81-8.50** moderately alkaline **8.51-9.0** strongly alkaline **>9.00** very strongly alkaline
2.	EC (ppm) (1ppm = 640 µmhos)	**Up to 1.00** Average **1.01-2.00** harmful to germination **2.01-3.00** harmful to crops (sensitive to salts)
3.	Organic Carbon	**Up to 0.2**: very less **0.21-0.4**: less **0.41-0.5** medium, **0.51-0.8**: on an average sufficient **0.81-1.00**: sufficient **>1.0** more than sufficient

8.4 Data Interpretation:

- **pH**

  For the month of April 2023, the value of pH ranges from 7.27-8.27, highest at location S-2 IFFCO Plant; while the average value was 7.81. Whereas, at Vadinar highest pH was observed at S-6 i.e., near Jetty Area (8.5) with the average soil pH as 8.21. As per the classification mentioned in the Handbook of Agriculture, the pH in Kandla varies from the Neutral to moderately alkaline. Whereas, pH of Soil at Vadinar was found to be moderately alkaline.

- **Electrical Conductivity (EC)**

  During the study period, at Kandla the value of EC ranges from 6040-39600 µs/cm, highest at location S-3 Khori creek (11700 µs/cm) and lowest at S-2 IFFCO Plant (6040 µs/cm); while the average value was 16545 µs/cm. Whereas, at Vadinar highest EC was observed at S-6 i.e., near Jetty Area (6.25 µs/cm) and lowest was observed at S-5 i.e., Near SPM (111 µs/cm), while the average value was 368 µs/cm.

  As per the classification mentioned in the Handbook of Agriculture, the Electrical Conductivity at Kandla the status of soil quality was found to be harmful to crops. Whereas, at Vadinar EC was observed to be below the average value of 640 µs/cm.

- **Inorganic Phosphate**

  During the monitoring period at Kandla the value of Inorganic Phosphate ranges from 11.01-27.6 mg/Kg, highest at location S-2 IFFCO Plant (27.6 mg/Kg) and lowest at S-1 Oil Jetty-7 (11.01 mg/Kg); while the average value was 17.595 mg/Kg. Whereas, at

Vadinar highest Inorganic Phosphate was observed at S-6 i.e., near Jetty Area (5.1 mg/Kg) and lowest was observed at S-5 i.e., Near SPM (5.64 mg/Kg), while the average value was 5.37 mg/Kg.

- **Total organic Carbon (TOC)**

  At Kandla the value of TOC ranges from 0.03 to 1.88 % highest at location S-3 Khori creek (1.18%) and lowest at S-1 Oil Jetty-7 (0.03%); while the average value was 0.68%. Whereas, at Vadinar highest TOC was observed at S-5 i.e., Near SPM (0.85%) and lowest was observed at S-6 i.e., near Jetty Area (0.3%). As per the classification mentioned in the Handbook of Agriculture, the Organic Carbon at Kandla and Vadinar was on an average in sufficient concentration.

- **Heavy Metals**

  For the sampling period, the concentration of **Aluminium** in the soil samples at varies from 1368.22 to 1569.23 mg/kg at Kandla and 1425.5 to 1480.53 mg/kg at Vadinar with mean value reported as 1429.59 and 1453.01 mg/kg at Kandla and Vadinar monitoring station respectively

  The concentration of **Chromium** in the soil samples varies from 69.92 to 79.5623 mg/kg at Kandla and 91.88 to 106mg/kg at Vadinar with mean value 72.41 and 98.94 mg/kg at Kandla and Vadinar monitoring station respectively.

  The concentration of **Nickel** in the soil samples of DPA Kandla varies from 27.16 to 33.32 mg/kg at Kandla and 40.89 to 42.68 mg/kg at Vadinar with mean value 29.88 and 41.78 mg/kg at Kandla and Vadinar monitoring station respectively.

  The concentration of **Copper** in the soil samples of DPA Kandla varies from 25.33 to 148.05 mg/kg and 98.2 to 123.18 mg/kg at Vadinar with mean value 68.88 and 110.69 mg/kg at Kandla and Vadinar monitoring station respectively.

  The concentration of **Zinc** in the soil samples of DPA Kandla varies from 52.29 to 155.24 mg/kg and 52.89 to 83.05mg/kg at Vadinar with mean value 92.25 and 67.97 mg/kg at Kandla and Vadinar monitoring station, respectively.

  The concentration of **Lead** in the soil samples of DPA Kandla varies from 3.45 to 17.33 mg/kg and BQL to 0.91 mg/kg at Vadinar with mean value 9.33 and 0.91 mg/kg at Kandla and Vadinar monitoring station, respectively.

  The concentration of **Arsenic** in the soil samples of DPA Kandla varies from BQL to 8.4 mg/kg with mean value 5.76 mg/Kg and observed below the detection Limit for Vadinar.

  The concentration of **Water Holding Capacity** in the soil samples of DPA Kandla varies from 25.98 to 45.84% and 39.85 to 54.23% at Vadinar and mean value 40.66% and 47.04 % for Kandla and Vadinar respectively.

  Heavy Metals like **Mercury and Cadmium** in the Soil was found to "Below the detection limit" for majority the soil samples collected at Kandla and Vadinar.

The soil texture observed at all the locations of Kandla and Vadinar for the sampling period was "Sandy Loam".

8.5 Conclusion:

The soil quality of Kandla and Vadinar was assessed based on the Handbook of Agriculture. As per the said comparison, the pH in Kandla varies from the Slightly acidic to moderately alkaline. Whereas, pH of Soil at Vadinar was found to be moderately alkaline, the Organic Carbon at Kandla and Vadinar was on an average in sufficient concentration, whereas, the Electrical Conductivity at Kandla for both the months of April and May was found to be harmful to crops. There are several reasons that can contribute to soil quality degradation at port areas, such as:

- **Contamination:** Port areas are prone to various types of contamination due to the handling, storage, and transportation of goods and materials. Spills of hazardous substances, leakage from storage tanks, and improper disposal of waste can result in soil contamination. Chemicals such as heavy metals, petroleum products, and industrial pollutants can accumulate in the soil, making it less suitable for plant growth and potentially harmful to human health.
- **Erosion:** Ports are often located near coastlines or rivers, where erosion can be a significant issue. The construction of port infrastructure, such as breakwaters, jetties, and embankments, can alter natural sediment flow and wave patterns, leading to increased erosion of nearby soils. Erosion can cause loss of topsoil, which is rich in organic matter and essential nutrients for plant growth.
- **Increased salinity:** Ports situated in coastal areas may experience saltwater intrusion into the soil. Dredging activities, land reclamation, and alteration of natural water flow can disrupt the balance between freshwater and saltwater, resulting in increased salinity in the soil. High salt concentrations can hinder plant growth, reduce crop productivity, and adversely affect soil structure.
- **Compaction:** Heavy machinery, trucks, and containers moving in port areas can exert significant pressure on the soil, leading to compaction. Compacted soils have reduced pore spaces, limiting air and water movement and impeding root penetration. This can result in poor drainage, decreased nutrient availability, and restricted plant growth.
- **Loss of organic matter**: Port areas often undergo significant land transformation, including the removal of vegetation and topsoil during construction. The removal of organic matter-rich topsoil reduces the soil's fertility and capacity to retain moisture, making it less suitable for supporting plant life.

8.6 Measures against adverse effects

Addressing soil quality degradation at port areas requires implementing measures such as proper soil management practices, regular monitoring and testing for contaminants, erosion control measures, and the use of sustainable construction techniques. Additionally, promoting the restoration of vegetation and implementing strategies to minimize the introduction and spread of invasive species can help mitigate soil degradation in port areas.

CHAPTER 9: SEWAGE TREATMENT PLANT MONITORING

9.1 Sewage Treatment Plant (STP) Monitoring:

The principal objective of Sewage Treatment Plant is to remove contaminants from sewage to produce an effluent that is suitable to discharge to the surrounding environment or an intended reuse application, thereby preventing water pollution from raw sewage discharges. As defined in the scope by Deendayal Port Authority (DPA), Kandla, the Sewage Water Treatment Plant Monitoring as to be carried out at three locations, one at Kandla, one at Gopalpuri and one STP at Vadinar. The samples each from the treated wastewater of the STP have to be collected weekly. The details of the locations of Sewage Treatment Plants to be monitored for Kandla and Vadinar are as mentioned in **Table 29** as follows:

Table 29: Details of the monitoring locations of Sewage Water Treatment Plants

Sr. No..	Location Code		Location Name	Latitude Longitude
1.	Kandla	STP-1	STP Kandla	23.021017N 70.215594E
2.		STP-2	STP Gopalpuri	23.077783N 70.136759E
3.	Vadinar	STP-3	STP at Vadinar	22.406289N 69.714689E

The Consolidated Consent and Authorization (CC&A) issued by the Gujarat Pollution Control Board (GPCB) were referred for the details of the Sewage Treatment Plant (STP) for Kandla and Gopalpuri. The said CC&A of Kandla and Gopalpuri suggests that the domestic effluent generated shall be treated as per the norms specified in **Table 30.** The treated effluent conforming to the norms shall be discharged on the land within the premises strictly for the gardening and plantation purpose. Whereas, no sewage shall be disposed outside the premises in any manner.

Table 30: Norms of treated effluent as per CC&A for Kandla

Sr. No.	Parameters	Prescribed limits
1.	pH	6.5-8.5
2.	BOD (3 days at 27°C)	30 mg/L
3.	Suspended Solids	100 mg/L
4.	Fecal Coliform	< 1000 MPN/100 ml

The detailed process flow diagram of the Kandla and Gopalpuri STP have been mentioned in **Figure 14 and 15** as follows:

Process Flow Diagram of Kandla Sewage Treatment Plant (STP)

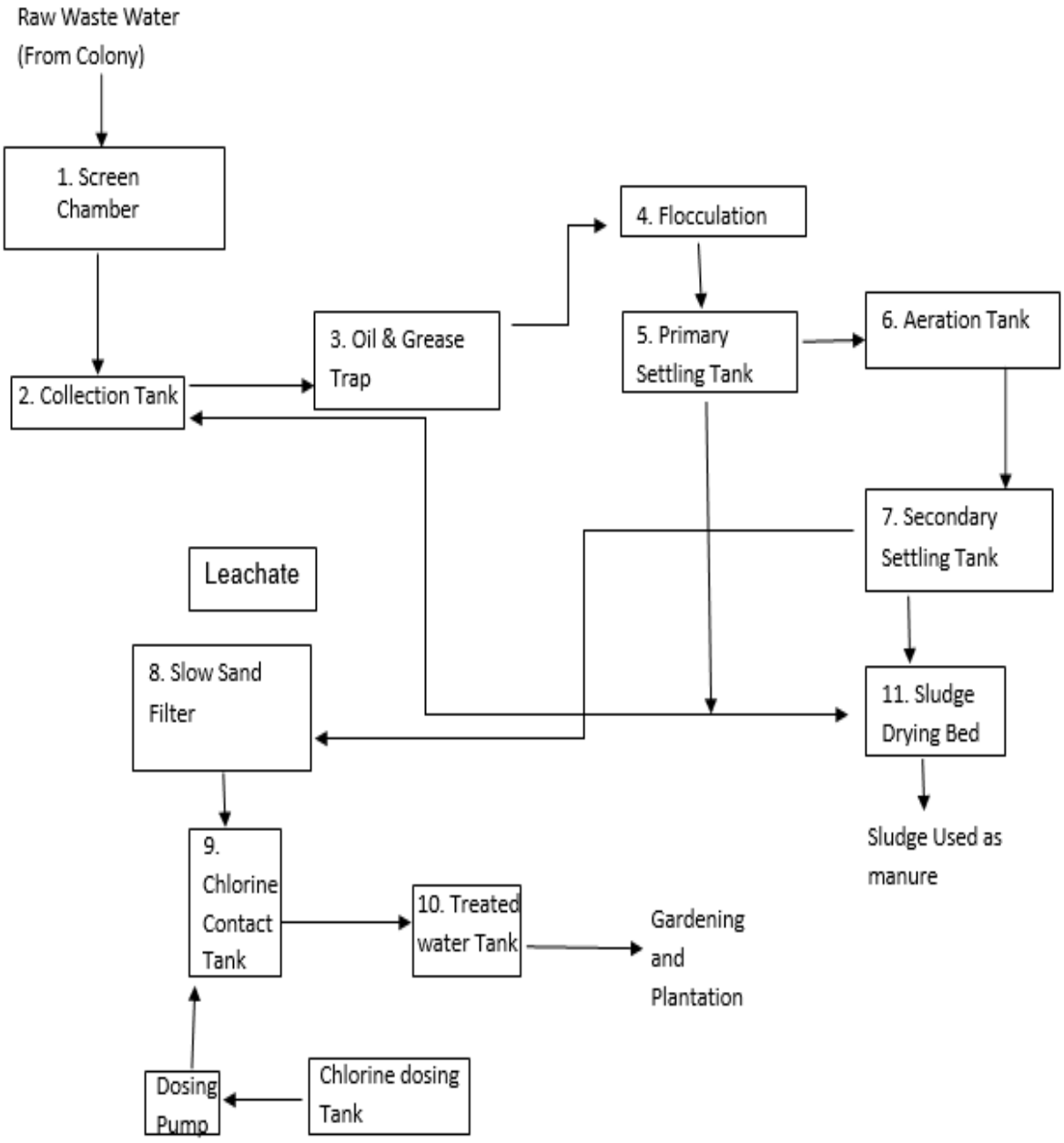

Figure 14: Process flow diagram of Kandla STP

Process Flow Diagram of Gopalpuri Sewage Treatment Plant (STP)

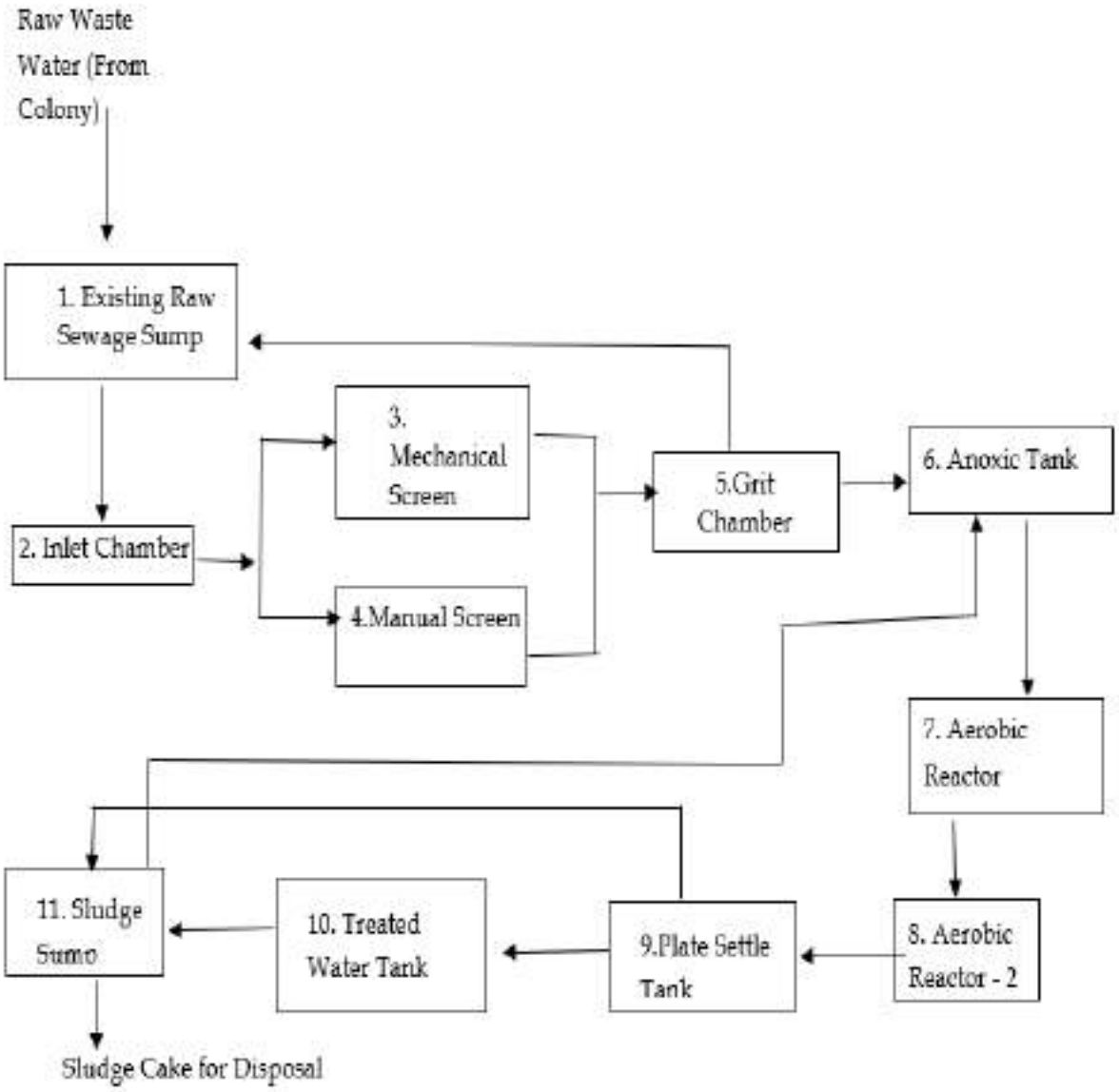

Figure 15: Process flow diagram of Gopalpuri STP

The STP at Vadinar has been built with a treatment capacity of 450 KLD/day. The Consolidated Consent and Authorization (CC&A) issued by the Gujarat Pollution Control Board (GPCB) were referred for the details of the Sewage Treatment Plant (STP) for Kandla and Gopalpuri. The said CC&A of the Vadinar STP suggests that the domestic effluent generated shall be treated as per the norms specified in **Table 31**. The treated effluent conforming to the norms shall be discharged on the land within the premises strictly for the gardening and plantation purpose. Whereas, no sewage shall be disposed outside the premises in any manner.

Table 31: Norms of treated effluent as per CC&A for Vadinar

Sr. No.	Parameters	Prescribed limits
1.	pH	5.5-9
2.	BOD (3 days at 27°C)	10 mg/L
3.	Suspended Solids	20 mg/L
4.	Fecal Coliform	Desirable 100 MPN/100 ml Permissible 230 MPN/100 ml
5.	COD	50 mg/L

The detailed process flow diagram of the Vadinar STP have been mentioned in **Figure 16** as follows:

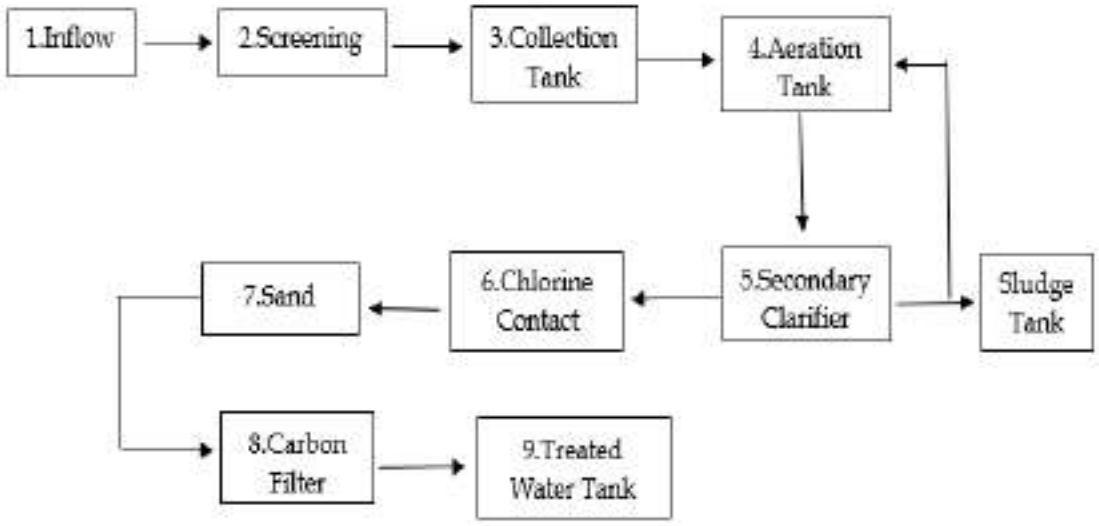

Figure 16: Process flowchart for the Vadinar STP

The map depicting the locations of Sewage Water Treatment Plant Monitoring to be monitored in Kandla and Vadinar have been shown in **Figure 17 and 18** as follows:

Figure 17: Location Map for STP Monitoring at Kandla

Figure 18: Location Map for STP Monitoring at Vadinar

9.2 Methodology of Monitoring:

As per the defined scope by Deendayal Port Authority (DPA), the sampling and analysis of water samples from the inlet and outlet of the STP of Kandla and Vadinar are carried out once a week, i.e., four times a month.

The water samples were collected from inlet and the outlet of the STP's and analyzed for physico-chemical and microbiological parameter. Collection and analysis of these samples was carried out as per established standard methods and procedures for the examination of water. The samples were analyzed for selected parameters to establish the existing water quality of the inlet and outlet points of the STP. GEMI has framed its own guidelines for collection of water/wastewater samples titled as 'Sampling Protocol for Water & Wastewater'; which has been approved by the Government of Gujarat vide letter no. ENV-102013-299-E dated 24-04-2014 under the provision of Water (Preservation and Control of Pollution) Act 1974. The sample collection and preservation are done as per the said Protocol.

Under the project, the list of parameters to be monitored for the STP have been mentioned in **Table 32** as follows:

Table 32: List of parameters monitored for STP's at Kandla and Vadinar

Sr. No.	Parameters	Units	Reference method	Instruments
1.	pH	-	APHA, 23rd edition, 4500- H^+ B, 2017	pH Meter
2.	TDS	mg/L	APHA, 23rd Edition, 2540 C: 2017	Vacuum Pump with filtration assembly and Oven
3.	TSS	mg/L		
4.	DO	mg/L	APHA, 23rd Edition, 4500 C: 2017	Titration Apparatus
5.	COD	mg/L	APHA, 23rd Edition, 5220 B: 2017	Titration Apparatus plus Digester
6.	BOD	mg/L	IS-3025, Part 44, 1993	BOD Incubator plus Titration Apparatus
7.	SAR	meq/L	IS 11624: 2019	Flame Photometer
8.	Total Coliforms	MPN/100ml	IS 1622: 2019	LAF/ Incubator

9.3 Result and Discussion

The quality of the water samples collected from the inlet and the outlet of the STP's of Kandla and Vadinar has been summarized in **Table 33 and 34** for the monitoring period. The said water quality has been represented in comparison with the standard values specified in the Consolidated Consent and Authorization (CC&A) of the STPs.

Table 33: Water Quality of inlet and outlet of STPs for Kandla

Sr No.	Parameter	Units	GPCB Norms (Kandla)	Kandla															
				Week 3 (April)				Week 4 (April)				Week 1 (May)				Week 2 (May)			
				STP-1 (I)	STP-1 (O)	STP-2 (I)	STP-2 (O)	STP-1 (I)	STP-1 (O)	STP-2 (I)	STP-2 (O)	STP-1 (I)	STP-1 (O)	STP-2 (I)	STP-2 (O)	STP-1 (I)	STP-1 (O)	STP-2 (I)	STP-2 (O)
1.	pH	-	**6.5-8.5**	7.04	7.15	6.97	8.88	7.22	7.4	7.14	7.18	6.96	7.1	7.06	7.09	7.13	7.21	6.85	7.37
2.	TDS	mg/L	-	2522	3586	484	820	2688	4616	512	546	2564	3776	588	556	2280	3612	528	512
3.	TSS	mg/L	**100**	148	66	146	10	918	88	52	6	1648	32	138	12	102	28	150	4
4.	DO	mg/L	-	BQL	2	6.6	BQL	BQL	3.21	BQL	6.6	BQL	1	BQL	7.6	BQL	3.4	BQL	4.8
5.	COD	mg/L	-	255.06	117.41	275.3	76.92	307.5	202.2	200.8	60.24	135.46	277.09	388.65	67.73	156.63	96.39	333.33	68.27
6.	BOD	mg/L	**30**	65.77	25.1	56	18.45	80.78	27.89	40.16	11.12	32	52.4	76.1	13	36.45	22	71	15.1
7.	SAR	meq/L	-	11.36	12.58	2.71	2.89	12.65	14.98	2.67	2.85	9.69	12	3.63	3.31	12.81	16.02	3.48	3.22
8.	Total Coliforms	MPN/ 100ml	**<1000**	1600	1600	1600	BQL	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600

Table 34: Water Quality of inlet and outlet of STP for Vadinar

Sr No.	Parameter	Units	GPCB Norms (Vadinar)	Vadinar (April)				Vadinar (May)			
				Week 3		Week 4		Week 1		Week 2	
				STP-3 (Inlet)	STP-3 (Outlet)	STP-3 (Inlet)	STP-3 (Outlet)	STP-3 (Inlet)	STP-3 (Outlet)	STP-3 (Inlet)	STP-3 (Outlet)
1.	pH	-	**5.5-9**	7.1	7.08	7.32	7.38	7.1	7.18	7.15	7.42
2.	TDS	mg/L	-	496	468	515	446	538	458	536	450
3.	TSS	mg/L	**20**	64	36	61	21	40	10	26	12
4.	DO	mg/L	-	BQL	4.6	BQL	4.24	BQL	1.7	0.5	7.4
5.	COD	mg/L	**50**	197.58	52.42	184.54	54.5	149.19	40.32	165.99	48.58
6.	BOD	mg/L	**10**	45	11	36.24	10.88	31	8	37.1	10
7.	SAR	meq/L	-	2.96	3.06	3.44	3.20	3.13	3.03	3.3	2.98
8.	Total Coliforms	MPN/100ml	**100-230**	1600	1600	1600	1600	1600	1600	1600	1600

BQL: Below Quantification limit; Total Suspended Solids (QL=2), Dissolved Oxygen (QL=0.5)

9.4 Data Interpretation:

- **pH**: As per the norms, pH of the treated domestic effluent should conform to the standard of 6.5-8.5. the pH for the STP-1 and STP-2 of Kandla. Whereas for STP-3 at Vadinar falls within the 5.5-9 and hence conforms to the stipulated norms.
- **Total Suspended Solids**: The TSS for the STP-1 and STP-2 of Kandla and STP-3 of Vadinar falls within the stipulated norms of 100 mg/L and hence conforms to the norms specified.
- As per the norms, the **Chemical Oxygen Demand** (COD) for the outlet for Vadinar STP shall be 50 mg/L. COD exceeds slightly for month of April 2023 for Vadinar STP. Whereas, the COD was observed to comply with the stipulated norms for the month of May 2023.
- 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 was observed to have BOD values within the stipulated norms at STP-1, STP-2 and STP-3 for the sampling conducted during the month of April and May 2023. Exceeding value of BOD were observed at STP-1, during the sampling conducted in the first week of May 2023.
- The **Total Coliforms** were observed to exceed the norms at all the locations of the STP outlets of Kandla and Vadinar. This indicates that the method of disinfection applied is not adequate.

9.5 Conclusions:

During the monitoring period, only Total Coliforms and COD at STP Kandla, are found exceeding the limit while rest of the sewage parameters for STP outlet were within norms of CCA at both the monitoring sites. The treated sewage water of Kandla STP, Deendayal Port Colony (Gopalpuri) STP and Vadinar STP were in line with the standards set by the Central Pollution Control Board. Regular monitoring of the STP performance should be conducted on regular basis to ensure adequate treatment as per the norms.

9.6 Remedial Measures:

- The quantum of raw sewage (influent) entering the STP should be monitored flow meter. If the quantity of the sewage exceeds the treatment capacity of the treatment plant, then provision of additional capacity of collection sump should be provided.
- The adequacy and efficacy of the stages of Sewage treatment units shall be conducted.
- The treatment parameters such as retention time, Mixed Liquor Suspended Solids (MLSS), Mixed liquor volatile suspended solids (MLVSS), Recirculation rate, sludge generation, etc should be monitored timely.
- During the treatment, the required retention time and rate of aeration should be maintained, so that the efficiency of the treatment plant is maintained.
- The dosage of chemicals administered during the treatment should be reviewed and alterations in the dosage should be done.
- The results show the presence of total coliforms; hence the method of disinfection (Chlorination) sodium or calcium Hypochlorite can be used.
- Effectiveness of any technology depends on factors such as the specific pollutants in the wastewater, plant size, local regulations, and available resources. There are several processes that may be implemented such as - Advanced oxidation process involve using strong oxidants to break down complex organic compounds. Methods like Fenton's reagent (hydrogen peroxide and iron catalyst) and UV/H2O2 treatment can help in reducing COD through oxidation.
- Electrochemical processes like Electrocoagulation (EC) and Electrooxidation (EO) that involve the application of an electric current to facilitate the removal of pollutants through coagulation, flocculation, and oxidation. These methods can be useful for treating sewage containing various pollutants.
- Enhanced biological treatment processes, such as Moving Bed Biofilm Reactors (MBBR), Integrated Fixed-film Activated Sludge (IFAS) systems, and Membrane Bio-Reactors (MBRs) are utilised to improve the efficiency of organic matter and nutrient removal from wastewater.

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CHAPTER 10: MARINE WATER QUALITY MONITORING

10.1 Marine Water:

Deendayal Port is one of the largest ports of the country and thus, is engaged in wide variety of activities such as movement of large vessels, oil tankers and its allied small and medium vessels and handling of dry cargo several such activities whose waste if spills in water, can cause harmful effects to marine water quality.

Major water quality concerns at ports include wastewater and leakage of toxic substances from ships, stormwater runoff, etc. This discharge of wastewater, combined with other ship wastes which includes sewage and wastewater from other on-board uses, is a serious threat to the water quality as well as to the marine life. As defined in the scope by Deendayal Port Authority (DPA), the Marine Water sampling and analysis has to be carried out at a total of eight locations, six at Kandla and two at Vadinar. The marine water sampling was be carried out with the help of Niskin Sampler with a capacity of 5L. The Niskin Sampler is a device used to take water samples at a desired depth without the danger of mixing with water from other depths. The details of the locations to be monitored is as mentioned in **Table 35:**

Table 35: Details of the sampling locations for Marine water

Sr. No.	Location Code		Location Name	Latitude Longitude
1.	Kandla	MW-1	Near Passenger Jetty One	23.017729N 70.224306E
2.		MW-2	Kandla Creek (nr KPT Colony)	23.001313N 70.226263E
3.		MW-3	Near Coal Berth	22.987752N70.227923E
4.		MW-4	Khori Creek	22.977544N 70.207831E
5.		MW-5	Nakti Creek (nr Tuna Port)	22.962588N 70.116863E
6.		MW-6	Nakti Creek (nr NH-8A)	23.033113N 70.158528E
7.	Vadinar	MW-7	Near SPM	22.500391N 69.688089E
8.		MW-8	Near Vadinar Jetty	22.440538N 69.667941E

The map depicting the locations of Marine Water to be sampled and analysed in Kandla and Vadinar have been mentioned in **Map 19 and 20** as follows:

Figure 19: Location Map for Marine Water Monitoring at Kandla

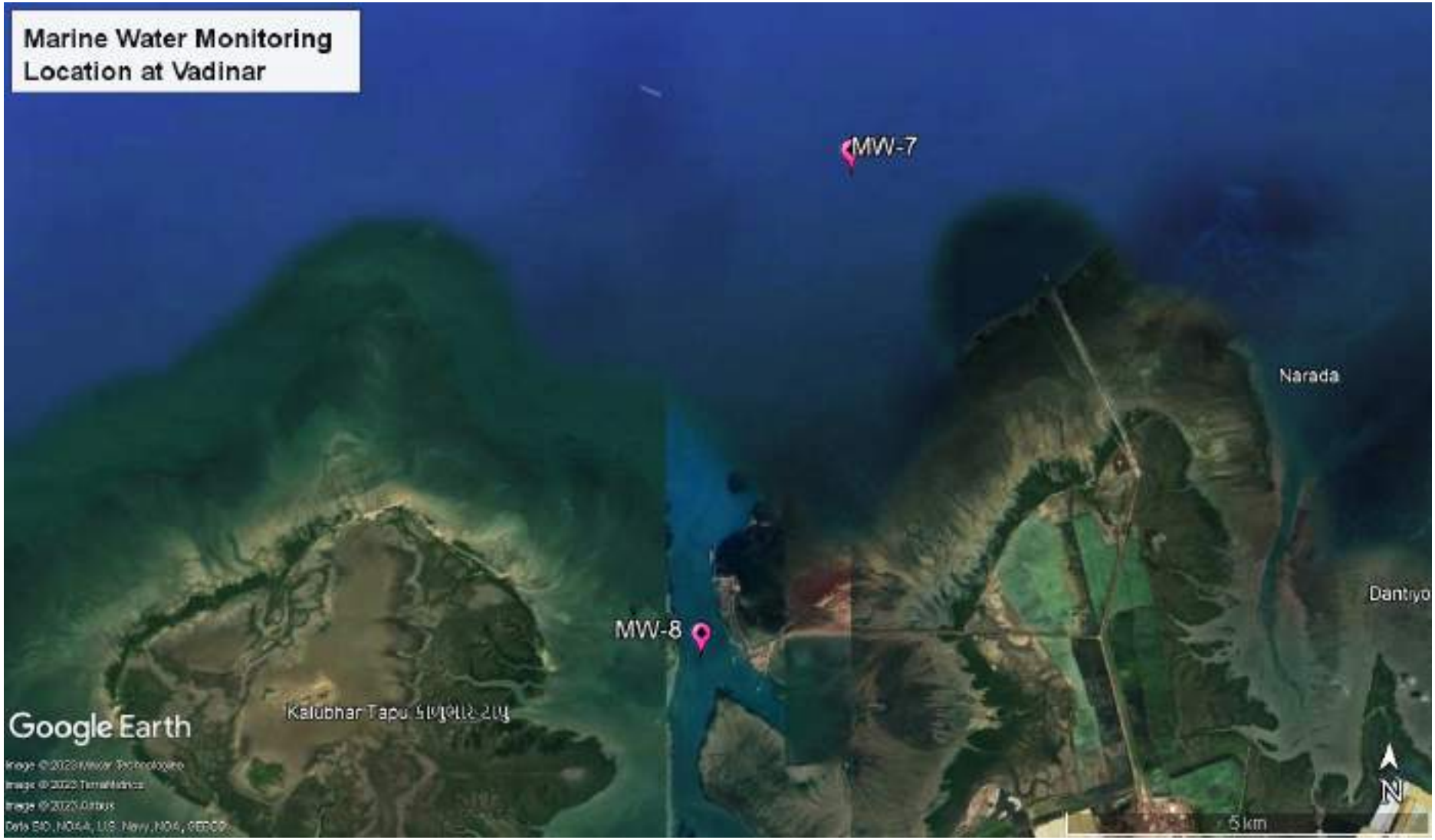


Figure 20: Location Map for Marine Water Monitoring at Vadinar

Frequency

As defined in the scope by Deendayal Port Authority (DPA), the sampling and analysis of Marine Water has to be carried out once a month at the eight locations (i.e., six at Kandla and two at Vadinar).

10.2 Methodology

Similar to the methodology adopted for the sampling and monitoring of Drinking water under the study, the sampling of Marine Water was carried out as per the '**Sampling Protocol for Water & Wastewater'** developed by GEMI as well as the CPCB guidelines. The water samples collected through the Niskin Sampler are collected in a clean bucket to reduce the heterogeneity. From the collected water sample 1 liter of water sample is separated in an opaque plastic bottle for the estimation of chlorophyll. The list of parameters to be monitored under the project for the Marine Water quality have been mentioned in **Table 36** along with the analysis method and instrument.

Table 36: List of parameters monitored for Marine Water

Sr. No	Parameters	Units	Reference method	Instrument
1.	Electrical Conductivity	µS/cm	APHA, 23rd Edition (Section-2510 B):2017	Conductivity Meter
2.	Dissolved Oxygen (DO)	mg/L	APHA, 23rd Edition, 4500 O C, 2017	Titration Apparatus
3.	pH		APHA, 23rd Edition (Section-4500-H^+B):2017	pH meter
4.	Color	Hazen	APHA, 23rd Edition, 2120 B: 2017	Color comparator
5.	Odour		IS 3025 Part 5: 2018	Heating mantle & odour bottle
6.	Turbidity	NTU	IS 3025 Part 10: 1984	Nephlo Turbidity Meter
7.	Total Dissolved Solids (TDS)	mg/L	APHA, 23rd Edition (Section-2540 C):2017	Vaccum Pump with Filtration Assembly and Oven
8.	Total Suspended Solids (TSS)	mg/L	APHA, 23rd Edition, 2540 D: 2017	
9.	Particulate Organic Carbon	mg/L	APHA, 23rd Edition, 2540 D and E	TOC analyser
10.	Chemical Oxygen Demand (COD)	mg/L	IS-3025, Part- 58: 2006	Titration Apparatus plus Digester
11.	Biochemical Oxygen Demand (BOD)	mg/L	IS-3025, Part 44,1993,	BOD Incubator plus Titration apparatus
12.	Silica	mg/L	APHA, 23rd Edition, 4500 C, 2017	UV- Visible Spectrophotometer
13.	Phosphate	mg/L	APHA,23rd Edition, 4500 P-D: 2017	

Sr. No	Parameters	Units	Reference method	Instrument
14.	Sulphate	mg/L	APHA, 23rd Edition, 4500 SO4-2 E: 2017	
15.	Nitrate	mg/L	APHA, 23rd Edition, 4500 NO3-B: 2017	
16.	Nitrite	mg/L	APHA, 23rd Edition, 4500 NO2- B: 2017	
17.	Sodium	mg/L	APHA,23rd Edition, 3500 Na-B: 2017	Flame photometer
18.	Potassium	mg/L	APHA,23rd Edition, 3500 K-B: 2017	
19.	Manganese	mg/L	APHA,23rd Edition, ICP Method 3120 B: 2017	ICP-OES
20.	Iron	mg/L	APHA,23rd Edition, ICP Method 3120 B: 2017	
21.	Total Chromium	mg/L	APHA, 23rd Edition, 3500 Cr B: 2017	
22.	Hexavalent Chromium	mg/L		UV- Visible Spectrophotometer
23.	Copper	mg/L	APHA, 23rd Edition, ICP Method 3120 B: 2017	ICP-OES
24.	Cadmium	mg/L		
25.	Arsenic	mg/L		
26.	Lead	mg/L		
27.	Zinc	mg/L		
28.	Mercury	mg/L	EPA 200.7	
29.	Floating Material (Oil grease scum, petroleum products)	mg/L	APHA, 23rd Edition, 5520 C: 2017	Soxhlet Assembly
30.	Total Coliforms (MPN)	MPN/ 100ml	IS 1622: 2019	LAF/ Incubator

10.3 Result and Discussion

The quality of the Marine water samples collected from the locations of Kandla and Vadinar during the monitoring period has been summarized in the **Table 37**. The said water quality has been represented in comparison with the standard values as stipulated by CPCB.

Table 37: Results of Analysis of Marine Water Sample

Sr. No.	Parameters	Unit	Primary Water Quality Criteria for Class SW-IV Waters	Kandla						Vadinar	
				MW-1	MW-2	MW-3	MW-4	MW-5	MW-6	MW-7	MW-8
1.	Density	kg/m³	-	1.021	1.021	1.022	1.021	1.022	1.022	1.022	1.022
2.	pH	-	6.5-9.0	7.76	7.74	7.83	7.81	7.84	8.04	8.07	8.11
3.	Color	Hazen	No Noticeable	9	12	15	10	9	11.6	4	5
4.	EC	µS/cm	-	60,391	58,491	57,913	54,179	55,587	61,528	55,871	52.119
5.	Turbidity	NTU	-	>50	>50	>50	>50	>50	>50	3.2	4.5
6.	TDS	mg/L	-	41,930	39,386	38,688	38,072	39,434	38,587	34,950	34,892
7.	TSS	mg/L	-	184	334	124	740	642	852	220	151
8.	COD	mg/L	-	72	76	81	81	71	78	75	75
9.	DO	mg/L	3.0 mg/L	5.6	5.5	5.4	5.6	5.7	5.7	7.3	7.4
10.	BOD	mg/L	5.0 mg/L	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
11.	Oil & Grease	mg/L	-	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
12.	Sulphate	mg/L	-	2747.55	2665.78	2433.35	2684.05	2771.15	3156.54	2212.35	2441.56
13.	Nitrate	mg/L	-	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
14.	Nitrite	mg/L	-	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
15.	Phosphate	mg/L		0.46	0.09	1.46	0.75	0.57	0.54	0.64	1.43
16.	Silica	mg/L	-	0.32	1.51	0.65	2.79	1.74	0.33	BQL	BQL
17.	Sodium	mg/L	-	>10,000	>10,000	>10,000	>10,000	>10,000	>10,000	>10,000	>10,000
18.	Potassium	mg/L	-	385.03	397.63	347.34	424.53	423.34	442.63	321.10	351.13
19.	Hexavalent Chromium	mg/L	-	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
20.	Odour	-	-	1	1	1	1	1	1	1	1
21.	Arsenic	mg/L	-	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
22.	Cadmium	mg/L	-	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
23.	Copper	mg/L	-	5.10	6.07	BQL	12.01	7.60	10.2	BQL	BQL
24.	Iron	mg/L	-	1.03	1.05	2.2	5.4	3.9	5.3	BQL	BQL
25.	Lead	mg/L	-	BQL	1.7	1.32	6.2	2.21	3.41	BQL	BQL
26.	Manganese	mg/L	-	73.11	75.21	85.71	121.79	86.75	86.24	BQL	BQL
27.	Total Chromium	mg/L	-	BQL	5.62	BQL	15.71	8.25	BQL	BQL	BQL
28.	Zinc	mg/L	-	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
29.	Mercury	mg/L	-	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
30.	Total Coliform	MPN /100 ml	500/100 ml	900	35	10	55	30	44	BQL	BQL
31.	Particulate Organic Carbon	mg/L	-	0.32	0.16	0.56	0.25	0.35	0.29	0.36	0.39

Sr. No.	Parameters	Unit	Primary Water Quality Criteria for Class SW-IV Waters	Kandla						Vadinar	
				MW-1	MW-2	MW-3	MW-4	MW-5	MW-6	MW-7	MW-8
32.	Floating Material (Oil grease scum, petroleum products)	mg/L	10 mg/L	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL

BQL- Below Quantification Limit; Turbidity (DL=50), Biochemical Oxygen Demand (QL=3), Oil & Grease (QL=1), Nitrate as NO3 (QL=1), Nitrite as No2 (QL=0.1), Phosphorous (QL=0.5), Silica (QL=0.05), Sodium as Na (QL=10,000), Hexavalent Chromium (QL=0.01), Arsenic (QL=5), Cadmium (QL=2), Copper (QL=5), Iron (QL=0.1), Lead (QL=2), Manganese (QL=40), Total Chromium (QL=5), Zinc (QL=0.5), Mercury (QL=0.5)

10.4 Data Interpretation:

The Marine water quality of Deendayal Port Harbor waters at Kandla and Vadinar has been monitored for various physico-chemical and biological parameters during the high tide at sampling time.

- The parameter **pH** was observed in the range of 7.74-8.04, with the average pH as 7.83 for the locations of Kandla, whereas for the locations of Vadinar, pH was observed in the range of 8.07-8.11, with the average pH as 8.09.
- The **Color** was observed in the range of 9-15 Hazen, with the average color as 11.1 Hazen for the locations of Kandla, whereas for the locations of Vadinar, color was observed in the range of 4-5 Hazen, with the average color as 4.5 Hazen.
- The **Density** of marine water for the locations of Kandla and Vadinar was observed to vary from 1.021-1.022 Kg/m^3.
- **Turbidity** for all locations of Kandla was observed >50 NTU for all the locations. Whereas for the locations of Vadinar, lower values of turbidity were observed. 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. Materials that cause water to be turbid include clay, silt, finely divided organic and inorganic matter, soluble color organic compounds, plankton and microscopic organisms. Turbidity affects the amount of light penetrating to the plants for photosynthesis.
- The parameter **Electrical conductivity (EC)** was observed in the range of 54179-61528 µS/cm, with the average EC as 58014.83 µS/cm for the locations of Kandla, whereas for the locations of Vadinar, EC was observed in the range of 52119-55871 µS/cm, with the average EC as 53995 µS/cm.

- **Total Dissolved Solids (TDS**) values in the studied area during high Tide varied between 38072-41930 mg/L at DPA Kandla and 34892-34950 mg/L at Vadinar with the average value as 39349.5 mg/L and 34921 mg/L respectively for Kandla and Vadinar.
- **Total Suspended Solids (TSS**) values in the studied area during high Tide varied between 124-852 mg/L at DPA Kandla and 151-220 mg/L at Vadinar, with the average value as 479.33 mg/L and 185.5 mg/L respectively for Kandla and Vadinar.
- **Chemical Oxygen Demand (COD)** values in the studied area varied between 71-81 mg/L at DPA Kandla and 74-75 mg/L at Vadinar, with the average value as 76.5 mg/L and 74.5 mg/L respectively for Kandla and Vadinar.
- **Dissolved Oxygen (DO)** level in the studied area during high Tide varied between 5.4-5.7 mg/L at DPA Kandla and 7.3-7.4 mg/L at Vadinar. The value of DO was found to exceed the minimum concentration of 3.0 mg/L for majority of the locations, which represents that the marine water quality is good and hence suitable for the aquatic species.
- The parameters BOD, Oil & Grease, Nitrate, Nitrite, Hexavalent Chromium, Arsenic, Cadmium, Zinc and Mercury were observed to have concentrations "Below the Quantification Limits (BQL)" for all the locations of Kandla and Vadinar.
- **Sulphate** concentration in the studied area during high Tide varied between 2433.35-3415.54 mg/L at DPA Kandla and 2212.35-2441.56 mg/L at Vadinar.
- The concentration of **Phosphate** in the studied area during high Tide varied between 0.09-1.46 mg/L at DPA Kandla, while at Vadinar, the concentration of Phosphate was observed to range from 0.64-1.43 mg/L at Vadinar.
- The concentration of **Potassium** in the studied area during high Tide varied between 347.34-442.63 mg/L at DPA Kandla and 321.10-351.13 mg/L at Vadinar, with the average value as 403.41 mg/L and 336.11 mg/L respectively for Kandla and Vadinar.
- The concentration of **Sodium** was detected to be >10,000 mg/L for the locations of Kandla and Vadinar.
- Under the study, the parameters BOD, Oil and Grease, Hexavalent and Total Chromium, Nitrate, Nitrite, Arsenic, Lead, Manganese, Cadmium, Zinc and Mercury were found to have concentrations "Below the detection limit" for both the locations of Kandla and Vadinar.
- **Total Coliforms (TC)** at Kandla were observed to be within the range of 10-900 MPN/100 ml. On the contrary, the TC were observed "Below the detection limit" for the months at Vadinar.
- **Floating Material (Oil grease scum, petroleum products)** was observed to be "Below the quantification limit" all the locations of Kandla and Vadinar.

10.5 Conclusion

During the Monitoring period, marine water samples were analysed and found in line with Primary Water Quality criteria for class-IV Waters (For Harbour Waters).

10.6 Measures against adverse effects

Appropriate regulations on ship discharges and provision of reception facilities are indispensable for proper control of emissions and effluent from ships. Detection of spills is also important for regulating ship discharges. Since accidental spills are unavoidable, recovery vessels, oil fences, and treatment chemicals should be prepared with a view to minimizing dispersal. Proper contingency plans and a prompt reporting system are keys to prevention of oil dispersal. Periodical clean-up of floating wastes is also necessary for preservation of port water quality.

CHAPTER 11: MARINE SEDIMENT QUALITY MONITORING

11.1 Marine Sediment Monitoring:

Marine sediment, or ocean sediment, or seafloor sediment, are deposits of insoluble particles that have accumulated on the seafloor. These particles have their origins in soil and rocks and have been transported from the land to the sea, mainly by rivers but also by dust carried by wind. The unconsolidated materials derived from pre-existing rocks or similar other sources by the process of denudation are deposited in water medium is known as sediment. For a system, like a port, where large varieties of raw materials and finished products are handled, expected sediment contamination is obvious.

The materials or part of materials spilled over the water during loading and unloading operations lead to the deposition in the harbour water along with sediment and thus collected as harbour sediment sample. These materials, serve as receptor of many trace elements, which are prone to environment impact. In this connection it is pertinent to study the concentration and distribution of environmentally sensitive elements in the harbour sediment. 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.

As defined in the scope by Deendayal Port Authority (DPA), the Marine Sediment sampling is required to be carried out once in a month at total eight locations, i.e., six at Kandla and two at Vadinar. The sampling of the Marine Sediment is carried out using the Van Veen Grab Sampler of the make Holy Scientific Instruments Pvt. Ltd. The Van Veen Grab sampler is an instrument to sample (disturbed) sediment up to a depth of 20-30 cm into the sea bed. While letting the instrument down on the seafloor, sediment can be extracted. The details of the locations of Marine Sediment to be monitored under the study are mentioned in **Table 38** as follows:

Table 38: Details of the sampling locations for Marine water

Sr. No	Location Code		Location Name	Latitude Longitude
1.	Kandla	MS-1	Near Passenger Jetty One	23.017729N 70.224306E
2.		MS-2	Kandla Creek	23.001313N 70.226263E
3.		MS-3	Near Coal Berth	22.987752N 70.227923E
4.		MS-4	Khori Creek	22.977544N 70.207831E
5.		MS-5	Nakti Creek (near Tuna Port)	22.962588N 70.116863E
6.		MS-6	Nakti Creek (near NH-8A)	23.033113N 70.158528E
7.	Vadinar	MS-7	Near SPM	22.500391N 69.688089E
8.		MS-8	Near Vadinar Jetty	22.440538N 69.667941E

The map depicting the locations of Marine Sediment sampling in Kandla and Vadinar have been mentioned in **Map 21 and 22** as follows:

Figure 21: Location Map of Marine Sediment Monitoring at Kandla

Figure 22: Locations Map of Marine Sediment Monitoring at Vadinar

The list of parameters to be monitored under the projects for the Marine Sediment sampling been mentioned in **Table 39** as follows:

Table 39: List of parameters to be monitored for Sediments at Kandla and Vadinar

Sr. No.	Parameters	Units	Reference method	Instruments
1.	Texture		Methods Manual Soil Testing in India January 2011,01	Hydrometer
2.	Organic Matter	%	Methods Manual Soil Testing in India January, 2011, 09. Volumetric method (Walkley and Black, 1934)	Titration apparatus
3.	Inorganic Phosphates	mg/Kg	Practical Manual Chemical Analysis of Soil and Plant Samples, ICAR-Indian Institute of Pulses Research 2017	UV- Visible Spectrophotometer
4.	Silica	mg/Kg	EPA METHOD 6010 C & IS: 3025 (Part 35) – 1888, part B	
5.	Phosphate	mg/Kg	EPA Method 365.1	
6.	Sulphate as SO4- (Available)	mg/Kg	IS: 2720 (Part 27) - 1977	
7.	Nitrite	mg/Kg	ISO 14256:2005	
8.	Nitrate	mg/Kg	Methods Manual Soil Testing in India January, 2011, 12	
9.	Calcium as Ca	mg/Kg	Methods Manual Soil Testing in India January 2011, 16.	Titration Apparatus
10.	Magnesium as Mg	mg/Kg	Method Manual Soil Testing in India January 2011	
11.	Sodium	mg/Kg	EPA Method 3051A	Flame Photometer
12.	Potassium	mg/Kg	Methods Manual Soil Testing in India January, 2011	
13.	Aluminium	mg/Kg	EPA Method 3051A	ICP-OES
14.	Chromium	mg/Kg		
15.	Nickel	mg/Kg		
16.	Zinc	mg/Kg		
17.	Cadmium	mg/Kg		
18.	Lead	mg/Kg		
19.	Arsenic	mg/Kg		
20.	Mercury	mg/Kg		

11.2 Result and Discussion

The quality of Marine Sediment samples collected from the locations of Kandla and Vadinar has been summarized in the **Table 40.**

Table 40: Summarized Results of Marine Sediment Quality

Sr. No.	Parameters	Unit	Kandla						Vadinar	
			MS-1	MS-2	MS-3	MS-4	MS-5	MS-6	MS-7	MS-8
1.	Inorganic Phosphate	kg/ Hectare	16.85	14.37	11.55	18.94	14.25	17.34	14.55	18.51
2.	Phosphate	mg/Kg	3247.85	1497.25	2571.43	2671.98	3741.91	3541.28	2357.68	3217.54
3.	Organic Matter	mg/Kg	0.32	1.60	0.50	1.21	0.94	1.14	0.26	0.38
4.	Sulphate as SO^{4-}	mg/Kg	759	849	555	496	768	732	296	179.43
5.	Calcium as Ca	mg/Kg	2657	1259	962	1102	1089	1162	2585	2463
6.	Magnesium as Mg	mg/Kg	1259	924	764	987	1032	953	1348	1167
7.	Silica	g/Kg	498.5	465.12	571.51	549.6	531.88	487.2	379.45	492.5
8.	Nitrite	mg/Kg	0.75	0.18	0.15	0.19	0.16	0.13	0.11	0.12
9.	Nitrate	mg/Kg	19.75	20.98	10.22	21.64	9.67	15.34	25.33	24.82
10.	Sodium	mg/Kg	3410	3670	4432	3940	3725	2394	9082	8854
11.	Potassium	mg/Kg	241	276	264	294	322	394	1082	1028
12.	Aluminium	mg/Kg	3517.25	4834.50	4317.46	4552.39	3751.85	4579.21	4138.27	4528.35
13.	Chromium	mg/Kg	56.17	32.74	42.38	53.30	51.33	36.71	45.20	41.85
14.	Nickel	mg/Kg	16.80	11.54	18.94	25.60	24.00	12.80	14.70	20.50
15.	Zinc	mg/Kg	38.22	32.11	48.20	34.98	19.54	32.00	42.80	40.30
16.	Cadmium	mg/Kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
17.	Lead	mg/Kg	6.1	5.84	4.25	5.85	5.71	4.24	6.88	7.41
18.	Arsenic	mg/Kg	BQL	BQL	BQL	BQL	BQL	BQL	2.74	5.17
19.	Mercury	mg/Kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
20.	Texture		Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam

11.3 Data Interpretation

- **Inorganic Phosphate** was observed in the range of 11.55 to 18.94 Kg/Ha for Kandla and 11.85 to 15.84 Kg/Ha for Vadinar.
- **Phosphate** was observed in the range of 1497.25 to 3741.91 mg/Kg for Kandla and 2357.68 to 3217.54 mg/Kg for Vadinar.
- **Organic Matter** was observed in the range of 0.32 to 1.6 % for Kandla and 0.26 to 0.38 % for Vadinar.
- **Sulphate** was observed in the range of 496 to 849 mg/Kg for Kandla and 179.43 to 296 mg/Kg for Vadinar.
- **Calcium** was observed in the range of 962 to 2657 mg/Kg for Kandla and 2463 to 2585 mg/Kg for Vadinar.
- **Magnesium** was observed in the range of 764 to 1259 mg/Kg for Kandla and 1167 to 1348 mg/Kg for Vadinar.
- **Nitrate** was observed in the range of 9.67 to 21.64 mg/Kg for Kandla and 24.82 to 25.33 mg/Kg for Vadinar.
- **Nitrite** was observed in the range of 0.13 to 0.75 mg/Kg for Kandla and 0.11 to 0.12 for Vadinar.

- **Sodium** was observed in the range of 2394 to 4432 for Kandla and 8854 to 9082 mg/Kg for Vadinar.
- **Silica** was observed in the range of 465.12 to 571.51 mg/Kg for Kandla and 379.45 to 492.5 mg/Kg.
- **Potassium** was observed in the range of 241 to 394 mg/Kg for Kandla and 1028 to 1082 mg/Kg for Vadinar.
- **Aluminium** was observed in the range of 3517.25 to 4834.5 mg/Kg for Kandla and 4138.27 to 4528.35 mg/Kg for Vadinar.
- **Mercury** was observed below the detection limit was limit for Kandla and Vadinar.
- Texture was observed to be "**Sandy Loamy**" in both Kandla and Vadinar.

Heavy Metals

The sediment quality of Kandla and Vadinar has been compared with respect to the Average Standard guideline applicable for heavy metals in marine sediment specified by EPA have been mentioned in **Table 41**.

Table 41: Standard Guidelines applicable for heavy metals in sediments

Sr. No.	Metals	Sediment quality (mg/kg)			Source
		Not polluted	**Moderately polluted**	**Heavily polluted**	
1.	As	<3	3-8	>8	EPA
2.	Cu	<25	25-50	>50	
3.	Cr	<25	25-75	>75	
4.	Ni	<20	20-50	>50	
5.	Pb	<40	40-60	>60	
6.	Zn	<90	90-200	>200	
7.	Cd	-	<6	>6	
ND = Not Detected					

(Source: G Perin et al. 1997)

The details of the said comparison have been mentioned in the **Table 42** as follows:

Table 42: Comparison of Heavy metals with Standard value in marine sediment

Sr. No.	Parameters	Kandla						Vadinar	
		MS-1	**MS-2**	**MS-3**	**MS-4**	**MS-5**	**MS-6**	**MS-7**	**MS-8**
1.	Arsenic	BQL	BQL	BQL	BQL	BQL	BQL	2.74	5.17
2.	Copper	5.6	11.4	4.2	6.8	12	8.9	5.5	8.2
3.	Chromium	56.17	32.74	42.38	53.30	51.33	36.71	45.20	41.85
4.	Nickel	16.80	11.54	18.94	25.60	24.00	12.80	14.70	20.50
5.	Lead	6.1	5.84	4.25	5.85	5.71	4.24	6.88	7.41
6.	Zinc	38.22	32.11	48.20	34.98	19.54	32.00	42.80	40.30
7.	Cadmium	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL

- **Arsenic** was observed below the detection limit for Kandla in both the monitoring period of April and May. While for Vadinar 2.74 to 5.17 mg/Kg range in the month of

April. The Sediment quality in both the monitoring period at Kandla and Vadinar show the concentration of Arsenic in range of 3-8 mg/Kg which indicate the moderately polluted status of Sediment for both the April and May, 2023.

- **Copper** was observed in the range of 4.2 to 12 mg/Kg for Kandla and 5.5 to 8.2 mg/Kg for Vadinar for the month of April. The Sediment quality in both the monitoring period at Kandla and Vadinar show the concentration of Copper <25 mg/Kg which indicate the non-polluted status of Sediment for both the April and May, 2023.
- **Chromium** was observed in range of 32.74 to 56.17 mg/Kg for Kandla and 41.85 to 45.2 mg/Kg for Vadinar for the month of April. The Sediment quality in both the monitoring period at Kandla and Vadinar show the concentration of Chromium in range of 25-75 mg/Kg which indicates that the sediment is moderately polluted for both April and May, 2023.
- **Nickel** was observed in the range of 11.54 to 25.60 mg/Kg for Kandla and 14.17-20.50 mg/Kg for Vadinar for the month of April. The Sediment quality in both the monitoring period at Kandla and Vadinar show the concentration of Nickel in range of 20-50 mg/Kg which indicate the moderately polluted Sediment for both the April and May, 2023.
- **Lead** was observed in the range of 4.24 to 6.10 mg/Kg for Kandla and 6.88 to 7.41 mg/Kg for Vadinar for the month of April. The Sediment quality in both the monitoring period at Kandla and Vadinar show the concentration of Lead <40 mg/Kg which indicate the non-polluted status of Sediment for both the April and May, 2023.
- **Zinc** was observed in the range of 19.54 to 48.20 mg/Kg for Kandla and 40.30 to 42.8 mg/Kg for Vadinar for the month of April. The Sediment quality in both the monitoring period at Kandla and Vadinar show the concentration of Zinc <90 mg/Kg which indicate the non-polluted status of Sediment for both the April and May, 2023.
- **Cadmium** was observed below the detection limit was limit for Kandla and Vadinar in both April and May month, which indicates that the sediment is non polluted.

11.4 Conclusion:

Analysis of the sediments does not indicate any pollution. However, it may be noted that, the sediments are highly dynamic being constantly deposited and carried away by water currents. Hence maintaining the quality of sediments is necessary as it plays a significant role in regulating the quality of the marine water and the marine ecology.

CHAPTER 12: MARINE ECOLOGY MONITORING

2.4 Marine Ecological Monitoring

The monitoring of the biological and ecological parameters is important in order to assess the marine environment. 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. Deendayal Port and its surroundings have mangroves, mudflats and creek systems as major ecological entities.

As defined in the scope by Deendayal Port Authority (DPA), the Marine Ecological Monitoring is required to be carried out once a month specifically at eight locations, six at Kandla and two at Vadinar. The sampling of the Benthic Invertebrates has been carried out with the help of D-frame nets, whereas the sampling of zooplankton and phytoplankton has been carried out with the help of Plankton Nets (60 micron and 20 micron). The details of the locations of Marine Ecological Monitoring have been mentioned in **Table 43** as follows:

Table 43: Details of the sampling locations for Marine Ecological

Sr. No.	Location Code		Location Name	Latitude Longitude
1.	Kandla	ME-1	Near Passenger Jetty One	23.017729N 70.224306E
2.		ME-2	Kandla Creek (near KPT Colony)	23.001313N 70.226263E
3.		ME-3	Near Coal Berth	22.987752N 70.227923E
4.		ME-4	Khori Creek	22.977544N 70.207831E
5.		ME-5	Nakti Creek (near Tuna Port)	22.962588N 70.116863E
6.		ME-6	Nakti Creek (near NH - 8A)	23.033113N 70.158528E
7.	Vadinar	ME-7	Near SPM	22.500391N 69.688089E
8.		ME-8	Near Vadinar Jetty	22.440538N 69.667941E

The map depicting the locations of Marine Ecological monitoring in Kandla and Vadinar have been mentioned in **Map 23 and 24** as follows:

Figure 23: Locations Map of Marine Ecological Monitoring at Kandla

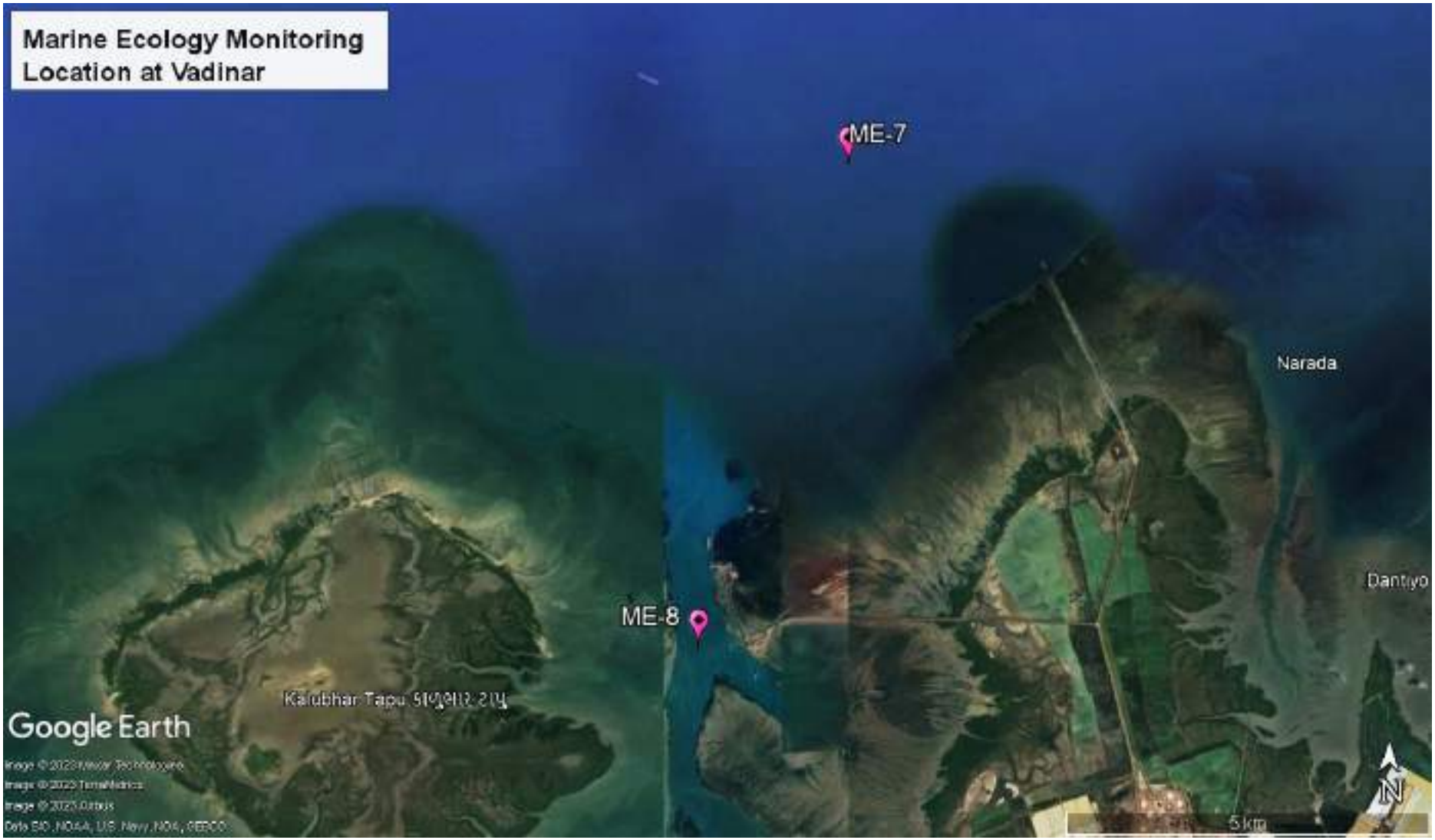


Figure 24: Locations Map of Marine Ecological Monitoring at Vadinar

The various parameters to be monitored under the study for Marine Ecological Monitoring are mentioned in **Table 44** as follows:

Table 44: List of parameters to be monitored for Marine Ecological Monitoring

Sr. No.	Parameters
1.	Productivity (Net and Gross)
2.	Chlorophyll-a
3.	Pheophytin
4.	Biomass
5.	Relative Abundance, species composition and diversity of phytoplankton
6.	Relative Abundance, species composition and diversity of zooplankton
7.	Relative Abundance, species composition and diversity of benthic invertebrates (Meio, Micro and macro benthos)
8.	Particulate Oxidisable Organic Carbon
9.	Secchi Depth

2.5 Sampling Methodology

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.

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*). Phytoplankton also include numerous and diverse collection of extremely small, motile algae which are termed micro flagellates (naked flagellates) as well as Cyanophytes (Bluegreen 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 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. 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.

Diversity Index

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

- The basic idea of diversity index is to obtain a quantitative estimate of biological variability that can be used to compare biological entities composed of discrete components in space and time. Biodiversity is commonly expressed through indices based on species richness and species abundances. 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.

1. **Simpson's index:**

A reasonably high level of dominance by one or a small number of species is indicated by the range of **0.89 to 0.91**. The general health and stability of the ecosystem may be impacted by this dominance. Community disturbances or modifications that affect the dominant species may be more likely to have an impact. The dominating species determined by the Simpson's index can have big consequences on how the community is organised and how ecological interactions take place.

The formula for calculating D is presented as:

$$D = 1 - \sum (p_i \hat{} 2)$$

Where, ∑ = Summation symbol, pi = Relative abundance of the species

2. **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. Shannon-Wiener's index (H) reproduces community parameters to a single number by using an equation are as follow:

$$H' = \sum p_i * \ln (p_i)$$

Where, ∑ = Summation symbol,
pi = Relative abundance of the species,
ln = Natural logarithm

More diverse ecosystems are considered healthier and more resilient. Higher diversity ecosystems typically exhibit better stability and greater tolerance to fluctuations. e.g., The Shannon diversity index values between 2.19 and 2.56 indicate relatively high diversity within the community compared to communities with lower values. It suggests that the community likely consists of a variety of species, and the species are distributed somewhat evenly in terms of their abundance.

3. **Margalef's diversity index:**

The number of species is significantly related to the port's vegetation cover surface, depth, and photosynthetic zone. The habitat heterogeneity is a result of these three elements. Species richness is related to the number of distinct species present in the analysed area. Margalef's index has a lower correlation with sample size. Small species losses in the community over time are likely to result in inconsistent changes.

Margalef's index D_{Mg}, which is also a measure of species richness and is based on the presumed linear relation between the number of species and the logarithm of the number of individuals. It is given by the formula:

$$D_{Mg}=\frac{S-1}{lnN}$$

Where N = total number of individuals collected
S = No. of taxa or species or genera

4. **Berger-Parker index:**

This is a useful tool for tracking the biodiversity of deteriorated ecosystems. Environmental factors have a considerable impact on this index, which accounts for the dominance of the most abundant species over the total abundance of all species in the assemblage. The preservation of their biodiversity and the identification of the fundamental elements influencing community patterns are thus critical for management and conservation. Successful colonising species will dominate the assemblage, causing the Berger-Parker index to rise, corresponding to well-documented successional processes. The environmental and ecological features of the system after disturbance may therefore simply but significantly determine the identity of the opportunistic and colonising species through niche selection processes.

The Berger-Parker index is a biodiversity metric that focuses on the dominance or relative abundance of a single species within a community. It provides a measure of the most abundant species compared to the total abundance of all species present in the community. Mathematically, it can be represented as follows:

$$d = \frac{N_{max}}{\mathrm{N}_i}$$

Where,

N_{max} = Max no of individuals of particular genera or species

$\sum N_i$ = Total no of individuals obtained.

The resulting value of the Berger-Parker index ranges between 0 and 1. A higher index value indicates a greater dominance of a single species within the community. Conversely, a lower index value suggests a more even distribution of abundance among different species, indicating higher species diversity. The range of the Berger-Parker index can be interpreted as when the index value is close to 0, it signifies a high diversity with a more even distribution of abundances among different species. In such cases, no single species dominates the community, and there is a balanced representation of various species.

5. **Relative Abundance:** The species abundance distribution (SAD) from disturbed ecosystems follows even/ uneven pattern. E.g., If relative abundance is 0.15, then the found species are neither highly dominant nor rare.

$$RA = \frac{No.of\ Individuals\ of\ Sp.}{Total\ no.of\ Individual} * 100\%$$

6. **Evenness index–**

Evenness index determines the homogeneity (and heterogeneity) of the species' abundance. Intermediate values between 0 and 1 represent varying degrees of evenness or unevenness in the distribution of individuals among species. Value of species evenness represents the degree of redundancy and resilience in an ecosystem. High species evenness = All species of a community can perform similar ecological activities or functions= even utilization of available ecological niches = food web more stable = ecosystem is robust (resistant to disturbances or environmental changes). Intermediate values between 0 and 1 represent variable degrees of evenness or unevenness.

$$EI = \frac{H}{\ln(S)}$$

Where,

H= Shannon value

ln(S) = the natural logarithm of the number of different species in the community

2.6 Result and Discussion and Conclusion

The details of Marine Ecological Monitoring conducted for the locations of Kandla and Vadinar during the monitoring period has been summarized in the **Table 45.**

Table 45: Summarized Results of Biomass, Net Primary Productivity (NPP), Gross Primary Productivity (GPP), Pheophytin and Chlorophyll

Sr. No.	Parameters	Units	Kandla						Vadinar	
			ME-1	ME-2	ME-3	ME-4	ME-5	ME-6	ME-7	ME-8
1.	Biomass	mg/l	78	81	111	88	85	91	26	32
2.	Net Primary Productivity	mg/L/hr	7.21	8.25	7.33	8.87	8.32	7.12	6.52	7.64
3.	Gross Primary Productivity	mg/L/hr	8.55	7.12	8.32	8.71	6.45	7.13	6.94	5.74
4.	Pheophytin	mg/m^3	NIL	3	NIL	NIL	NIL	6	7.21	6.74
5.	Chlorophyll-a	mg/m^3	3.16	BQL	1.82	BQL	4.23	BQL	1.34	BQL
6.	Particulate Oxidizable Organic Carbon	mg/L	0.32	0.16	0.56	0.25	0.35	0.29	0.36	0.39
7.	Secchi Depth	ft	0.89	0.84	0.76	0.91	0.72	0.81	5.30	4.26

- **Biomass:**

  The value of **Biomass** reported from location ME-1 to ME-6 in range between 78-111 g/m^2 where highest biomass present in ME-3 (Near Coal Berth) and lowest biomass present in ME-1 (Near passenger Jetty 1) during sampling period. In Vadinar, the value of biomass was observed 26 g/m^2 at ME-7 (Near SPM), monitoring station and 32 g/m^2 in ME-8 (Near Vadinar Jetty).

- **Chlorophyll-a**

  In the sub surface water, the monitoring station reported the maximum **Chlorophyll-a** value at ME-5 (Nakti creek) i.e., 4.23 mg/m^3 and the value observed to be "Below the detection limit" at three locations (ME-2, ME-4 and ME-6) during the sampling. In the Vadinar, the value of chlorophyll-a was observed 1.34 mg/m^3 at ME-7 (Near SPM), monitoring station and ME-8 (Near Vadinar Jetty) recorded below the detection limit.

- **Pheophytin**
  The level of **Pheophytin** was detected or found nil in majority of the monitoring location in Kandla except for location ME-2 and 6 (Kandla and Nakti Creek) where it was recorded 3 and 6, respectively. While it was observed 7.21 and 6.74 in ME-7 (Near SPM) and ME-8 (Near Vadinar Jetty) respectively, in Vadinar.
- **Secchi Depth**
  In monitoring station of Kandla from ME-1 to ME-6 the level of **Secchi Depth** was observed between 0.72 to 0.91 ft whereas the value recorded in Near SPM (ME-7) is 5.30ft and in Near Vadinar Jetty is 4.26 ft.
- **Productivity (Net and Gross)**
  Gross primary productivity (GPP) is the rate at which organic matter is synthesised by producers per unit area and time (GPP). The amount of carbon fixed during photosynthesis by all producers in an ecosystem is referred to as gross primary productivity. The monitoring station reported **GPP** value in range between 6.45-8.71 mg/L/hr where the highest value recorded in Khori creek and lowest recorded at Nakti creek (near Tuna port) during sampling period. In the Vadinar, the value of **GPP** was observed 6.94 mg/L/hr at ME-7 (Near SPM) monitoring station and ME-8 (Near Vadinar Jetty) recoded 5.74 mg/L/hr.
  Net primary productivity, is the amount of fixed carbon that is not consumed by plants, and it is this remaining fixed carbon that is made available to various consumers in the ecosystem. The Net primary productivity of the monitoring location at Kandla from (ME-1 to ME-6) has been estimated to be between 7.12 to 8.87 mg/L/hr, while for Vadinar the value of NPP recorded 6.52 mg/L/hr and 7.64 mg/L/hr in ME-7 and ME-8 during the monitoring month.
- **Particulate Oxidisable Organic Carbon**
  For the month of April, the concentration of the Particulate oxidisable organic Carbon was observed to fall within the range of 0.16-0.35 mg/L at Kandla and 0.36-0.39 mg/L for Vadinar.
- **Ecological Diversity**
  Phytoplankton: For the evaluation of the Phytoplankton population in DPA Kandla and Vadinar within the immediate surroundings of the port, sampling was conducted between **mid-April to May**, 2023. Total 8 sampling locations were studied i.es. sampling locations (6 from Kandla and two from Vadinar). The details of variation in abundance and diversity in phytoplankton communities is mentioned in **Table 46**.

Table 46: Phytoplankton variations in abundance and diversity in sub surface sampling stations

Genera	ME-1	ME-2	ME-3	ME-4	ME-5	ME-6	ME-7	ME-8
Bacillaria sp.	460	700	680	750	660	850	650	700
Biddulphia sp.	650	510	-	650	-	-	755	350
Chaetoceros sp.	350	765	680	530	755	550	800	480
Chlamydomonas sp.	150	560	-	-	380	860	420	545
Cyclotella sp.	-	-	800	540	650	880	-	390
Ditylum sp	900	780	390	685	-	350	450	600

Genera	ME-1	ME-2	ME-3	ME-4	ME-5	ME-6	ME-7	ME-8
Coscinodiscus sp.	-	500	950	320	600	820	785	-
Fragilaria sp.	650	600	580	-	700	-	710	840
Gomphonema sp.	550	840	-	360	-	350	900	-
Gyrosigma sp.	410	500	650	750	-	685	400	655
Pleurosigma sp.	-	385	-	480	-	700	455	350
Navicula sp.	800	750	440	885	670	600	550	400
Nitzschia sp.	785	550	600	500	750	540	800	685
Skeletonema sp.	500	765	480	-	-	740	655	-
Synedra sp.	800	480	-	556	-	700	-	750
Planktothrix sp.	-	780	500	680	730	750	500	-
Oscillatoria sp.	940	-	670	-	845	800	-	785
Density-Units/l	**7945**	**9465**	**7420**	**7686**	**6740**	**10175**	**8830**	**7530**
No. of genera	**13**	**15**	**12**	**13**	**10**	**15**	**14**	**13**

The phytoplankton community of the sub surface water in the Kandla and Vadinar was represented by, Diatoms, blue green algae and Cynobacteria. Diatoms were represented by 14 genera, Blue green algae were represented by 1 genera and Cynobacteria were represented by 2 genera during the sampling period.

The density of phytoplankton of the sampling stations from ME-1 to ME-6 (Kandla) varying from 6800-7220 units/L, while for Vadinar its density of phytoplankton observed 6535 units/L at ME-7 and 8360 units/L at ME-8. During the sampling, phytoplankton communities were dominated by *Cyclotella sp. and Navicula sp.* in Kandla, while *Nitzschia sp.* in Vadinar.

Table 47: Species richness Index and Diversity Index in Phytoplankton

Indices	ME-1	ME-2	ME-3	ME-4	ME-5	ME-6	ME-7	ME-8
Taxa S	12	12	14	13	16	13	12	14
Individuals	7450	8745	9155	9100	10310	7990	8025	9650
Shannon diversity	2.49	2.68	2.46	2.53	2.29	2.68	2.61	2.52
Simpson 1-D	0.91	0.93	0.91	0.92	0.90	0.93	0.92	0.98
Species Evenness	0.97	0.99	0.99	0.99	0.99	0.99	0.99	0.98
Margalef richness	1.34	1.53	1.23	1.34	1.02	1.52	1.43	1.34
Berger-Parker	0.12	0.09	0.13	0.12	0.13	0.09	0.10	0.11
Relative abundance	0.16	0.16	0.16	0.17	0.15	0.15	0.16	0.17

- **Shannon-Wiener's Index (H)** of phytoplankton communities at the sampling stations was in the range of 2.29-2.68 between selected sampling stations from ME-1 to ME-6 with an average value of 2.52 at Kandla creek and nearby creeks which indicate the higher and stable diversity. Shannon-Wiener's Index (H) of phytoplankton communities in the sampling stations was in the range of 2.52–2.61 between selected sampling stations with an average value of 2.56 at Vadinar. The apportionment of the numbers of individuals

among the species observed higher in Nakti Creek in Kandla and Near Vadinar Jetty (Vadinar).

- In the month of **April, Margalef's diversity index** (Species Richness) of phytoplankton communities in the Kandla and nearby creeks sampling stations was varying from 1.02-1.53 with an average of 1.33 during the sampling. While for Vadinar Margalef's diversity index (Species Richness) of phytoplankton communities observed 1.43 at ME-7 and 1.34 at ME-8 with an average value of 1.38.
- **Simpson diversity index (1-D)** of phytoplankton communities was ranged between 0.90-0.93 at Kandla creek and nearby creeks, with an average of 0.91 in studied location. Similarly, for Vadinar Simpson diversity index (1-D) of phytoplankton communities was 0.92 at ME-7 and 0.98 at ME-8 with an average of 0.92. Both the Monitoring station of Kandla and Vadinar shows a good diversity of phytoplankton communities.
- **Berger-Parker Index (d)** of phytoplankton communities in the sampling stations was in the range of 0.09-0.13 between selected sampling stations from ME-1 to ME-6 with an average value of 0.11 at Kandla creek and nearby creeks. Berger-Parker Index (d) of phytoplankton communities in the sampling stations of Vadinar, was in the range of 0.10–0.11 with an average value of 0.11 All the monitoring station signifies a low diversity with an even distribution among the different species.
- **Relative Abundance** of phytoplankton communities in the sampling stations was in the range of 0.15-0.17 between selected sampling stations from ME-1 to ME-6 with an average value of 0.15 at Kandla creek and nearby creeks. Relative Abundance of phytoplankton communities in the sampling stations was in the range of 0.16–0.17 with an average value of 0.17 at Vadinar. The average relative abundance is found in range of 0.15, thus the studied species can be stated as neither highly dominant nor rare.
- The **Species Evenness** is observed in the range of 0.99 to 1 for all the eight-monitoring station of Kandla and Vadinar, indicate varying degrees of evenness or unevenness in the distribution of individuals among the studied species. The details of variation in abundance and diversity in zooplankton communities is mentioned in **Table 48**.

Table 48: Zooplankton variations in abundance and diversity in sub surface sampling stations

Genera	ME-1	ME-2	ME-3	ME-4	ME-5	ME-6	ME-7	ME-8
Acartia sp.	-	3	1	4	3	1	2	
Acrocalanus	1	2	7	4	1	1	3	5
Amoeba	6	1		3	6	2	4	1
Brachionus sp.	2	4	2	1		8	5	-
Calanus sp.	1	1	-	3	-	2	2	2
Cladocera sp.	1	-	-	2	1	1	2	3
Copepod larvae	3	8	5	6	5	3	10	3
Cyclopoida	2	4	1	3	2	-	1	1
Diaptomus sp.	4	1	3	1	10	1	1	3
Eucalanus sp.	5	-	1	4	4	8	7	9
Mysis sp.	-	11	8	4	-	2	7	-
Oithona sp.	1	2	5	2	1	2	3	9

Genera	ME-1	ME-2	ME-3	ME-4	ME-5	ME-6	ME-7	ME-8
Paracalanus sp.	12	10	13	18	15	15	20	17
Density Unit/L	**38**	**47**	**46**	**55**	**48**	**46**	**66**	**53**
No. of genera	**11**	**11**	**10**	**13**	**10**	**12**	**12**	**10**

A total of 13 groups/taxa of zooplankton were recorded in Kandla and Vadinar during the study period which mainly constituted by copepods, branchiopoda, monogononata, fish and shrimp larval forms. Copepods had the largest representation at all stations from (ME-1 to ME-8). The density of Zooplankton of the sampling stations from ME-1 to ME-6 (Kandla) varying from 67-187 units/L, while for Vadinar its density of phytoplankton observed 198 units/L at ME-7 and 133 units/L at ME-8. During the sampling, zooplankton communities were dominated by *Mysis sp.* in Kandla, while *Paracalanus sp.* in both the monitoring location of Kandla and Vadinar.

Table 49: Species richness Index and Diversity Index in Zooplankton

Indices	ME-1	ME-2	ME-3	ME-4	ME-5	ME-6	ME-7	ME-8
Taxa S	11	11	10	13	10	12	12	10
Individuals	38	47	46	55	48	46	66	53
Shannon diversity	2.05	2.08	1.99	2.23	1.94	2.03	2.15	1.95
Simpson (1-D)	0.85	0.87	0.85	0.86	0.84	0.84	0.86	0.83
Species Evenness	0.85	0.87	0.86	0.87	0.84	0.82	0.87	0.85
Margalef	2.75	2.6	2.35	2.99	2.32	2.87	2.63	2.27
Berger-Parker	0.32	0.23	0.28	0.33	0.31	0.33	0.3	0.32
Relative abundance	28.95	23.4	21.74	23.64	20.83	26.09	18.18	18.87

- **Shannon-Wiener's Index (H)** of Zooplankton communities, at sampling stations was in the range of 1.94-2.23 between selected sampling stations from ME-1 to ME-6 with an average value of 2.05 at Kandla creek and nearby creeks**.** Shannon-Wiener's Index (H) of zooplankton communities in the sampling stations was in the range of 1.95-2.15 between selected sampling stations with an average value of 2.05 at Vadinar. The diversity of zooplankton species was observed to be less in both the monitoring location of Kandla and Vadinar.
- **Margalef's diversity index** (Species Richness) of zooplankton communities in the Kandla and nearby creeks sampling stations was varying from 2.32-2.99 with an average of 2.64 during the sampling. While for Vadinar Margalef's diversity index (Species Richness) S of zooplankton communities observed 2.63 at ME-7 and 2.27 at ME-8 with an average of 2.45. The higher value was observed in Khori creek (ME-4), Kandla and in ME-7 (near SPM), Vadinar.
- **Simpson diversity index (1-D)** of zooplankton communities was ranged between 0.84-0.87 at all sampling stations in Kandla creek and nearby creeks, with an average of 0.85. While for Vadinar, Simpson diversity index (1-D) of zooplankton communities was 0.86 at ME-7 and 0.83 at ME-8 with an average of 0.84.

- **Berger-Parker Index (d)** of zooplankton communities in the sampling stations was in the range of 0.23-0.33 between selected sampling stations from ME-1 to ME-6 with an average value of 0.3 at Kandla creek and nearby creeks. Berger-Parker Index (d) of zooplankton communities in Vadinar sampling stations was found in range of 0.3–0.32 with an average value of 0.31. All the monitoring station signifies a low diversity with an even distribution among the different species.
- **Relative Abundance** of zooplankton communities at sampling stations was in the range of 20.83-28.95 between selected sampling stations from ME-1 to ME-6 with an average value of 24.10 at Kandla creek and nearby creeks. Relative Abundance of zooplankton communities in the sampling stations was in the range of 18.18–18.87 with an average value of 18.52 at Vadinar.
- The **Species Evenness** is observed in the range of 0.82 to 0.87 for all the eight-monitoring station of Kandla and Vadinar, the highest value recorded in ME-2,4&7 (Kandla & Khori Creek, near SPM), Kandla & Vadinar and the lowest value found in ME-6 (Nakti Creek).

Table 50: Benthic Fauna variations in abundance and diversity in sub surface sampling stations at Kandla and Vadinar

Genera	ME-1	ME-2	ME-3	ME-4	ME-5	ME-6	ME-7	ME-8
Diapatra sp.	1	2	1	6	2	4	1	3
Mollusca sp.	3	1	4	3	1	-	1	-
Odonata sp.	4	1	1	-	1	3	4	5
Coleoptera sp.	1	2	2	3	-	1	3	1
Crustacea sp.	-	1	3	5	1	3	1	-
Hemiptera sp.	3	6	-	2	2	1	-	1
Tricoptera sp.	3	6	4	-	2	5	2	1
Density-Units/l	**15**	**19**	**15**	**19**	**9**	**17**	**12**	**11**
No of genera	**6**	**7**	**6**	**5**	**6**	**6**	**6**	**5**

Few Benthic organisms were observed in the collected sample by using the Van-Veen grabs during the sampling conducted in the month of April and May from DPA Kandla and Vadinar. Majority of the species were found under the Macro-benthic organisms during the sampling period were represented by Diapatra sp., Mollusca sp., Odonata sp., Crustacea sp. Etc. The density of benthic fauna was varying from 10-14- Unit/L. The dominating benthic communities at Kandla Creek and nearby creek (Nakti and Khori creek) were represented Diapatra sp. While lowest number of benthic species was represented by Hemiptera sp. Their population was found as 16 Unit /L at Near SPM and 5 Unit/L near Vadinar Jetty area during both the sampling period.

Table 51: Species richness Index and Diversity Index in Benthic Organism

Indices	ME-1	ME-2	ME-3	ME-4	ME-5	ME-6	ME-7	ME-8
Taxa S	6	7	6	5	6	6	6	5
Individuals	15	19	15	19	9	17	12	11
Shannon diversity	1.68	1.67	1.66	1.54	1.74	1.65	1.63	1.37
Simpson 1-D	0.86	0.81	0.85	0.81	0.92	0.84	0.85	0.76
Species Evenness	0.94	0.86	0.93	0.96	0.97	0.92	0.91	0.85
Margalef	1.85	2.04	1.85	1.36	2.28	1.76	2.01	1.67
Berger-Parker	0.27	0.32	0.27	0.32	0.22	0.29	0.33	0.45
Relative abundance	40	36.84	40	26.32	66.67	35.29	50	45.45

- **Shannon-Wiener's Index (H)** of Benthic organisms at sampling stations was in the range of 1.54-1.74 between selected sampling stations from ME-1 to ME-6 with an average value of 1.65 at Kandla creek and nearby creeks**.** Shannon-Wiener's Index (H) of Benthic organisms in the sampling stations was in the range of 1.37–1.63 between selected sampling stations with an average value of 1.5 at Vadinar. Diversity of zooplankton species was observed to be less in both the monitoring location of Kandla and Vadinar.
- **Margalef's diversity index** (Species Richness) of Benthic organisms in the Kandla and nearby creeks sampling stations was varying from 1.36-2.28 with an average of 1.85 during the sampling period. While for Vadinar Margalef's diversity index (Species Richness) of Benthic organisms observed 2.01 at ME-7 and 1.67 at ME-8 with an average of 1.84.
- **Simpson diversity index (1-D)** of Benthic organisms was ranged between 0.81-0.92 at all sampling stations in the Kandla creek and nearby creeks, with an average of 0.84. The highest value was observed at ME-5. While for Vadinar Simpson diversity index (1-D) of benthic organism was 0.85 at ME-7 and 0.76 at ME-8 with an average of 0.80 during the sampling period.
- **Berger-Parker Index (d)** of Benthic organisms in the sampling stations was in the range of 0.22-0.32 between selected sampling stations from ME-1 to ME-6 with an average value of 0.28 at Kandla creek and nearby creeks. Berger-Parker Index (d) of Benthic organisms in Vadinar sampling stations was found in range of 0.33–0.45 with an average value of 0.39. Thus, all the eight-monitoring station of Kandla and Vadinar signifies a moderate diversity with an even distribution among the different species.
- **Relative Abundance** of benthic organism at sampling stations was in the range of 26.32-66.67 between selected sampling stations from ME-1 to ME-6 with an average value of 40.85 at Kandla creek and nearby creeks. Relative Abundance of phytoplankton communities in the sampling stations was in the range of 45.45–50 with an average value of 47.73 at Vadinar. The average relative abundance is found in range of 0.15, thus the studied species can be stated as neither highly dominant nor rare.
- The **Species Evenness** is observed in the range of 0.85 to 0.97 for all the eight-monitoring station, with an average value of 0.91 at Kandla and Vadinar indicate varying degrees of evenness or unevenness in the distribution of individuals among the studied species.

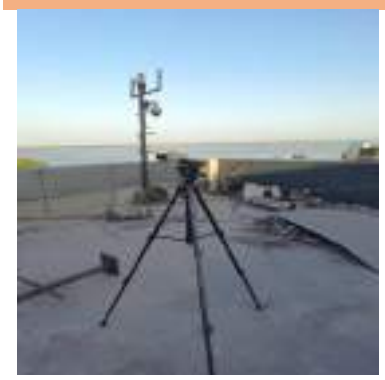
Annexure 1: Photographs of the Environmental Monitoring conducted at Kandla and Vadinar for April-May 2023

Ambient Air Monitoring at Kandla and Vadinar






Noise Monitoring at Kandla and Vadinar




Sewage Treatment Plant Monitoring at Kandla and Vadinar



Drinking Water Monitoring at Kandla and Vadinar






Soil Monitoring at Kandla and Vadinar



Phytoplankton, Zooplankton and Bio-monitoring




Marine Water and Sediment Monitoring

Source : GEMI

Gujarat Environment Management Institute (GEMI)

(An Autonomous Institute of Government of Gujarat)

'An ISO 9001:2015, ISO 14001:2015 & ISO 45001:2018 Certified Institute'

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"We Provide Environmental Solutions"

ANNEXURE – IV

mitigation measures submitted in the EIA report prepared in matrix format

Subject: Compliance of mitigation measures suggested in EIA report of "***Creation of water front facilities (Oil Jetties 8, 9, 10 & 11) and development of land of area 554 acres for associated facilities for storage at Old Kandla, Gandhidham, Kutch, Gujarat by M/s Deendayal Port Authority (Erstwhile Deendayal Port Trust)***"

Reference: Point No. XII of Environmental and CRZ Clearance granted by MoEF&CC, GoI vide letter vide file no. 10-1/2017-IA-III dated 20/11/2020.

Table 9.1: EMP for Construction Phase

Sr. no.	Environmental Aspect	Project activity and source of impact /and impact	Mitigation measures and reporting and records check required to be in place	Responsibility	Compliance
	Air	**Construction of Jetty** Emissions from generator sets (NOx, SO_2, hydrocarbons and CO) for operation of barges; ▪ Emissions from other construction equipment and machinery (cranes, anchored piling barges etc.); ▪ Dust emissions from on land vehicular movement (PM);	Ensuring frequent water sprinkling on roads to reduce dust during vehicular movement on land	Contractor & DPT	• DPA has installed Mist Canon at the Port area to minimize the dust. To control dust pollution, regular sprinkling of water through tankers on roads and other area is being done
			Minimization of movement of project vehicles at night and especially during peak hour traffic (9-11 am, 2-3 pm and 5-6 pm)		Point noted. it is relevant to mention here that, for diversion of port-related traffic and transportation, DPA has obtained Environmental & CRZ Clearance from SEIAA, GoG vide letter dated 19/06/2020 for construction of Interchange cum Road Over Bridge. The construction work of ROB is ongoing
			Covering Vehicles / Barges with tarpaulin during transportation of construction material to site		In this regard, it is to state that, vehicles are being covered with tarpaulin during transportation of construction material to site.
			Ensuring that contractors are maintaining engines and that machinery deployed during construction are complying with emission standards		DPA has included clause in the tender for the Contractor to ensure supply, use and maintenance of all construction plant and equipment for its efficient working. **Details submitted along with compliance submitted on 05/05/2023.**
			The diesel generator (DG) sets will be provided with adequate stack height as per applicable regulations and will use low sulphur diesel in DG sets Regular maintenance of diesel generators engines		DG sets are used only during power failure and vent of sufficient height are provided in line with the guidelines
			Regular maintenance of diesel generators engines		DPA has included clause in the tender for the Contractor to ensure supply, use and maintenance of all construction

Sr. no.	Environmental Aspect	Project activity and source of impact /and impact	Mitigation measures and reporting and records check required to be in place	Responsibility	Compliance
					plant and equipment for its efficient working. **Details submitted along with compliance submitted on 05/05/2023.**
			Monitoring of stack emissions at intervals as specified in the CFE and its comparison with the emission standards as specified in CFE; and		Point noted
			Regular Ambient air quality monitoring as per conditions stipulated in the CFE		DPA has been conducting regular Monitoring of environmental parameters since the year 2016. The Environmental Monitoring Reports is enclosed with the EC compliance report
			Documentation: ▪ Construction contractor will be required to prepare a Pollution Prevention and Control Plan to address the prevention and control of pollution, including exhaust emissions. ▪ Maintain Construction Equipment Maintenance Records. ▪ Inspection of Maintenance Records		DPA has included clause in tender for the Contractor to maintain Construction progress Documentation comprising of Detailed Construction Sequence and Methodology, Daily site records, weekly progress reports, and environmental monitoring report. **Details submitted along with compliance submitted on 05/05/2023.**
		Capital Dredging ▪ Emissions from generators Sets (NOx, SO2, hydrocarbons and CO) for operation of dredgers/ rigs; ▪ Drilling Rig Engine Emissions	▪ The dredging activities will be performed by the specialist contractors using purpose-built dredgers and under the active supervision of the port operator. ▪ Providing adequate stack height of diesel generators for proper dispersion of pollutants; ▪ Ensuring diesel generator sets are maintained and low sulphur content diesel is used; ▪ Monitoring of stack emissions at intervals as specified in the Consent for Establishment (CFE) and its comparison with the emission standards as specified in CFE; ▪ Ensuring that dredging contractors are maintaining equipment	Contractor & DPT	Point noted Dredging activity not yet started

Sr. no.	Environmental Aspect	Project activity and source of impact /and impact	Mitigation measures and reporting and records check required to be in place	Responsibility	Compliance
			maintenance records; and Documentation: ▪ Inspection of condition of contractors dredging equipment before start of work. ▪ Inspection of Maintenance Records		
	Noise	**Construction of Jetty** Hammering during piling activity and noise generated from other construction equipment	▪ Regular Ambient Noise Monitoring as per conditions stipulated in the CFE at receptors and construction site. ▪ If noise levels are above acceptable limits, adequate measures will be implemented (eg. Use of sound dampening blanket, physical barriers etc.).	Contractor & DPT	• DPA has been conducting regular Monitoring of environmental parameters since the year 2016. The Environmental Monitoring Reports is enclosed with the EC compliance report. • 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), which can act as a natural barrier for attenuation of noise. The work is already completed. Further, DPA has appointed the Gujarat Institute of Desert Ecology (GUIDE) for "Green belt development in Deendayal Port Authority and its Surrounding Areas, Charcoal site' (Phase-I)" vide Work Order No.EG/WK/4757/Part [Greenbelt GUIDE, dated 31st May 2022 • Further DPA has accorded the work of "Green belt development in DPA and its surrounding area (Phase II) to Gujarat Institute of Desert Ecology (GUIDE), Bhuj for the plantation of 10000 saplings of suitable species vide work order dated 23/06/2023. The same is in process
		Capital Dredging Noise generated from equipment's used during Dredging activity (Dredger-Mechanical/Hydraulic, generator, pumps etc.)	▪ Avoiding high noise activity during night time; ▪ Provide Diesel generators with acoustic enclosure; ▪ Use of ear plugs by personnel working onsite in high noise	Contractor & DPT	Point Noted. • Dredging activity not yet started

Sr. no.	Environmental Aspect	Project activity and source of impact /and impact	Mitigation measures and reporting and records check required to be in place	Responsibility	Compliance
			generating areas (above 75 dB (A); ▪ Encourage and support the workers to also use ear plugs during day time activities; ▪ Use of low speed rotary equipment; ▪ Use of high suction performance pump; ▪ Use of grease free bearings for all on board equipment; ▪ Maintenance of equipment used for dredging. ▪ Regular Ambient Noise Monitoring as per conditions stipulated in the CFE. *Documentation* ▪ Inspection of Maintenance Records Maintain Equipment Maintenance Records		
	Surface/ Groundwater/ Marine Water	**Construction of Jetty**	A method statement will be developed for the piling activity.		DPA has included clause in tender/ Concession agreement for the contractor to undertake piling installation in accordance with IS 2911 and maintain record of installation of Piles. **Details submitted along with compliance submitted on 05/05/2023.**
		Capital Dredging ▪ Disturbance of seafloor, the suspension of fine sediments and the re-deposition of coarse factions causing turbidity in marine water; ▪ Siltation and erosion along the coastline resulting in change of coastal morphology; (this was not anticipated as an impact in	▪ Prior to dredging, dredge area co-ordinates will be delineated, climatic conditions will be noted, and condition of equipment etc. will be checked; ▪ Use of Sophisticated Dredgers to avoid or minimize scattering of dredge sediments during dredging; ▪ Controlled dredging operations during high tidal disturbances; ▪ Continuous monitoring of turbidity and suspended sediment	Contractor & DPT	Point Noted. Dredging activity not yet started

Sr. no.	Environmental Aspect	Project activity and source of impact /and impact	Mitigation measures and reporting and records check required to be in place	Responsibility	Compliance
		the chapter 5) ▪ Turbidity in Marine water is expected to have an impact on Marine flora and fauna and other ecological issues	concentration; Regular check on Turbidity Levels & Dissolved Oxygen levels;		
	Biological Environment (Terrestrial & Marine)	**Construction of Jetty** Seabed disturbance due to piling activity, increased turbidity, and impact on benthic habitat.	▪ Regular monitoring of Marine Water & Sediment quality; ▪ Positioning of jack-up barge primarily in areas where the seabed has recently been dredged, rather than in previously less disturbed areas to avoid unnecessary disturbance to more established benthic habitat.	Contractor & DPT	• DPA has been conducting regular Monitoring of environmental parameters since the year 2016. The Environmental Monitoring Reports is enclosed with the EC compliance report. Point noted for compliance
		Capital Dredging ▪ Siltation and erosion during dredging activity ▪ Increased in turbidity levels of sea Impact on fishing activity	▪ Use of sophisticated dredgers to avoid or minimize scattering of dredge sediments during dredging; ▪ Controlled dredging operations at the time of high tidal disturbances; ▪ Check sediment quality for presence of heavy metals; ▪ Disposal at approved dumping ground in the sea as per Central Water and Power Research Station (CWPRS).	Contractor & DPT	Point Noted. Dredging activity not yet started • Dredged Material will be disposed of at designated location as identified by the CWPRS, Pune.
	Land / Soil	**Construction of Jetty** No impacts being offshore activity	▪		
		Capital Dredging No impacts being offshore activity	▪		
	Socio-economic and cultural	**Construction of Jetty** ▪ Damages to fishing nets ▪ Navigational problems to the fishing community ▪ Loss of marine species, especially fishes ▪ Immigration of construction workforce seeking proper	▪ Being an existing port, the fishing activity is very limited. ▪ Planned marine traffic management by the port authorities,	Contractor& DPT	• There is no fishing in the proposed project area, being no fishing zone. Kindly refer Point No. 13 of Standard Compliance under Compliance to the Terms of Reference specified in the EIA report. **Details submitted along with compliance submitted on 05/05/2023.**

Sr. no.	Environmental Aspect	Project activity and source of impact /and impact	Mitigation measures and reporting and records check required to be in place	Responsibility	Compliance
		facility	▪ If there is any loss of fishing net due to the said construction then same to be suitably compensated. ▪ Rest rooms with canteen facility and potable water to be provided to construction labour.		• Deendayal Port Authority had already installed and operates the Vessel Traffic Management System in the Gulf of Kachchh. There is no fishing in the proposed project area, being no fishing zone. Kindly refer Point No. 13 of Standard Compliance under Compliance to the Terms of Reference specified in the EIA report. **Details submitted along with compliance submitted on 05/05/2023.** • DPA has included clause in the tender for the contractor to make arrangement for water requirement for labours and also make provisions for the construction labour with necessary infrastructure including canteen facility. **Details submitted along with compliance submitted on 05/05/2023.**
		Capital Dredging ▪ Damages to fishing nets ▪ Navigational problems to the fishing community Loss of marine species, especially fishes	▪ Prior to dredging, dredge area co-ordinates will be delineated, climatic conditions will be noted, and condition of equipment etc. will be checked; ▪ Controlled Dredging operations during at the time of high tidal disturbances; ▪ Any damages to nets and equipment would be promptly compensated after a fair negotiation; ▪ Any disruption of fishing movement will need to be communicated in a timely manner, and minimized during peak fishing season; ▪ The process of dredging and	Contractor & DPT	Point Noted. • Dredging activity not yet started

Sr. no.	Environmental Aspect	Project activity and source of impact /and impact	Mitigation measures and reporting and records check required to be in place	Responsibility	Compliance
			dumping to be taken by experienced personnel and should be carefully done to minimize impact on marine ecology; ▪ Regular monitoring of Marine Water and Sediment Quality especially for heavy metals for taking necessary corrective measures if significant changes are observed; ▪ Constant check on Turbidity Levels & Dissolved Oxygen levels;		

9.4 Environmental Management Plan during Operation Phase

During the Operation phase, activities will include operation of jetties and maintenance dredgingThe EMP for the operational phase is summarized below in ***Table 9.2***

Table 9.2 : EMP for operation Phase

Sr. no	Environmental Aspect	Project activity and source of impact /and impact	Mitigation measures and reporting and records check required to be in place	Responsibility	Compliance
	Air	**Maintenance Dredging** ▪ Emissions from generator sets (NOx, SO2, hydrocarbons and CO) for operation of dredgers/rigs; ▪ Drilling Rig Engine Emissions;	▪ Providing adequate stack height of diesel generators for proper dispersion of pollutants in compliance with CPCB standards; ▪ Use of Low sulphur diesel in DG sets; ▪ Regular maintenance of diesel generators engines; ▪ Monitoring of stack emissions at regular intervals as specified in Consent for Operation (CFO) and its comparison with the emission standards as specified in CFO; ▪ Regular Ambient air quality monitoring as per conditions stipulated in the CFO. ▪ Follow Dredging Management Plan; *Documentation:* ▪ Inspection of condition of contractors dredging equipment; ▪ Inspection of Maintenance Records	Dredging Contractor and DPT	Point noted. Construction phase ongoing for Oil Jetty No. 8
	Noise	**Maintenance Dredging** Noise generated from equipment's used during Dredging activity	▪ Same as followed for Capital Dredging during construction phase Please refer to Table 9.1.	Dredging Contractor and DPT	Point noted. Construction phase ongoing for

		(Dredger-Mechanical/Hydraulic, generator, pumps etc.			Oil Jetty No. 8
	Surface/ Ground water /Marine Water	**Maintenance Dredging** Turbidity in marine water is expected to have an impact on Marine fauna	▪ Same as for Capital Dredging. ▪ Use of sophisticated dredgers to avoid or minimize scattering of dredge sediments during dredging; ▪ Controlled dredging operations during high tidal disturbances; ▪ No open discharge of oily wastes in marine waters; ▪ Constant check on Turbidity Levels & Dissolved Oxygen levels; ▪ Inspection of Analysis Records. ***Documentation*** ▪ Wastewater Monitoring as per Monitoring Plan ▪ Inspection of Monitoring Records	Dredging Contractor and DPA	Point noted. Construction phase ongoing for Oil Jetty No. 8
	Socio-Cultural	**Maintenance Dredging** ▪ Damages to fishing nets ▪ Navigational problems to thefishing community ▪ Loss of marine species.	▪ Planned marine traffic management by the port authorities, and if any loss of fishing net occurs due to the dredging activity, then same to be suitable compensated. ▪ Dredging Plan to be followed	Dredging Contractor, DPA	Point noted. Construction phase ongoing for Oil Jetty No. 8

ANNEXURE – V

Details of CSR Activities undertaken & planned

Annexure C

CSR Activities at Deendayal 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					
				61 of 30.08.2012	564.00 Lakh	564.00	Nil	Works completed
3	2013 -2014	99 of 30.09.2013	6.43 Cr					
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
	TOTAL	563.35

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
	TOTAL	206.22

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
	TOTAL	**88.00**

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 Meghvad 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
	TOTAL	**140.30**

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	**Rs. 39.80 Lakhs** *Approx. estimated Cost Rs.99.50 Lakhs, of which 40% to be contributed by DPT.*
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	**40 Lakhs**
6	Construction of internal roads at Bhaktinagar Society, Kidana	Smt Maltiben Maheshwari, MLA	**15 Lakh**
		TOTAL	**155.10**

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	**24.00**
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	**18.00**
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	**1.50**
4	CSR work for Providing Drainage Line at MeghparBorichi village, AnjarTaluka	Shri Vasanbhai Ahir, MLA, Gujarat Govt	**25.00**
5	CSR work for Construction of Health Centre at Kidana Village	Shri Vinod L Chavda, MP	**13.00**
6	CSR work to provide 4 Nos. of Big Dust Bin for MithiRoharJuth Gram Panchayat.	Shri Sarapanch, Mithi RoharJuth Gram Panchayat	**3.40**

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**
		TOTAL	**154.90**

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 Vasanbhai 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 (SardarValabhbhai 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**
		TOTAL	**1838.57**

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	**Appx Cost – Rs 25.00 Lakhs** **Cost for** – 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	**Appx cost –Rs 20.00 Lakhs** (Two times CSR works carried out at school by DPT)
3	CSR activities for the VadhiyarVankarSamajvaadi, NaviSunderpuriGim	SmtMaltiben K Maheswari, MLA	**Appx Cost Rs 6.00 Lakhs** 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.	**Appx Cost Rs 51.00 Lakhs** (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	**Appx Cost Rs. 25 Lakhs** **Cost for :-**

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
	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	**Cost Rs 25,000.00** (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.	**AppxCost Rs 20.00 Lakhs** (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	**Appx Cost Rs. 40.00 Lakhs** (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	**Cost Rs 1.50 Lakhs** (School Managed by G'dhamMaitry Mandal, Adipur)

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
14	CSR activities for DONATION various Medical Equipment for the Hospital of Gandhidham Jain SevaSamiti, Adipur	Gandhidham Jain SevaSamiti, Adipur	**Cost for** :- 1) Fresenius Haemodialysis Machine Rs 38.00 Lakh 2) Maltislice Helical CT Scanner- Rs 52.00 Lakhs 3) Others Rs 54.00 Lakhs (**Total Appx Cost Rs 144 Lakhs**)
15	CSR activities for SHRI VIDI JUTH GRAM PANCHAYAT, Vidi, Anjar	Sarpanch, Vidi Gram	**Appx Cost Rs 30.00 Lakhs** Cost for- Drainage , Garbage vehicle, and Cattle shed (Already applied earlier at Sr-5/12)
16	CSR activities for SOS CHILDRESN'S VILLAGES INDIA, Madhapar, Bhuj	Director, SOS Children's Village of India-Bhuj	**Appx Cost Rs 31.00 Lakhs** (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 BOAD, GANDHINAGAR	**Requirement-** Financial Support from DPT for **AppxRs 1.88 Cr.** (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 Sharpanchs 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	**Appx Cost Rs 30 Lakhs** (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.	**Appx Cost Rs 31.36 Lakhs** (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	**Appx cost Rs 30 Lakhs.** (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	**Appx Cost Rs 80.00 Lakhs** (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	**Appx Cost Rs21.50 Lakhs** (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 **GauSevaSamiti-Tappar** at Gram-Tappar, Ta Anjar.	Shri Vinod Chavda, MP &Presedent , GauSevaSamiti, village Tappar, Ta-Anjar	**Appx Cost Rs84 Lakhs** (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	**Cost not mentioned.** (Facilities to be provided

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
	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.	**Cost not mentioned.** (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 (**Appx Cost Rs67.00 Lakhs**) 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
	CSR Applications kept pending in last year Agenda:-		
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)	As per CSR Guideline- ➢ Env Sustainability ➢ Eradicating extreme hunger and poverty (to be Consider for health Center ,Drainage line, Water sump etc activities) **(Appx Cost - 51.00 Lakhs)** (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)	As per CSR Guideline- ➢ 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 (**Appx Cost Rs 67.00 Lakhs**) 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)	**AppxRs 5.00 Lakhs** As per CSR Guideline- ➢ Promotion of Education (to be consider for 20 Computers)

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
			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	**AppxRs 15.00 Lakhs** (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	**AppxRs 30.00 Lakhs** As per CSR Guideline- ➢ 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, **Mumbai.**	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 2nd Floor of Shri MaheswariMeghwadSamaj, Gandhidham. (Sr no-20)	Shri MaheswariMeghwadSamaj, Gandhidham	**AppxRs. 15.00 Lakhs** (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.	**AppxRs 22.00 Lakhs** (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- **Rs 539 Lakhs** 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 –Rs**88.75 Lakhs**)
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**Cost Rs 48 Lakhs**)

ANNEXURE – VI

Green belt development in Deendayal Port Authority and its Surrounding Areas – Final Report

Final Report

On

Greenbelt Development for the Deendayal Port Authority at Kandla Port

Submitted to

Deendayal Port Authority
Administrative Office Building
Post Box No.50, Gandhidham (Kachchh)
Gujarat-370201

Prepared by

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Final Report

on

Greenbelt Development for the Deendayal Port Authority at Kandla Port, Kandla

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Introduction

Green vegetation cover surrounding human environment is a vital entity for supply of oxygen, food, fodder and medicine for the survival of all living being, and also it has played an important role in maintaining ecological balance, climate regulation, biodiversity conservation, retention of soil moisture, control of soil erosion, increasing soil fertility, maintaining pleasant micro climate of the region, etc. In addition, vegetation cover also absorbs various pollutants from the environment and thus helps in effective pollution control. However, due to the various types and extent of economic development like industrialization, mining, infrastructural development, etc. has reducing and fragmenting natural vegetation cover day-by day all over the world. The infrastructural and industrial development leads to influence the life of all the living organisms in two directions: either upwards or downwards. In the upward mode, human being gets opportunities for luxuriant life with easy accessibility to the resources while in downward, the quality of ecosystem services gets affected. Most of the industrial and infra-structural developmental activities generate pollution of one or other types with varying magnitudes, which makes susceptible to all the organisms, nevertheless, the power of resistance of each organism helps themselves to overcome the hazards caused by such pollutants.

Therefore, development of green belts alongside of industries, mines, thermal power station, roadsides, and other development unit is an effective mechanism to rejuvenate vital vegetation cover for safeguarding health of human and other living being. Green belts in and around urban and industrial areas are important to the ecological health of any given region. Greenbelt is the raw of trees planted along the industrial units, mines, roadside for reducing the pollution originating from these operations (Flemming, 1967; Hanson and Throne, 1970; Warren, 1973; Ganguly, 1976). Greenbelt has developed considering following factors; (i) physical characteristics of the green belt eg. Distance from the source, width, and height and leaf surface area density (ii) aerodynamic properties eg. Wind speed through greenbelt and effective height of the incident air stream (iii) deposition velocity of the pollutant and (iv) atmospheric stability conditions (CPCB, 2000).

As per the National Forest Policy (NFP-1988), it is necessary to encourage the planting of trees alongside of roads, railway lines, rivers and streams and canals, and on other

unutilized lands under state/corporate, institutional or private ownership. NFP give emphasis on the green belt developments. It says – Green belts should be raised in urban/industrial areas as well as in arid tracts. Such a programme will help to check erosion and desertification as well as improve the microclimate.

Green infrastructure serves to provide on ecological framework for social, economic and environmental health of the surroundings. The main components of this approach include storm water management, climate adaptation, less heat stress, more biodiversity, food production, better air quality, sustainable energy production, clean water and healthy soils, as well as the more anthropocentric functions such as increased quality of life through recreation and providing shade and shelter in and around infrastructure and industrial areas. Green infrastructure is thought to be effective in such scenarios, where green plants from a surface capable of absorbing air pollutants and act as a sink for pollutants. Leaves with their vast leaf area in the tree canopy, absorbs pollutants on their surface. Thus, effectively reduce their concentrations in the ambient air. Often the absorbed pollutants are incorporated in metallic streams and thus the air is purified. Plants grown in such a way as to function as pollutant sinks are collectively referred to as green infrastructure or green belts. Apart from functioning as a pollutant sink, green belts would also provide other benefits like aesthetic improvement and providing possible habitats for birds and animals along with maintain the soil moisture regime with the soil microorganisms and improve the Soil quality and ground water recharge. The greenbelts has helps in improving the ecology, maintenance of biodiversity, mitigation of dust pollution and fugitive emission, control of noise pollution, provide fresh air, mitigates soil erosion, increasing aesthetic values of an area and overall improvement of the landscape.

Rationale

Deendayal Port in Kachchh District of Gujarat State (formerly Kandla Port Trust), operated by Deendayal Port Authority (DPA), is a gateway Port to the hinterland in the western and northern states of India. It is one of the 11 major Ports of India situated at 22°59'39.77'' N latitude and; 70°13'20.14'' E longitude on Kandla creek at Gulf of Kachchh. The inclusion of Karachi Port in Pakistan after India's partition and heavy traffic congestion at the then Bombay Port gave impetus for promoting Deendayal Port during the year 1950s. In 1955, Deendayal Port acquired the status of a major Port in India. Because of its proximity to the Gulf countries, large quantities of crude petroleum and other assorted cargo are imported through Deendayal Port. The Port presently has 14 jetties, six oil terminals, and several allied facilities for handling dry and liquid cargo. Regular expansion/developmental activities such as the addition of jetties, allied Special Economic Zones (SEZ hereafter), industrial parks and ship bunkering facilities are underway to cope with the increasing cargo handling demands. Shri Mansukh Mandaviya, Minister of State for Ports, Shipping and Waterways (I/C) appreciated the efforts taken by Deendayal Port and added that it is indeed the major achievements in the challenging (COVID) times and it is significant indication that economy is bouncing back to achieve pre-COVID times.

Major commodities handled by the Deendayal Port are Crude Oil, Petroleum product, Coal, Salt, Edible Oil, Fertilizer, Sugar, Timber, Soya bean, Wheat. This major achievement can be attributed to the user-friendly approach of port with the Shipping fraternity / stakeholders and constant consultations with them to improve ease of doing business. An assortment of liquid and dry cargo is being handled at Deendayal Port. The dry cargo includes fertilizers, iron crap, steel, food grain, metal products, ores, cement, coal, machinery, sugar, wooden logs, salt extractions, etc. The liquid cargo includes edible oil, crude oil and other petroleum products. DPA created a new record by handling 127.10 million metric tonnes of cargo during FY 2021-22 compared to 117.566 MMT in FY 2020-21, with a growth of 8.11%. Incidentally, DPA is the only major Indian Port to handle more than 127 MMT cargo throughput, and it has also registered as the highest cargo throughput in its history. The Port has handled 3151 vessels during FY 2021-22 compared to 3095 vessels in FY 2019-20. 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 September 2021. Deendayal Port is a natural harbour located on the eastern bank of North-South trending Kandla creek at an aerial distance of 145 km from the Gulf's mouth.

Being located at the inner end of the Gulf of Kachchh (GoK), Deendayal Port has a fragile marine ecosystem with a vast expanse of mangroves, mudflats, creek systems and allied biota. The Port location is marked by a network of major and minor mangrove-lined creek systems with a vast extent of mudflats. The coastal belt in and around the Port has an irregular and dissected configuration.

There are no perennial or seasonal rivers in Gandhidham taluka where the part is located. Total rainy days during the monsoon season is limited to only 15-20 days and used to be erratic. Freshwater input into the near coastal waters is relatively meagre and appears to have less influence on the ambient coastal water quality except during monsoon months, during which freshwater through flash floods get discharged in the near coastal waters. The annual average humidity is 60%, which increases to 80% during the southwest monsoon (June to September) and decreases to 50% during the months of November and December. The drought phenomenon is common with two drought years in a cycle of 5 years.

The coastal belt in and around the Kandla region is characterized by a network of creek systems and mudflats covered by sparse halophytic vegetation, creek water and salt-encrusted land mass, which forms the major land forms. The surrounding environment in a radius of 10 km from the Port is mostly built-up areas consisting of salt works, human habitations and Port related structures on the west and north, creek system, mangrove formations and mudflats on the east and south. The Deendayal Port and its surroundings have mangroves, mudflats and creek systems as major ecological entities.

DPA is committed towards environment protection since its establishment and has taken many initiatives towards increasing green cover and greenbelt development in various areas under DPA through intensive plantation activities and developing greenbelt around its established port and jetty areas and human habitations.

In order to enhance and strengthen Greenbelt Development, the DPA has approached GUIDE to develop the greenbelt area within the port area in phase wise manner. It was finalised to raise 5000 plants at a suitable site during the first phase.

Project Site

Based on observation made by the GUIDE Team and Officials from Deendayal Port Authority, a site at adjacent to Berth 11-12 (Wood log site) have been selected on the peripheral boundary of two sides.

The area proposed for green development of Deendayal Port is barren land without any vegetation. The soil of the area is black muddy highly saline soil and with saline ground water. The area is very dry and hot during the summer. The highest temperature used to be recorded in this area.

Scope of Works

The overall objective is to Development Greenbelt at Deendayal Port. The following activities of the Greenbelt development have been carried out:

1. To make an inventory of suitable sites for greenbelt development in and around the Deendayal Port at Kandla.
2. To carryout Soil and Moisture Conservation (SMC) of the selected sites.
3. Identification of suitable native species of plants for the greenbelt plantation.
4. Adopting plantation technique of plant saplings.
5. Regular monitoring (survival and growth) of the plantation.
6. Suggest measures for management and improvement of the greenbelt.

Approach and Methodology for Greenbelt Development

Following steps have been adopted for greenbelt development:

- Removal of exotic/unwanted plants plant species from the entire area demarcated for green belt development: The entire selected site have been cleared by removing

unwanted weeds and material such as stones, plastics etc.by JCB and also with labours.

- Landscaping of the area and land preparation Trench line of 2.5x 2.5 ft. have been dig out through JCB along the boundary adjacent to birth 11 & 12 wood log area up to approximately 5000 ft.
- Soil and moisture conservation work since the port area is highly saline, SMC work was very much essential for better survival of the plants. Eight dumper of fertile soil from the field have been added.

- Identification of native species of plants for plantation in greenbelt as per the site suitability the site was very challenging for greenbelt development since the water and soil is highly saline with the extreme climatic condition, the selection of plant species for plantation has been made very carefully. 40 % of plants have been selected as native species for plantation where as 60% species of *Conocarpus*.
- Procurement of sapling of identified species or Nursery management or seeding of tree/shrub species all the saplings were procured where of 3-4 ft. in height from reliable nursery. All saplings were of tree species.

- Installation of irrigation facilities was not feasible therefore activity was planned preferably through tankers. The watering of the plantation have been schedule as per the seasons which is given in table. Regular watering as per the scheduled have been provided by the water tanker under the supervision of team expert
- Use of Manure, preferably organic fertilizer for enhancing soil fertility best quality organic manure of 12,500 kg have been provided to the saplings for better growth and survival. Weed management and trench repairing have been carried out periodically also as and when it required.

- Regular monitoring and management of the saplings by a qualified team from GUIDE the selected site is wood log site hence, the wood log used to roll down on a path for water tanker while uploading and downloading the wood log. The regular visit to the site has been made for monitoring and clearing the road for water tanker for irrigation. Gap filling were also made during the period.

Plantation Techniques:

- Site development for a plantation includes clearance for weeds and it involves, bush cutting, soil and moisture conservation works in 'nalas', construction of bunds or check dams, marking of pits for planting of saplings etc.
- After clearing the land sites for digging of pits, plantation have been marked on ground using a measuring tape to ensure the desired spacing.
- Pits of the size 45 cm x 45 cm and 45 cm depth have been dug for tree plantation. Pits have been deep enough to ensure that the roots of the plants do not curl up once the planting material is placed in it.
- Since the soil is highly saline, a fertile soil around 6 dumper have been added for better survival of plants
- Organic manure around 12,500 kg. Have been given for better growth and survival.
- The pit have been filled a little above the ground level so that after the earth settles the upper surface of the pit is level to the ground thus avoiding any water logging.
- The plantation has been out in two phase since the some areas were blocked by wood logs.
- Around 4100 saplings have been planted during the month of September 2022 at available plantation area.
- The remaining and gap filling of 1500 saplings have been planted after the clearance of the area during the month of Feb.2023. A total number of 5000 plantations, were completed in the area.

Selection of Plant Species for Plantation:

Various indigenous tree species suitable for the area have been identified and selected for plantation in suitable areas based on the assessment of soil quality, available water facility, and other environmental parameters.

Number of Sapling:

Approximate numbers of saplings to be required for the greenbelt are as follows:

- Peripheral plantation adjacent to birth 11-12 (along the boundary of the wood log area both sides): 5000 saplings

Management and Monitoring of Greenbelt:

The plantation within the identified site have been managed and monitored for a period of one year from June 2022 to June 2023 The management of plantation includes appropriate irrigation of the plantation in regular intervals, during summer and winter periods and if required even during monsoon with dry spells.

Watering have been made through tanker service at given schedule during the different seasons. (Table 1)

The all plants are growing very well and reached more 4-6 ft. height. The survival of plants have been noted very high as 98% during June 2023.

Table: 1 Time Schedule for Watering

Sr. No.	Month & Year	Number of Time
1	September 2022	4 times/month
2	October 2022	5 times/ month
3	November 2022	8 times/ month
4	December 2022	8 times/ month
5	January 2023	8 times/ month
6	February 2023	8 times/ month
7	March 2023	12 times/ month
8	April 2023	12 times/ month
9	May 2023	12 times/ month
10	June 2023	2 times/ month (end of the project 4th June 2023

Table: 2 List of Plants for Plantation at Site for Greenbelt Development

SI. No.	Scientific Name	Local Name	No. of Plant
1	*Conocarpus lancifolius*	Conocarpus	3500
2	*Ficus religiosa*	Piplo	100
3	*Azadirachta indica*	Limblo	200
4	*Peltophorum pterocarpum*	Pletoforam	300
5	*Millettia pinnata*	Karanj	300
6	*Cassia fistula*	Garmalo	100
7	*Delonix regia*	Gulmahor	300
8	*Mimusops elengi*	Borssalii	200

Fig. 1 Before Plantation

Fig. 2 Map of Plantation Area

Fig. 3 Digging Out Trench for Plantation

Fig. 4 Transportation of Plants to Site

Fig. 5 Fertile Soil for Better Survival of Plants

Fig. 6 Plantation Pits of Soil Filling

Fig. 7 Organic Manure for Better Growth and Survival

Fig. 8 Regular Watering of the plants by tanker

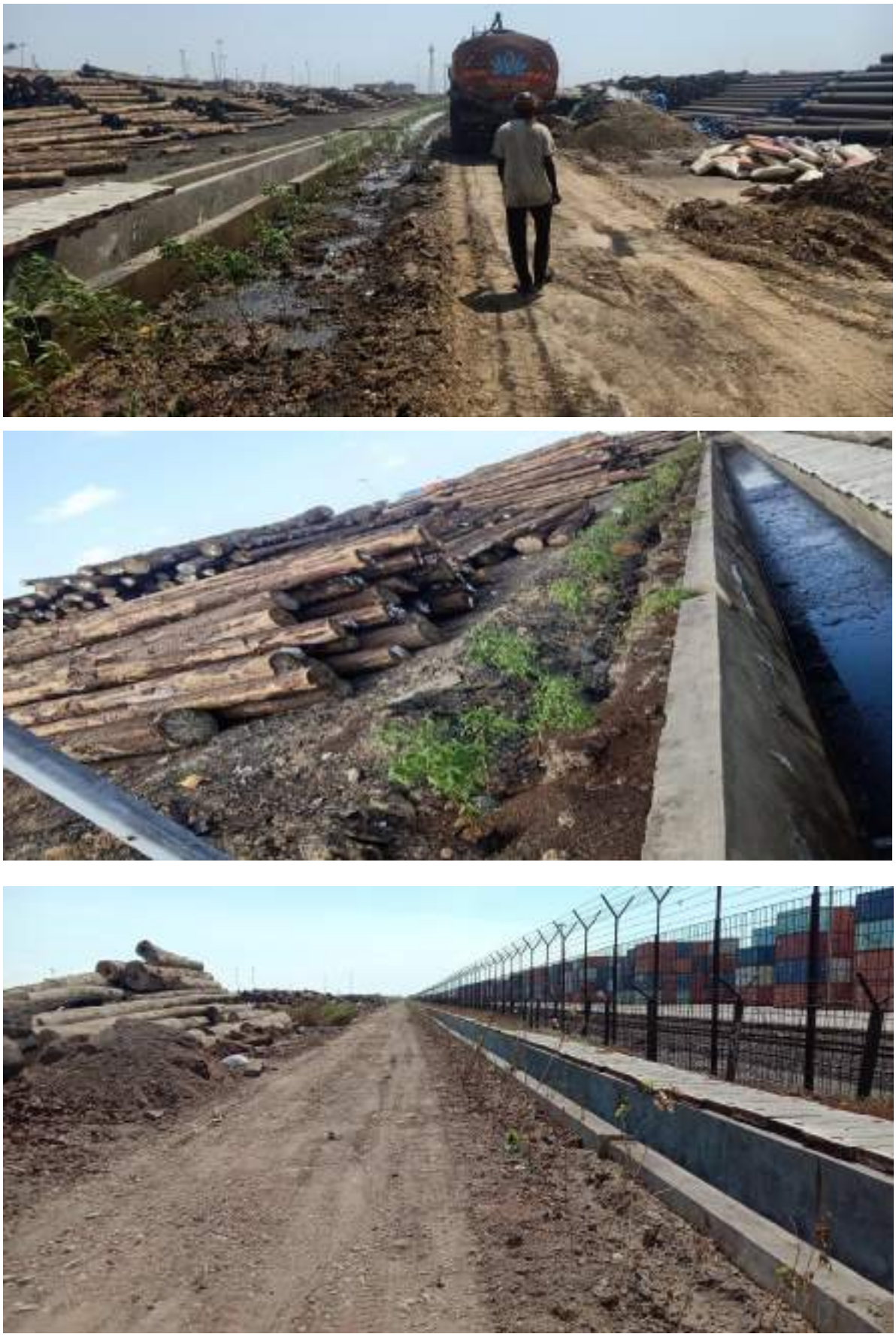

Fig. 9 Plantation in October 2022

Fig. 10 Plantation in December 2022

Fig. 11 Plantation in February 2023

Fig. 12 Plantation in May 2023

ANNEXURE – VII

Statement of Mangrove Plantation in 1600 ha Area

DEENDAYAL PORT TRUST

DETAILS OF MANGROVE PLANTATION ALREDY CARRIED OUT & Proposed To be Carried Out:

Sr. No.	Name of the Organization	Total Mangrove Plantation carried out in Hectares till date and place of plantation and agency	Cost incurred
	(A)MANGROVE PLANTATION ALREDY CARRIED OUT		
1	DEENDAYAL PORT TRUST (CRZ Recommendation 13th to 16th CB issued by the GCZMA) (Total 1000 ha.)	20 Hectares – 2005-06 Satsida Bet,Kandla, by GUIDE,Bhuj 50 Hectares – 2008-09 Nakti Creek,Kandla by Patel Construction 100 Hectares – 2010-11 Nakti Creek ,Kandla by GEC. (Board 29/1/2010) 200 Hectares – 2011-12 by Forest Department, GoG at Satsaida Bet	Rs. 8.8 lakhs Rs. 27.4 lakhs Rs.24.5 lakhs Rs. 66.5 lakh Rs. 157.5 lakhs (total 630 hectares)
2	Creation of Berthing & allied Facilities off- tekra near Tuna (Outside Kandla Creek) – EC & CRZ Clearance. (Total 500 ha. – 250Ha. by DPT & 250 ha by Adani (concessionaire) MOU signed with GEC during Vibrant Gujarat	300 Hectares – 2015-17 by GEC at Kantiyajal, Bharuch District	Rs. 90.0 lakhs
3.	EC & CRZ Clearance dated 19/12/2016 for Developing 7 integrated facilities (Condition 100 Ha)	100 Ha. –2018- 20 by GEC	Rs. 45 lakhs
4.	EC and CRZ Clearance dated 18/02/2020 (Dev of 3 remaining facility) and EC and CRZ Clearance dated 19/02/2020(Development of Integrated facilities 5 projects (Stage II) Ref : CRZ recommendation GCZMA 100 ha (50+50 Ha)	100 ha by GEC 2021-22 (Kantiyajal, Bharuch)	Rs 45 Lakhs
TOTAL MANGROVE Plantation till date by DPT 1500 Ha.		**– Total 464.7 lakhs**	

	(A) Proposed Mangrove Plantation		
1.	**CRZ recommendation outfitting jetty & floating dry Dock at Vadinar by DPA**	**100 Ha by GEC (work in progress)work order dated 02/06/2022**	**Rs 50 Lakhs**

ANNEXURE – VIII

Letter dated 05/05/2023 informed regional office details w.r.t to the development of back up area of Oil Jetty no. 8 to 11 (Phase I)

DEENDAYAL PORT AUTHORITY
(Erstwhile Deendayal Port Trust)

दीनदयाल पत्तन प्राधिकरण
DEENDAYAL PORT AUTHORITY

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

www.deendayalport.gov.in

EG/WK/5202 (D)/Part (CRZ 2) /294

Date: 05/05/2023

To,
The Deputy Director General of Forests (C),
Ministry of Environment, Forest & Climate Change
Integrated Regional Office,
Gandhinagar, A wing-407 & 409
Aranya Bhavan Near CH-3 Circle
Sector 10A, Gandhinagar – 382010

Sub: Creation of water front facilities (Oil Jetties 8, 9, 10 & 11) and development of land of area 554 acres for associated facilities for storage at Old Kandla, Gandhidham, Kutch, Gujarat by M/s Deendayal Port Trust (Now Deendayal Port Authority) - **Submission of detail w.r.t. Para B Standard Conditions - Point XI Miscellaneous vii of EC & CRZ Clearance accorded by the MoEF&CC, GoI reg.**

Ref.: 1) Environmental & CRZ Clearance accorded by the Ministry of Environment, Forests & Climate Change, GoI vide F. no. 10-1/2017-IA-III dated 20/11/2020
2) DPT Letter No. EG/WK/5202(D)/Part (CRZ 2) dated 10/2/2021

Sir,

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

In this connection, it is to state that, the MoEF&CC, GoI had accorded Environmental & CRZ Clearance for the subject proposal vide above referred letter dated 20/11/2020.

In this regard, as directed under Para B - Standard Conditions- Point No. XI : Miscellaneous (vii) of the above referred EC & CRZ Clearance accorded by the MoEF&CC, GoI dated 20/11/2020 i.e. ***The project proponent shall inform the Regional Office as well as the Ministry, the date of financial closure and final approval of the project by the concerned authorities, commencing the land development work and start of production operation by the project***; DPA vide letter dated 10/02/2021 informed about the MoEF&CC, GoI the requisite details w.r.t. Oil Jetty No. 8 (Jetty & Allied Facilities) (**Copy – Annexure A**).

...contd...

Now, w.r.t. development of land of area 554 acres, the requisite details are mentioned as under:

1)Date of Financial Closure : Through Internal Resources of Deendayal Port Authority.
2)Final approval of the project : Board of DPA accorded approval dated 28/02/2022.

In this regard, it is to state that, Deendayal Port Authority has issued work order to M/s Neelkanth Industries Pvt. Ltd., Gandhidham vide letter no. CN/WK/1582/Work/358 dated 14/12/2022 (**Copy – Annexure B**) for "Development of back up area of Oil Jetty No. 8 to 11 (Phase I)" and accordingly the project implementation work has been initiated by the Contractor.

However, for the remaining Oil Jetties no. 9, 10 & 11 to be implemented on BOT/PPP Mode (under bidding stage) the requisite details will be communicated in due course.

This is for kind information please.

Yours faithfully,

05/05/23

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

Copy to :

Shri Amardeep Raju,
Scientist E,
Ministry of Environment, Forests & Climate Change, GoI,
Indira Paryavaran Bhavan,
3rd floor, Vayu wing,
Jor Bagh Road, Aliganj,
New Delhi – 110 003.

Annexure -A

DEENDAYAL PORT TRUST

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

www.deendayalport.gov.in

EG/WK/5202 (D)/Part (CRZ 2) Dated: 10/2/2021

The Deputy Director General of Forest (Central),
Ministry of Environment, Forests & Climate Change,
Regional Office, Western Region
Kendriya Paryavaran Bhavan
Link Road No.3,Ravi Shankar Nagar,
Bhopal- 462 016(M.P.).
Email : rowz.bpl-mef@nic.in, eccompliance-guj@gov.in

Sub: Creation of water front facilities (Oil Jetties 8, 9, 10 & 11) and development of land of area 554 acres for associated facilities for storage at Old Kandla, Gandhidham, Kutch, Gujarat by M/s Deendayal Port Trust – **Submission of detail w.r.t. Para B Standard Conditions - Point XI Miscellaneous (vii) of EC & CRZ Clearance accorded by the MoEF&CC,GoI reg.**

Ref.: Environmental & CRZ Clearance accorded by the Ministry of Environment, Forests & Climate Change, GoI vide F. no. 10-1/2017-IA-III dated 20/11/2020.

Sir,

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

In this connection, it is to state that, the MoEF & CC, GoI had accorded Environmental & CRZ Clearance for the subject proposal vide above referred letter dated 20/11/2020 **(Copy enclosed at Annexure A)**.

In this regard, it is to state that, in the above referred EC & CRZ Clearance, the MoEF &CC, GoI under Para B - Standard Conditions- Point No. XI : Miscellaneous (vii) had directed that ***"The project proponent shall inform the Regional Office as well as the Ministry, the date of financial closure and final approval of the project by the concerned authorities, commencing the land development work and start of production operation by the project".***

Accordingly, w.r.t. project of Oil Jetty No. 8 (Jetty & allied facilities), the requisite details are mentioned as under:

1) Date of Financial Closure : Through Internal Resources of Deendayal Port Trust.
2) Final approval of the project : Board of DPT accorded approval dated 11/1/2019.

.....Cont.....

Now, after receipt of EC & CRZ Clearance dated 20/11/2020 from the MoEF&CC,GoI, out of total four Oil jetties, Deendayal Port Trust has issued work order to M/s Kargwal KM Joint Venture, Mumbai vide letter no. CN/WK/1571/Work/243 dated 3/2/2021 **(Copy – Annexure B)** for ***"Construction of Oil Jetty No. 8 at Kandla"*** and accordingly they may start the project implementation work. However, for balance Oil Jetties no. 9, 10 & 11 to be implemented on BOT/PPP Mode (under approval stage) and for development of Land (under approval stage), the requisite details will be communicated in due course.

This is for kind information please.

Yours faithfully,

10/2/2021

Encl. : As above.

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

Copy to:

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

Annexure -B

DEENDAYAL PORT AUTHORITY

ISO 9001:2008 | ISO 14001 | ISPS Compliant Port

KANDLA SAGARMALA

Office of the
Superintending Engineer (Project),
Nirman Building, Room No. 200,
New Kandla - 370 210
Mob. 9725338260

No. CN/WK/1582/Work /3588(3)

Date: 14/12/2022

To,
M/s Neelkanth Infratech Pvt. Ltd.,
"NEELKANTH"
B.B.Z., S-60, Zanda Chowk
Gandhidham – 370 201

WORK ORDER

Sub: "Development of back up area of Oil Jetty No. 8 to 11 (Phase-I)
Ref: LOA No. EG/WK/9129/374 dated 19/10/2022.

Sir,

Pursuant to your furnishing the requisite security as stipulated in clause 52 of Conditions of Contract and signing of the contract for execution of the "**Development of back up area of Oil Jetty No. 8 to 11**" you are hereby instructed to proceed with the execution of the said works on or before **21/12/2022** in accordance with the contract documents. It is hereby notified that the site is being handed over to you for execution of work in accordance with the contract documents.

You are requested to furnish the maximum numbers of labours to be engaged by you per day for the above work and obtain the necessary License from Assistant Labour Commissioner, Gopalpuri under the applicable Act.

Accordingly, a copy of Form-III is enclosed herewith for information and necessary action please.

Encl: Form - III

Supdt. Engineer (Project) i/c
Deendayal Port Authority

Monitoring the implemental Safe guards
Ministry of Environment, Forests & Climate Change
Regional office (WZ), Bhopal.
Monitoring Report (upto May, 2023)
DATA SHEET

ANNEXURE II

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	Creation of water front facilities (Oil Jetties 8,9,10 & 11) and development of land of area 554 acres for associated facilities for storage at Old Kandla, Gandhidham, Kachchh (Gujarat)
3.	Clearance Letter (s). OM no and date	The MoEF&CC, GoI New Delhi vide File No. 10-1/2017-1A-111 dated 20/11/2020 granted Environmental & CRZ Clearance.
4.	Location a) District (s) b) State (s) c) Location/latitude/longitude	 Dist: Kachchh State: Gujarat Location: Geo Coordinates: Latitude: 23.051704 N to 23.069488 N Longitude: 70.171017 E to 70.219725 E
5.	Address for Correspondence a) address of Concerned Project Chief Engineer (with pin code & telephone/telex/fax numbers b) Address of Executive project Engineer/manager/ (with pin code 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. Superintending Engineer (Project), Office of the Superintending Engineer (P), Nirman Building, New Kandla (Kutch) pin 370 210. Gujarat.
6.	Salient features a) Of the Project b) Of the Environmental Management Plan	• The Capacity of each jetty is 3.5 MMTPA for handling of all types of Liquid Cargo (Total Capacity: 14 MMTPA – 3.5 MMTPA X 4 Oil Jetties). • Area to be developed for associated facilities for storage: 554 acres • Dimension of jetty: Each Jetty consists of 110 m (L) & 12.8 m (W) (Main platform) and mooring dolphins. Connecting approach each: 90 m X 10 m to common approach trestle of length 1225 m. • Dredging Quantity and Draught: Draught 13 m in front of jetty & approach. Capital Dredging Requirement: 16, 56,058 M^3 (Berth basin + Patches in approach channel) and Maintenance Dredging of 1, 07,500 m3 Per annum. • The dredged material will be disposed of at the designated dumping location identified based on the scientific study done by the CWPRS and approved by the MOEF&CC, GoI. • Tentative Tankage Capacity: 2.28 Lakhs KL

		Salient Features of EMP as specified in the EIA/EMP report has already been communicated with the earlier compliance report submitted.
7.	Production Details during compliance period and (or) during the previous financial year	The work of Oil Jetty No. 8 & allied facilities has started (Under construction phase). However, for O.J. 9 to 11 (under bidding stage) and for area development, work is under progress.
8.	Breakup of the project area: a) Submergence area: forest & non-forest b) Others	 N/A. Project area is 554 acres
9.	Breakup of the project affected population with enumeration of those losing houses/dwelling units only agricultural land & landless laborer's/artisen a) SC. ST/Adivasis 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).	N/A as the project is to be implemented in DPA area. N/A N/A
10.	Financial details a) Project cost as originally planned and subsequent revised estimates and the year of prices reference. b) Allocation made for environmental management plans with item wise and year wise break-up c) Benefit cost ratio/Internal rate of Return and the year of assessment Whether (c) includes the cost of environmental management plans so far. d) Actual expenditure incurred on the project. e) Actual expenditure incurred on the environmental management plans so far.	 Estimated project cost is Rs. 1505.74 crores The allocation made under the scheme of "Environmental Services & Clearance thereof other related Expenditure" during BE 2023-24 is Rs. 274 Lakhs. IRR: 12.5 % OJ 8 & allied facilities: Rs. 94.41 Cr. Development of Land (area 554 acres): Rs. 26.82 Cr. Oil Jetties no. 9, 10 & 11: Construction not yet started The expenditure made under the scheme of "Environmental Services & Clearance thereof other related Expenditure" is Rs. 73.9 Lakhs for period up to May, 2023.
11.	Forest land requirement a) The status of approval for diversion of forest land for non-forestry use b) The status of clear felling c) The status of compensatory a forestation, if any	Nil (Not Applicable) N/A N/A N/A

	d) Comments on the viability & sustainability of compensatory a forestation programmed in the light of actual field experience so far	N/A
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 felling is required
13.	Status of construction: a) Date of commencement (Actual and/or planned) b) Date of completion (Actual and/or planned)	OJ 8 & allied facilities: Work order issued on 03.02.2021. The work is in progress. Oil Jetties no. 9, 10 & 11: O.J.s 9 to 11 to be implemented on BOT/PPP Basis are under bidding stage. Construction not yet started. Development of Land (area 554 acres): DPA had issued work order to the Contractor, M/s Neelkanth Infratech Pvt. Ltd., Gandhidham dated 14/12/2022 For OJ 8 & allied Facilities: Date of completion as per work order is 03.08.2022, further extended upto December, 2023. For OJ 9 to 11: The project is under bidding stage. For Development of Land (area 554 acres): The work is in progress. Scheduled completion period is 12 months i.e. from 21.12.2022 to 20.12.2023.
14.	Reasons for the delay if the Project is yet to start	1. The work of Oil Jetty No. 8 & allied facilities has started (Under construction phase). 2. For reclamation of Land (554 acres) – Work under progress. 3. However, Other OJs 9 to 11 to be implemented on BOT/PPP Basis is under bidding stage.
15.	Date of site visited a) The dates on which the project was monitored by the regional office on pervious occasion. if any b) The date site visit for this monitoring report	None
16.	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. (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.)	Chief Engineer, Deendayal Port Authority, A.O. Building, Annex, Post Box No.-50, Gandhidham- Kutch. Gujarat Pin – 370201 Tel: 02836-233192, Fax-02836-220050.