

DEENDAYAL PORT AUTHORITY
(Erstwhile: DEENDAYAL PORT TRUST)



www.deendayalport.gov.in

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

EG/WK/4751/Part (3 remaining facilities-II) / 75

Dated: 8 /10/2025

To,
The Deputy Director General of Forests (C),
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: Development of 3 Remaining Integrated Facilities (stage I) within the existing Deendayal Port Authority (Erstwhile: Deendayal Port Trust) at Gandhidham, Kutch, Gujarat - **Pointwise Compliance of the conditions stipulated in the EC&CRZ Clearance and Monitoring Report in Datasheet req.**

Ref.:

1. EC & CRZ Clearance accorded by the MoEF&CC, GoI, New Delhi vide no. 10-9/2017-IA-III dated 18/2/2020.
2. Regional Office, MoEF&CC, GoI, Bhopal letter vide F. No. 6-8/2020 (ENV)/324 dated 30/05/2020 (Received by DPT on 26/06/2020).
3. DPT letter no. EG/WK/4751/Part (3 remaining facilities)/968 dated 31(13)/7(8)/2020 along with requisite details.
4. Regional Office (Integrated), Gandhinagar, MoEF&CC, GoI, Bhopal letters dated 31/8/2020 & 18/11/2020 & response thereof from DPT vide letters dated 16/9/2020 & 24/12/2020 respectively.
5. DPT letter no. EG/WK/4751/Part (3 remaining facilities-II)/42 dated 13/07/2021.
6. DPT letter no. EG/WK/4751/Part (3 remaining facilities-II)/149 dated 8/2/2022.
7. DPA letter no. EG/WK/4751/Part (3 remaining facilities-II)/133 dated 06/07/2022
8. DPA letter no. EG/WK/4751/Part (3 remaining facilities-II)/280 dated 18/04/2023
9. DPA letter no. EG/WK/4751/Part (3 remaining facilities-II)/358 dated 12/09/2023
10. DPA letter no. EG/WK/4751/Part (3 remaining facilities-II) dated 13/03/2024
11. DPA letter no. EG/WK/4751/Part (3 remaining facilities-II)/133 dated 17/09/2024
12. DPA letter no. EG/WK/4751/Part (3 remaining facilities-II)/58 dated 02/04/2025

Sir,

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

In this regard, as directed in above referred EC letter dated 18/02/2020 of MoEF&CC, GoI, we are submitting herewith compliance report in the PARIVESH 2 PORTAL of the MoEF&CC, GoI vide F. no. 10-9/2017-IA-III dated 18/02/2020 (period October 2024 - March 2025). Further, we are also submitting herewith Monitoring Report in Data Sheet.

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This is for kind information and record, please.

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

Thanking you,

Yours faithfully,



XEN (EMC)
Deendayal Port Authority

Annexure -I

Half Yearly Compliance Report**2025****01 Jun(01 Oct - 31 Mar)****Acknowledgement**

Proposal Name	Development of 3 Remaining Integrated Facilities (stage I) within the existing Deendayal Port Authority (Erstwhile: Kandla Port Trust) at Gandhidham, Kutch, Gujarat.		
Name of Entity / Corporate Office	Deendayal Port Authority		
Village(s)	N/A		
District	KACHCHH		
Proposal No.	IA/GJ/MIS/61975/2017	Category	INFRA-2
Plot / Survey / Khasra No.	N/A	Sub-District	N/A
State	GUJARAT	Entity's PAN	*****EQUIRED
MoEF File No.	10.9/2017-IA-III	Entity name as per PAN	Deendayal Port Authority

Compliance Reporting Details**Reporting Year** 2025**Remarks (if any)****Reporting Period** 01 Jun(01 Oct - 31 Mar)**Details of Production and Project Area****Name of Entity / Corporate Office** Deendayal Port Authority

	Project Area as per EC Granted	Actual Project Area in Possession
Private	0	0
Revenue Land	0	0
Forest	0	0
Others	89.94	89.94
Total	89.94	89.94

Production Capacity

Sr. no	Product Name	units	Valid Upto	Capacity	Production last year	Capacity as per CTO
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Conditions**Specific Conditions**

Sr.No.	Condition Type	Condition Details
1	Statutory compliance	Construction activity shall be carried out strictly according to the

		provisions of the CRZ Notification, 2011. No construction work other than those permitted in Coastal Regulation Zone Notification shall be carried out in Coastal Regulation Zone area.
PPs Submission: Agreed to Comply For Project at Sr. No. 1 which is under construction, kindly refer compliance submitted by M/s HGCTKPL (concessionaire of the project) placed at Annexure A. The Projects at Sr. No. 2 and 3 of the EC and CRZ Clearance have already been completed.		Date: 08/10/2025
2	WASTE MANAGEMENT	No solid, semi-solid cargos would be handled.
PPs Submission: Agreed to Comply Project at Sr. No. 1, i.e., Development of Container Terminal at Tuna off-Tekra on BOT Basis: Containerized cargo will be handled. Project at Sr. no. 2, i.e., Providing a Railway Line from NH 8A to Tuna Port: For cargo movement in connection with the Dry Bulk Terminal at Tuna Tekra. Project at Sr. no. 3, i.e. Construction of Port Craft Jetty and Shifting of SNA Section : For parking of Port crafts.		Date: 03/07/2025
3	Statutory compliance	Consent to Establish/ Operate for the project shall be obtained from the State Pollution Control Board as required under the Air (Prevention and Control of Pollution) Act, 1981 and the Water (Prevention and Control of Pollution) Act, 1974.
PPs Submission: Complied The compliance had already been submitted by Deendayal Port Authority via communication no. EG/WK/4751 /Part (Remaining three facilities)/911 dated 3/12/2018 immediately after issuance of Minutes of the EAC (Infra.2) meeting held on 10/8/2018 (Agenda Item no. 33.4.12) vide which, the EAC (Infra.2) has recommended the subject proposal of DPA for grant of Environmental and CRZ Clearance to the MoEFandCC, GoI. However, a copy of the forwarding letter dated 3/12/2018 of DPA submitting requisite details, duly acknowledged by the MoEFandCC, GoI, Regional Office, Bhopal, dated 26/12/2018, had already been forwarded along with the compliance report submitted earlier.		Date: 03/07/2025
4	Statutory compliance	The project proponents will submit a declaration under Oath that the Railway line will not pass through mangrove area.
PPs Submission: Complied The compliance had already been submitted by Deendayal Port Authority via communication no. EG/WK/4751 /Part (Remaining three facilities)/911 dated 3/12/2018 immediately after issuance of Minutes of the EAC (Infra.2) meeting held on 10/8/2018 (Agenda Item no. 33.4.12) vide which, the EAC (Infra.2) has recommended the subject proposal of DPA for grant of Environmental and CRZ Clearance to the MoEFandCC, GoI. However, a copy of the forwarding letter dated 3/12/2018 of DPA submitting requisite details, duly acknowledged by the MoEFandCC, GoI, Regional Office, Bhopal, dated 26/12/2018, had already been forwarded along with the compliance report submitted earlier.		Date: 03/07/2025
5	MISCELLANEOUS	A detailed traffic management and traffic decongestion plan 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. and shall also have their consent to the implementation of components of the plan which involve the participation of these departments.
PPs Submission: Complied		Date:

<p>The compliance had already been submitted by Deendayal Port Authority via communication no. EG/WK/4751 /Part (Remaining three facilities)/911 dated 3/12/2018 immediately after issuance of Minutes of the EAC (Infra.2) meeting held on 10/8/2018 (Agenda Item no. 33.4.12) vide which, the EAC (Infra.2) has recommended the subject proposal of DPA for grant of Environmental and CRZ Clearance to the MoEFandCC, GoI. However, a copy of the forwarding letter dated 3/12/2018 of DPA submitting requisite details, duly acknowledged by the MoEFandCC, GoI, Regional Office, Bhopal, dated 26/12/2018, had already been forwarded along with the compliance report submitted earlier.</p>		03/07/2025
6	Marine/Coastal	<p>A detailed marine biodiversity impact assessment report and plan shall be drawn up and implemented to the satisfaction of the State Biodiversity Board and the CRZ authority. This shall be prepared through the NIOS or any other institute of repute on marine, brackish water and fresh water ecology and biodiversity. 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.</p>
<p>PPs Submission: Complied</p> <p>The compliance had already been submitted by Deendayal Port Authority via communication no. EG/WK/4751 /Part (Remaining three facilities)/911 dated 3/12/2018 immediately after issuance of Minutes of the EAC (Infra.2) meeting held on 10/8/2018 (Agenda Item no. 33.4.12) vide which, the EAC (Infra.2) has recommended the subject proposal of DPA for grant of Environmental and CRZ Clearance to the MoEFandCC, GoI. However, a copy of the forwarding letter dated 3/12/2018 of DPA submitting requisite details, duly acknowledged by the MoEFandCC, GoI, Regional Office, Bhopal, dated 26/12/2018, had already been forwarded along with the compliance report submitted earlier.</p>		Date: 03/07/2025
7	Statutory compliance	<p>The project proponent shall obtain all the documents/certificate mentioned in para (i) to (iv) above and submitted/uploaded online to the Ministrys Regional Office, Bhopal before starting implementation of the project.</p>
<p>PPs Submission: Complied Complied</p>		Date: 03/07/2025
8	Statutory compliance	<p>All the recommendations and conditions specified by the Gujarat Coastal Zone Management Authority who has recommended the project vide letter No. ENV-10-2015-249-E (T cell) dated 19.06.2017 shall be complied with.</p>
<p>PPs Submission: Agreed to Comply</p> <p>The specified CRZ recommendation letter ENV-10-2015-249-E (T cell) dated 19.06.2017 pertains to other organization i.e. Cargo Motors Pvt. Ltd. and does not pertain to DPA. However, the GCZMA had recommended the project for grant of CRZ Clearance vide letter no. ENV-10-2015-248-E (T-cell) dated 29/06/2016. The pointwise compliance of stipulated conditions mentioned therein is attached herewith as Annexure B.</p>		Date: 08/10/2025
9	Statutory compliance	<p>Notification GSR 94(E) dated 25.01.2018 of MoEFandCC regarding Mandatory Implementation of Dust Mitigation Measures for Construction and Demolition Activities for projects requiring Environmental Clearance shall be complied with.</p>
<p>PPs Submission: Agreed to Comply</p> <p>For Project at Sr. No. 1 which is under construction, kindly refer compliance submitted by M/s</p>		Date: 08/10/2025

		<p>HGCTKPL (concessionaire of the project) placed at Annexure A The Projects at Sr. No. 2 and 3 of the EC and CRZ Clearance have already been completed. DPA had already issued a general circular vide dated 3/9/2019 regarding Construction and Demolition Waste Management for strict implementation in DPA (A copy of the same has already been communicated with the last compliance report submitted). General Measures taken by DPA in the Port area at Kandla: DPA effectively implemented applicable measures for dust mitigation as follows: 1) All the vehicles carrying Construction material and waste are being covered. 2) Construction materials and waste are being stored in the earmarked area. 3) A wind-breaker of an appropriate height has been provided. 4) DPA has installed a Mist Canon at the Port area to minimize the dust. 5) Further, to control dust pollution in other areas, regular sprinkling through tankers on roads and other staking yards is being done.</p>	
10	Marine/Coastal	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.	
<p>PPs Submission: Agreed to Comply For Project at Sr. No. 1 which is under construction, kindly refer compliance submitted by M/s HGCTKPL (concessionaire of the project) placed at Annexure A. The Projects at Sr. No. 2 and 3 of the EC and CRZ Clearance have already been completed.</p>			<p>Date: 08/10/2025</p>
11	Marine/Coastal	Dredging, etc. shall be carried out in the confined manner to reduce the impacts on marine environment including turbidity.	
<p>PPs Submission: Agreed to Comply Point noted for compliance</p>			<p>Date: 03/07/2025</p>
12	WASTE MANAGEMENT	Dredged material shall be disposed safely in the designated areas	
<p>PPs Submission: Agreed to Comply Point noted for compliance</p>			<p>Date: 03/07/2025</p>
13	Statutory compliance	The project proponent shall ensure that the project is in consonance with the new CZMP prepared by the State Government under the provisions of the CRZ Notification, 2011.	
<p>PPs Submission: Agreed to Comply The MoEFandCC, GoI accorded EC and CRZ Clearance for the subject proposal of DPA dated 18/2/2020. For Project at Sr. No. 1 which is under construction, kindly refer compliance submitted by M/s HGCTKPL (concessionaire of the project) placed at Annexure A. Project at Sr. No. 2 and 3 is completed.</p>			<p>Date: 08/10/2025</p>
14	Marine/Coastal	Dredging shall not be carried out during the fish breeding season.	
<p>PPs Submission: Agreed to Comply Point noted for compliance</p>			<p>Date: 03/07/2025</p>
15	ENERGY PRESERVATION MEASURES	Compliance to Energy Conservation Building (ECBC-2017) shall be ensured for all the building complexes. Solar/wind or other renewable energy shall be installed to meet energy demand of 1 percent equivalent.	
<p>PPs Submission: Being Complied The projects mentioned in the EC and CRZ Clearance dated 18/2/2020 are mainly related to the construction of the jetty/berth (Container Terminal and Port Craft Jetty) and associated activities and the project related to the laying of the Railway line. DPA is already generating 20 MW of Wind energy. In addition to it, DPA has commissioned a 45 kWp Solar Plant at Gandhidham. Further, it is</p>			<p>Date: 31/07/2025</p>

<p>relevant to mention that, two out of four Nos. of Harbour Mobile Crane (HMC) made electric operated. Balance 02 Nos. shall be made electric operated by 2023-2024. Four Nos. of Diesel operated RTGs converted to e-RTGs. Retrofitting of hydrogen fuel cell in Tug Kalinga and Pilot Boat Niharika to be done as a pilot project under the guidance of MoPSW. Also, 14 Nos. of EV cars to be hired in this year and 03 Nos. EV Bus to be procured by the year 2023-24.</p>			
16	Marine/Coastal	Shoreline should not be disturbed due to dumping. Periodical study on shoreline changes shall be conducted, and mitigation carried out, if necessary. The details shall be submitted along with the six monthly monitoring report.	
<p>PPs Submission: Agreed to Comply Dredging material shall be disposed of at the designated location as identified by the CWPRS, Pune. DPA issued a work order vide no. EG/WK/4751/Part (EC- Shoreline study) Dated: 12/10/2021 to NCSCM, Chennai for Shoreline Change Study for Deendayal Port Authority, Kandla, Kachchh District, Gujarat, to Study the Effect of Dumping, if any reg. The final report submitted by the NCSCM, Chennai, has already been communicated with the six monthly compliance reports submitted via letter dated 06/07/2022.</p>			Date: 03/07/2025
17	Marine/Coastal	While carrying out dredging, an independent monitoring shall be carried out by Government Agency/Institute to check the impact and necessary measures shall be taken on priority basis if any adverse impact is observed.	
<p>PPs Submission: Agreed to Comply Point noted for compliance.</p>			Date: 03/07/2025
18	WATER QUALITY MONITORING AND PRESERVATION	Water will be received from high service reservoir near Bhachau and Narmada Canal through pipeline of Gujarat Water supply and Sewerage Board. 5.0 KLD water will be used for various purposes during the project. Rain water harvesting shall be followed as per local byelaw and harvested water shall be stored, treated and reused to reduce the additional water requirement since Chennai is a water deficient area, besides use of water efficient appliances.	
<p>PPs Submission: Agreed to Comply Water requirements will be met through procurement from GWSSB or private tankers. For Project at Sr. No. 1 which is under construction, kindly refer compliance submitted by M/s HGCTKPL (concessionaire of the project) placed at Annexure A. The Projects at Sr. No. 2 and 3 of the EC and CRZ Clearance have already been completed.</p>			Date: 08/10/2025
19	PUBLIC HEARING	The concerns expressed during the public hearing held by the M/s Kandla Port Authority for development of 3 remaining integrated facilities (Stage I) within the existing Kandla Port needs to be addressed during the project implementation. These would also cover socio-economic and ecological and environmental concerns, besides commitment by the management towards employment opportunities.	
<p>PPs Submission: Being Complied Not applicable, as a public hearing is exempted. Further, the details of CSR activities undertaken/to be undertaken by DPA are placed in Annexure C.</p>			Date: 08/10/2025
20	Marine/Coastal	The Marine biodiversity impact assessment report and management plan prepared by Gujarat Institute of Desert Ecology (GUIDE), Bhuj and approved by NIO and its mitigation measures for protection of sand dune vegetation, mangroves, sea grasses, macrophytes and phytoplankton etc., as given in the EIA-EMP Report shall be complied with in letter and spirit.	

PPs Submission: Being Complied

For Project at Sr. No. 1 which is under construction, kindly refer compliance submitted by M/s HGCTKPL (concessionaire of the project) placed at Annexure A. Further, the Projects at Sr. No. 2 and 3 of the EC and CRZ Clearance have already been completed. No industrial effluent is generated in the port area. The domestic sewage generated is treated in the STP (1.5 MLD) at Kandla. The treated sewages from STP of DPA are utilized for plantation / Gardening. DPA has entered into a 'Selling Agency' agreement with M/s. MSTC (Govt. of India Enterprise), Vadodara on 04/01/2022 for disposal of scrap, surplus items, unserviceable equipment, etc. The copy of the MoU has already been communicated with the last compliance report submitted. DPA had already issued circulars dated 3/9/2019 regarding Plastic Waste Management and Construction and Demolition Waste Management for strict implementation in DPA (The copy of the Circular has already been communicated with the last compliance report submitted). Further, DPA has appointed GEMI, Gandhinagar, for the work of Preparation of Plan for Management of Plastic Wastes, Solid Waste, including CandD waste, E-waste, Hazardous waste, including Biomedical and Non-Hazardous Waste in the Deendayal Port Authority vide Work Order dated 24/01/2023. Final report has already been submitted along with compliance report submitted on 02/04/2025. DPA assigned work to M/s GUIDE, Bhuj, for regular monitoring of Marine Ecology since the year 2017 and final reports prepared by GUIDE, Bhuj have already been communicated to the Integrated Regional Office, MoEFandCC, GoI, Gandhinagar as well as to the MoEFandCC, GoI, New Delhi along with compliance reports submitted from time to time. (Period from 2017 to 2021). Further, it is again to submit that DPA issued a work order to M/s GUIDE vide its letter no. EG/ WK/ 4751/ Part (Marine Ecology Monitoring) /11 dated 03/05/2021 for Regular monitoring of Marine Ecology in and around Deendayal Port Authority (Erstwhile Deendayal Port Trust) and continuous Monitoring Program covering all seasons on various aspects of the Coastal Environs for the period 2021-24. Final Reports for the period 2021-22, 2022-23 and 2023-24, have already been submitted along with compliance report submitted from time to time. In continuation of the same, DPA issued a work order to M/s GUIDE vide its letter no. EG/ WK/ 4751/ Part (Marine Ecology Monitoring) /72 dated 10/06/2024 for further period of 2024-27. A copy of 1st season report is placed herewith as Annexure D. The final report for the year 2023-24 has already been submitted along with compliance report submitted on 17/09/2024. In continuation to the same, DPA issued a work order to M/s GUIDE vide its letter no. EG/ WK/ 4751/ Part (Marine Ecology Monitoring) /72 dated 10/06/2024 for the period of 2024-27 (A copy of the same has already been submitted along with compliance report submitted on 17/09/2024) DPA has been appointing a NABL-accredited laboratory for monitoring environmental parameters, and reports are being submitted from time to time to the GPCB, IRO, MoEFandCC, GoI, and Gandhinagar. Recently, DPA appointed GEMI, Gandhinagar, to regularly monitor environmental parameters vide Work Order dated 15/02/2023. The work is in progress, and the latest environmental monitoring report submitted by GEMI, Gandhinagar, is attached herewith as Annexure E. DPA has undertaken a Mangrove Plantation in an area of 1600 Hectares since the year 2005. A copy of the details has already been communicated with the 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 submitted by M/s GUIDE, Bhuj, for the years 2017 to 2018 and 2021 to 2022 has already been submitted in the six-monthly compliance communicated via letter 06/07/2022. DPA already has an Environment Management cell. Further, the DPA has also appointed an expert agency to provide Environmental Experts from time to time. DPA appointed M/s Precitech Laboratories, Vapi, to provide Environmental Experts via a work order dated 5/2/2021. In addition, it is relevant to submit here that DPA had appointed a Manager (Environment) on a contractual basis for a period of 3 years, further extendable to 2 years (A copy of the details has already been communicated with the last compliance report submitted).

Date:
08/10/2025

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Marine/Coastal

A continuous monitoring programme covering all the seasons on various aspects of the coastal environs need to be undertaken by a competent organization available in the State or by entrusting to the National Institutes/renowned Universities/accredited Consultant with rich experiences in marine science aspects. The monitoring should cover various physico-chemical parameters coupled with biological indices such as sand dune vegetation, mangroves, sea grasses, macrophytes and phytoplankton on a periodic basis during construction and operation phase of the project. Any deviations in the parameters shall be given adequate care with suitable measures to

		conserve the marine environment and its resources.
	<p>PPs Submission: Being Complied</p> <p>DPA had assigned the work to M/s GUIDE, Bhuj, for continuous monitoring of Marine Ecology since the year 2017, and the reports in this regard are being submitted from time to time to the Regional Office, MoEFandCC, GoI, Gandhinagar, to the MoEFandCC, GoI, New Delhi along with six monthly compliance reports submitted. The final report for the year 2023-24 has already been submitted along with compliance report submitted on 17/09/2024. DPA assigned work to M/s GUIDE, Bhuj, for regular monitoring of Marine Ecology since the year 2017 and final reports prepared by GUIDE, Bhuj have already been communicated to the Integrated Regional Office, MoEFandCC, GoI, Gandhinagar as well as to the MoEFandCC, GoI, New Delhi along with compliance reports submitted from time to time. (Period from 2017 to 2021). Further, it is again to submit that DPA issued a work order to M/s GUIDE vide its letter no. EG/ WK/ 4751/ Part (Marine Ecology Monitoring) /11 dated 03/05/2021 for Regular monitoring of Marine Ecology in and around Deendayal Port Authority (Erstwhile Deendayal Port Trust) and continuous Monitoring Program covering all seasons on various aspects of the Coastal Environs for the period 2021-24. Final Reports for the period 2021-22, 2022-23 and 2023-24, have already been submitted along with compliance report submitted from time to time. In continuation of the same, DPA issued a work order to M/s GUIDE vide its letter no. EG/ WK/ 4751/ Part (Marine Ecology Monitoring) /72 dated 10/06/2024 for further period of 2024 27. A copy of 1st season report is placed herewith as Annexure D.</p>	<p>Date: 08/10/2025</p>
22	AIR QUALITY MONITORING AND PRESERVATION	Continuous online monitoring of for 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 MOEFandCC.
	<p>PPs Submission: Being Complied</p> <p>DPA has been appointing a NABL-accredited laboratory for monitoring environmental parameters, and reports are being submitted from time to time to the GPCB, IRO, MoEFandCC, GoI, and Gandhinagar. Recently, DPA appointed GEMI, Gandhinagar, to monitor environmental parameters regularly via Work Order dated 15/02/2023. The work is in progress, and the latest environmental monitoring report submitted by GEMI, Gandhinagar, is attached herewith as Annexure E. Further, DPA has already initiated the action for inviting the tenders for carrying out online ambient air quality monitoring system (24 X 7). However, no response received. Hence, now, DPA after obtaining in principal approval of the competent authority is in process to assign work to GUIDE, Bhuj on nomination basis.</p>	<p>Date: 08/10/2025</p>
23	AIR QUALITY MONITORING AND PRESERVATION	Ambient air quality shall be maintained at prescribed levels. The existing ambient air quality stations shall have a system of reporting exceedances separately to the Pollution Control Board.
	<p>PPs Submission: Being Complied</p> <p>DPA has been appointing a NABL-accredited laboratory for monitoring environmental parameters, and reports are being submitted from time to time to the GPCB, IRO, MoEFandCC, GoI, and Gandhinagar. Recently, DPA appointed GEMI, Gandhinagar, to regularly monitor environmental parameters vide Work Order dated 15/02/2023. The work is in progress, and the latest environmental monitoring report submitted by GEMI, Gandhinagar, is attached herewith as Annexure E.</p>	<p>Date: 08/10/2025</p>
24	MISCELLANEOUS	The project configuration should integrate and dovetail with the State Plan and not implemented unless the state plan is prepared and dovetailing ratified.
	<p>PPs Submission: Complied</p> <p>The Gujarat Coastal Zone Management Authority had already recommended the proposal vide letter dated 29/6/2016. Based on the same, the MoEFandCC, GoI has issued EC and CRZ Clearance for the subject proposal of DPA.</p>	<p>Date: 30/07/2025</p>
25	Marine/Coastal	Marine ecology shall be monitored regularly also in terms of sea weeds, sea grasses, mudflats, sand dunes, fisheries, echinoderms, shrimps, turtles, corals, coastal vegetation, mangroves and other

		marine biodiversity components as part of the management plan. Marine ecology shall be monitored regularly also in terms of all micro, macro and mega floral and faunal components of marine biodiversity	
	<p>PPs Submission: Being Complied DPA had assigned the work to M/s GUIDE, Bhuj, for continuous monitoring of Marine Ecology since the year 2017, and the reports in this regard are being submitted from time to time to the Regional Office, MoEFandCC, GoI, Gandhinagar, to the MoEFandCC, GoI, New Delhi along with six monthly compliance reports submitted. The final report for the year 2023-24 has already been submitted along with compliance report submitted on 17/09/2024. DPA assigned work to M/s GUIDE, Bhuj, for regular monitoring of Marine Ecology since the year 2017 and final reports prepared by GUIDE, Bhuj have already been communicated to the Integrated Regional Office, MoEFandCC, GoI, Gandhinagar as well as to the MoEFandCC, GoI, New Delhi along with compliance reports submitted from time to time. (Period from 2017 to 2021). Further, it is again to submit that DPA issued a work order to M/s GUIDE vide its letter no. EG/ WK/ 4751/ Part (Marine Ecology Monitoring) /11 dated 03/05/2021 for Regular monitoring of Marine Ecology in and around Deendayal Port Authority (Erstwhile Deendayal Port Trust) and continuous Monitoring Program covering all seasons on various aspects of the Coastal Environs for the period 2021-24. Final Reports for the period 2021-22, 2022-23 and 2023-24, have already been submitted along with compliance report submitted from time to time. In continuation of the same, DPA issued a work order to M/s GUIDE vide its letter no. EG/ WK/ 4751/ Part (Marine Ecology Monitoring) /72 dated 10/06/2024 for further period of 2024 27. A copy of 1st season report is placed herewith as Annexure D.</p>		Date: 08/10/2025
26	Marine/Coastal	Spillage of fuel/engine oil and lubricants from the construction site are a source of organic pollution which impacts marine life, particularly benthos. This shall be prevented by suitable precautions and also by providing necessary mechanisms to trap the spillage.	
	<p>PPs Submission: Agreed to Comply DPA already has an Oil Spill contingency plan, and accordingly, necessary precautions will be taken to prevent spillage of Fuel/Engine oil and lubricants.</p>		Date: 30/07/2025
27	MISCELLANEOUS	The handling of Hazardous Cargo should follow the provisions of the MSIHC Rules 1989 as amended. An onsite management plan shall be drawn up and integrated with that off site management plan. This shall be to the satisfaction of the state pollution control board, the Factory Department and the District Management.	
	<p>PPs Submission: Being Complied Before Loading or Unloading Dangerous Goods, Notification of Dangerous Goods is carried out by the Vessel Master and vessel Agents as per Dock Workers (Safety, Health and Welfare) regulation 1990 regulation No. 76. The notification covers mainly the following: 1. Undertaking from Master of the Ship 2. Ship Particular 3. MSDS of Dangerous Goods 4. Stowage Plan 5. Crew List DPA already has a Disaster Management Plan in place. A copy of the same has already been communicated with the earlier compliance report submitted.</p>		Date: 30/07/2025
28	WASTE MANAGEMENT	Necessary arrangements for the treatment of the effluents and solid wastes/ facilitation of reception facilities under MARPOL 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. The provisions of Solid Waste Management Rules, 2016. E - waste Management Rules, 2016, and Plastic Waste Management Rules, 2016 shall be followed	
	<p>PPs Submission: Being Complied No industrial effluent is generated in the port area. DPA issued a Grant of License/Permission to carry out the work of collection and disposal of Hazardous Waste/Sludge/ Waste Oil and Dry Solid</p>		Date: 30/07/2025

		Waste (Non- Hazardous) from Vessels calling at Deendayal Port through DPA contractors. Further, all ships are required to follow DG Shipping circulars regarding the reception facilities at the Swachh Sagar portal. DPA has entered into a Selling Agency agreement with M/s. MSTC (Govt. of India Enterprise), Vadodara on 04/01/2022 for disposal of scrap, surplus items, unserviceable equipment, etc. The copy of the MoU has already been communicated with the last compliance report submitted. DPA had already issued circulars dated 3/9/2019 regarding Plastic Waste Management and Construction and Demolition Waste Management for strict implementation in DPA (The copy of the Circular has already been communicated with the last compliance report submitted). Further, DPA has appointed GEMI, Gandhinagar, for the work of Preparation of Plan for Management of Plastic Wastes, Solid Waste, including CandD waste, E-waste, Hazardous waste, including Biomedical and Non-Hazardous Waste in the Deendayal Port Authority vide Work Order dated 24/01/2023. The work is completed. Final report has already been submitted along with compliance report submitted on 02/04/2025.	
29	GREENBELT	KPT shall take up massive greenbelt development activities in and around Kandla and also within the KPT limits.	
	PPs Submission: Agreed to Comply DPA had already taken up the greenbelt Development activity through the 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) (5000 plants) vide Work Order No.EG/WK/4757/Part Greenbelt GUIDE, dated 31st May 2022. The work is completed. Further, DPA assigned work to GUIDE, Bhuj, vide work order dated 23/06/2023 for Green belt development in Deendayal Port Authority and its Surrounding Areas (Phase II) (10000 plants). The work is completed and final report has already been submitted along with compliance report submitted on 02/04/2025.		Date: 31/07/2025
30	Risk Mitigation and Disaster Management	All the recommendations mentioned in the rapid risk assessment report, disaster management plan and safety guidelines shall be implemented.	
	PPs Submission: Being Complied The available safety measures implemented at Deendayal Port to overcome any unpredictable hazards have already been communicated with the earlier six monthly compliance reports submitted via letter dated 06/07/2022. Further, it is assured that all the recommendations mentioned in the Rapid Risk Assessment Report, Disaster Management Plan, and safety Guidelines will be implemented.		Date: 31/07/2025
31	Human Health Environment	Measures should be taken to contain, control and recover the accidental spills of fuel and cargo handle.	
	PPs Submission: Being Complied DPA already has an Oil Spill Contingency Plan. An adequate control measure has already been taken to control and recover accidental fuel and cargo handle spills.		Date: 31/07/2025
32	Human Health Environment	Necessary arrangement for general safety and occupational health of people should be done in letter and spirit.	
	PPs Submission: Being Complied Point Noted. Personal Protective Equipment for general safety is provided to the workers as well as visitors for their protection.		Date: 31/07/2025
33	Statutory compliance	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 Regional Office, MoEFandCC along with half yearly compliance report.	
	PPs Submission: Agreed to Comply		Date:

Compliance of mitigation measures suggested in the EIA report in the matrix format is attached herewith as Annexure F.		08/10/2025
34	Corporate Environmental Responsibility	As per the Ministry's Office Memorandum F. No. 22-65/2017-IA.III dated 1st May 2018, an amount of Rs. 8.04 Crore (0.25 percent of project Cost) shall be earmarked under Corporate Environment Responsibility (CER) for the activities such as drinking water, sanitation, health, education, skill development, roads, solar power, rain water harvesting, avenue plantation and plantation in the community areas. The activities proposed under CER shall be restricted to the affected area around the project. The entire activities proposed under the CER shall be treated as project and shall be monitored. The monitoring report shall be submitted to the regional office as a part of half yearly compliance report, and to the District Collector. It should be posted on the website of the project proponent.
PPs Submission: Agreed to Comply DPA has assigned work to The Gujarat Environment Management Institute (GEMI), Gandhinagar vide Work order no. Civil Engineering/EMC/1292/CER/2023/379 dated 25.10.2023 for Planning and monitoring of the activities to be undertaken under Environment Management Plan under EIA and EC. It is assured that, as per the condition stipulated, the activities under CER will be implemented in consonance with EMP activities.		Date: 31/07/2025
35	Statutory compliance	The project is recommended for grant of Environmental and CRZ Clearance subject to final outcome/legal opinion on the Order dated 22nd November, 2017 of Hon'ble NGT in the Original Application No. 424 of 2016 (Earlier O.A. No. 169 of 2015) and Original Application No. 11 of 2014 in the matter of M/s. Mehdad and Anr. Vs. Ministry of Environment, Forests and Climate Change and Ors. and Shamsunder Shridhar Dalvi and Ors. Vs. Govt. of India and Ors.
PPs Submission: Agreed to Comply Point Noted		Date: 31/07/2025
General Conditions		
Sr.No.	Condition Type	Condition Details
1	WATER QUALITY MONITORING AND PRESERVATION	Appropriate measures must be taken while undertaking digging activities to avoid any likely degradation of water quality.
PPs Submission: Agreed to Comply Point noted.		Date: 31/07/2025
2	MISCELLANEOUS	Full support shall be extended to the officers of this Ministry/Regional Office at Bhopal by the project proponent during inspection of the project for monitoring purposes by furnishing full details and action plan including action taken reports in respect of mitigation measures and other environmental protection activities.
PPs Submission: Agreed to Comply It is assured that full support shall be extended to the Officers of this Ministry/Regional Office at Bhopal/ Gandhinagar by the project proponent during the inspection of the project for monitoring purposes.		Date: 31/07/2025
3	Statutory compliance	The Ministry reserves the right to revoke this clearance if any of the conditions stipulated are not complied with the satisfaction of the

		Ministry
PPs Submission: Agreed to Comply Point Noted.		Date: 31/07/2025
4	Statutory compliance	In the event of a change in project profile or change in the implementation agency, a fresh reference shall be made to the Ministry of Environment, Forest and Climate Change.
PPs Submission: Agreed to Comply Point Noted.		Date: 31/07/2025
5	Statutory compliance	The project proponents shall inform the Regional Office as well as the Ministry, the date of financial closure and final approval of the project by the concerned authorities and the date of start of land development work.
PPs Submission: Being Complied DPA vide letter dated 22.03.2024 has already submitted desired details with respect to project at Sr. no. 1 to IRO, MoEFandCC. (Copy has already been submitted along with compliance report submitted on 17/09/2024) However, the stipulated condition shall be complied with.		Date: 31/07/2025
6	Statutory compliance	All other statutory clearances such as the approvals for storage of diesel from Chief Controller of Explosives, Fire Department, Civil Aviation Department, Forest Conservation Act, 1980 and Wildlife (Protection) Act, 1972 etc. shall be obtained, as applicable by project proponents from the respective competent authorities
PPs Submission: Agreed to Comply Point noted.		Date: 31/07/2025
7	Statutory compliance	The project proponent shall advertise in at least two local Newspapers widely circulated in the region, one of which shall be in the vernacular language informing that the project has been accorded Environmental and CRZ Clearance and copies of clearance letters are available with the State Pollution Control Board and may also be seen on the website of the Ministry of Environment, Forest and Climate Change at http://www.envfor.nic.in . The advertisement should be made within Seven days from the date of receipt of the Clearance letter and a copy of the same should be forwarded to the Regional office of this Ministry at Bhopal. The Clearance letter shall also be displayed at the Regional Office, District Industries Centre and Collector's Office/Tehsildars office for 30days.
PPs Submission: Complied DPA has already given advertisement in two local newspapers viz. KUTCH MITRA (In Gujarati) dated 23/2/2020 and in the Indian Express (In English) dated 22/02/2020 and also forwarded to the Regional Office, MoEFandCC, Bhopal vide letter dated 27/2/2020. Copy of the advertisement has already been communicated with the earlier six-monthly compliance report submitted vide letter dated 06/07/2022.		Date: 31/07/2025
8	Statutory compliance	A copy of the clearance letter shall be sent by the proponent to concerned Panchayat, Zilla Parisad/Municipal Corporation, Urban Local Body and the Local NGO, if any, from whom suggestions/representations, if any, were received while processing the proposal. The clearance letter shall also be put on the website of the company by the proponent.

PPs Submission: Complied Copy of the clearance letter dated 18/2/2020 was communicated to the concerned authorities along with the compliance report submitted vide letter 31(13)/7(8)/2020 and the same has been uploaded on the website of DPA.		Date: 31/07/2025
9	Statutory compliance	A six-Monthly monitoring report shall need to be submitted by the project proponents to the Regional Office of this Ministry at Bhopal regarding the implementation of the stipulated conditions
PPs Submission: Being Complied DPA has regularly submitted the compliance reports of stipulated conditions to the Regional Office of MoEFandCC, GoI.		Date: 31/07/2025
10	Statutory compliance	This clearance is subject to final order of the Hon'ble Supreme Court of India in the matter of Goa Foundation Vs. Union of India in Writ Petition (Civil) No.460 of 2004 as may be applicable to this project
PPs Submission: Agreed to Comply Point Noted.		Date: 31/07/2025
11	Statutory compliance	Ministry of Environment, Forest and Climate Change or any other competent authority may stipulate any additional conditions or modify the existing ones, if necessary in the interest of environment and the same shall be complied with
PPs Submission: Agreed to Comply Point Noted.		Date: 31/07/2025
12	Statutory compliance	A copy of this clearance letter shall also be displayed on the website of the concerned State Pollution Control Board.
PPs Submission: Agreed to Comply Point noted.		Date: 31/07/2025
13	Statutory compliance	Any appeal against this clearance shall lie with the National Green Tribunal, if preferred, within a period of 30 days as prescribed under Section 16 of the National Green Tribunal Act, 2010.
PPs Submission: Agreed to Comply Point Noted.		Date: 31/07/2025
14	Statutory compliance	Status of compliance to the various stipulated environmental conditions and environmental safeguards will be uploaded by the project proponent in its website.
PPs Submission: Being Complied DPA has been uploading the status of compliance of stipulated environmental conditions on its website www.deendayalport.gov.in.		Date: 31/07/2025
15	Statutory compliance	The proponent shall upload the status of compliance of the stipulated Clearance conditions, including results of monitored data on their website and shall update the same periodically. It shall simultaneously be sent to the Regional Office of MoEFandCC, the respective Zonal Office of CPCB and the SPCB.

PPs Submission: Being Complied DPA has been regularly uploading the status of compliance with the stipulated clearance conditions including results of monitored data on the website www.deendayalport.gov.in. Simultaneously, DPA has been submitting the six-monthly compliance report to the Regional Office of MoEFandCC, GoI and GPCB.		Date: 31/07/2025
16	Statutory compliance	The project proponent shall also submit six monthly reports on the status of compliance of the stipulated Clearance conditions including results of monitored data (both in hard copies as well as by e-mail) to the respective Regional Office of MoEFandCC, the respective Zonal Office of CPCB and the SPCB.
PPs Submission: Being Complied DPA has been submitting the six-monthly compliance report on the status of compliance with the stipulated Clearance conditions, including the monitored data, to the Regional Office of MoEFandCC, GoI and GPCB.		Date: 31/07/2025
17	Statutory compliance	The environmental statement for each financial year ending 31st March in Form-V as is mandated to be submitted by the project proponent to the concerned State Pollution Control Board as prescribed under the Environment (Protection) Rules, 1986, as amended subsequently, shall also be put on the website of the company along with the status of compliance of Clearance conditions and shall also be sent to the respective Regional Office of MoEFandCC by e-mail.
PPs Submission: Being Complied For project at Projects at Sr. No. 2 and 3 DPA has regularly submitted the Environmental Statement Form V to the GPCB. A copy of the Environmental Statement submitted to the GPCB (2023-24) for the entire DPA area is attached as Annexure G. Further, DPA also uploaded the said Environmental statement in Form V on the website www.deendayalport.gov.in.		Date: 08/10/2025
18	MISCELLANEOUS	The above stipulations would be enforced among others under the provisions of Water (Prevention and Control of Pollution) Act 1974, the Air (Prevention and Control of Pollution) Act 1981, the Environment (Protection) Act, 1986, the Public liability (Insurance) Act, 1991 and EIA Notification 1994, including the amendments and rules made thereafter
PPs Submission: Being Complied DPA has obtained consolidated consent and authorization vide GPCB (Consent Order no AWH 110594 dated issue 8/12/2020, with a validity period up to 21/7/2025) Detailed Order issued by the GPCB vide outward no. 581914 dated 22/1/2021 and subsequently, issued Correction in CCandA order vide letter no. PC/CCA-KUTCH-812(5)/GPCB ID 28494/588116 dated 9/4/2021. DPA has been appointing a NABL-accredited laboratory for monitoring environmental parameters, and reports are being submitted from time to time to the GPCB, IRO, MoEFandCC, GoI, and Gandhinagar. Recently, DPA appointed GEMI, Gandhinagar, to regularly monitor environmental parameters vide Work Order dated 15/02/2023. The work is in progress, and the latest environmental monitoring report submitted by GEMI, Gandhinagar, is attached herewith as Annexure E. Public Liability Insurance is renewed from time to time as required. The Public Liability Insurance has been renewed and is valid till 23/07/2024. The same has already been communicated with the last compliance report submitted.		Date: 08/10/2025
Visit Remarks		
Last Site Visit Report Date:		N/A
Additional Remarks:		

Note: This acknowledgement is as per the details submitted by project proponent. In no way is this document to be considered as conclusion on any action on the compliance of the project. This is strictly for the project proponent's reference purpose.

Annexure -A

24th June 2025

DP WORLD

To
The Chief Engineer
Deendayal Port Authority
Administrative Office
Gandhidham 370201

Sir,

Sub: Half-yearly Compliance Report Submission for development of
Tuna Tekra Container Terminal Project

The point-wise half yearly compliance report of the conditions stipulated in
EC-CRZ Clearance, CRZ Recommendation and CTE Compliance Reports for
March 2025 are enclosed.

Kindly acknowledge receipt of the aforesaid documents.

Thanking you,

Yours sincerely,

Hindustan Gateway Container Terminal Kandla Private Limited

Authorized Signatory

(SURESH JOSEPH)

Vice President - Projects - Ports and Terminals - Kandla

M 9387933440

E suresh.joseph@dpworld.comEnclosures:

1. EC-CRZ Clearance Compliance Report
2. CRZ Recommendation Compliance Report
3. CTE Compliance Report
4. Monitoring Datasheet

Registered Office:
Hindustan Gateway Container Terminal Kandla Private Limited
Atank Centre, A Wing, 5th Floor, Mittal Road, Kandla
Andhra Pradesh - 520 003, Mahabubnagar, India
CIN - U65249MH2023PLC008703
T: +91 22 69 61 2000, E: info@dpworld.com
dpworld.com

मुख्य जलियंता का कार्यालय
दीनरबाज परतन गार्डियन
बाबक संख्या: 412
दिनांक: 25/06/2025

Ashu (2)
26/06/2025
Shree Ashu
27/06/2025

25/7/25
26/6/25



GUJARAT POLLUTION CONTROL BOARD

PARYAVARAN BHAVAN, SECTOR 10-A,

GANDHINAGAR - 382010,

(T) 079-23232152

By R.P.A.D

AMENDMENT TO CONSENT TO ESTABLISH (CTE)

CTE-125870

NO: PC/ CCA- KUTCH-1231(2)/ GPCB ID: 44000 /

Date: -

To,
M/s. Kandla Port Trust,
Developing Integrated Facilities within existing KPT, at Kandla,
Kandla & Tuna area,
Tal : Gandhidham, Dist : Kutch - 370 201

Subject : Consent to Establish (CTE) issued vide CTE - 89537 vide letter no. PC/ CCA-
KUTCH-1231(2)/ GPCB ID: 44000 / 429717 dated 04/12/2017.

Reference : 1. Board has issued CTE vide letter PC/ CCA- KUTCH-1231(2)/ GPCB ID:
44000 / 429717 dated 04/12/2017.
2. Your application for CTE validity extension/ CTE Fresh Inward no. 271834
dated 07/01/2023.

Sir,

Without prejudice to the powers of this Board under the Water (Prevention and Control of Pollution) Act-1974, the Air (Prevention and Control of Pollution) Act-1981 and the Environment (Protection) Act-1986 and without reducing your responsibilities under the said Acts in any way. The Board had granted Consent to Establish (NOC) vide order no. CTE - 89537 vide letter no. PC/ CCA- KUTCH-1231(2)/ GPCB ID: 44000 / 429717 dated 04/12/2017 for the plant at Developing Integrated Facilities within existing KPT, at Kandla, Kandla & Tuna area, Ta. Gandhidham, Dist. Kutch.

The Board has right to review & amend the conditions of the said CTE order. Now considering your application for CTE-Amendment inward no. 271834 dated 07/01/2023 for validity extension of the CTE order dated 27/04/2023, the said order is amended as below:

1. The validity mentioned in the CTE order no- CTE - 89537 issued vide letter no. PC/ CCA- KUTCH-1231(2)/ GPCB ID: 44000 / 429717 dated 04/12/2017 shall be read as CTE order no. CTE-125870 dated 27/04/2023, valid up to 15/11/2025.
2. The rest of the conditions of Consent to Establish (CTE) order No: CTE - 89537 issued vide letter no. PC/ CCA- KUTCH-1231(2)/ GPCB ID: 44000 / 429717 dated 04/12/2017 shall remain unchanged and industry shall comply with the same judicially.

For and on behalf of
Gujarat Pollution Control Board


(T. C. Patel)
Unit Head
Page 1 of 1

Clean Gujarat Green Gujarat

Website : <https://gpcb.gujarat.gov.in>

ANNEXURE 1**EC AND CRZ COMPLIANCE REPORT (up to March 2025)**

Subject: Compliance of conditions stipulated by the Ministry of Environment, Forests & Climate Change (MoEF&CC), GoI in Environmental & CRZ Clearance granted for "**Development of 3 Remaining Integrated Facilities (stage I) within the existing Deendayal Port Trust (Erstwhile: Kandla Port Trust) at Gandhidham, Kutch, Gujarat.**"

Ref.: Environment and CRZ clearance accorded by the MoEF&CC, GoI vide file no. 10-9/2017-IA-III dated 18/2/2020.

Sr. No.	A. Specific Conditions	Compliance
I	Consent to Establish/ Operate for the project shall be obtained from the State Pollution Control Board as required under the Air (Prevention and Control of Pollution) Act, 1981 and the Water (Prevention and Control of Pollution) Act, 1974.	CTE attached as an Annexure-I , DPA had obtained CTE validity extension (CTE-125870) from GPCB vide Order dated 27/04/2023 with validity up to 15/11/2025.
II	The project proponents will submit a declaration under Oath that the Railway line will not pass through mangrove area.	Not applicable
III	A detailed traffic management and traffic decongestion plan 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. and shall also have their consent to the implementation of components of the	Not available as on date

	plan which involve the participation of these departments.	
iv	A detailed marine biodiversity impact assessment report and plan shall be drawn up and implemented to the satisfaction of the State Biodiversity Board and the CRZ authority. This shall be prepared through the NIOS or any other institute of repute on marine, brackish water and fresh water ecology and biodiversity. 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.	According to EC& CRZ clearance -Marine biodiversity impact assessment report attached as an Annexure-II

The project proponent shall obtain all the documents/certificate mentioned in para (i) to (iv) above and submitted/uploaded online to the Ministry's Regional Office, Bhopal before starting implementation of the project. -

V	Construction activity shall be carried out strictly according to the provisions of the CRZ Notification, 2011. No construction work other than those permitted in Coastal Regulation Zone Notification shall be carried out in Coastal Regulation Zone area.	Noted
Vi	All the recommendations and conditions specified by the Gujarat Coastal Zone Management Authority who has recommended the project vide letter No. ENV-10-2015-249-E (T cell) dated 19.06.2017 shall be complied with.	Noted
Vii	The project proponent shall ensure that the project is in consonance with the new CZMP prepared by the State	Noted

	Government under the provisions of the CRZ Notification, 2011.	
Viii	Notification GSR 94(E) dated 25.01.2018 of MoEF&CC regarding Mandatory Implementation of Dust Mitigation Measures for Construction and Demolition Activities for projects requiring Environmental Clearance shall be complied with.	Noted
ix	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.	Noted
x	No solid, semi-solid cargos would be handled.	Noted
xi	Dredging shall not be carried out during the fish breeding season.	Noted
xii	Dredging, etc., shall be carried out in the confined manner to reduce the impacts on the marine environment, including turbidity.	Noted
xiii	Dredged material shall be disposed safely in the designated areas	Not applicable as yet
xiv	Shoreline should not be disturbed due to dumping. Periodical study on shoreline changes shall be conducted, and mitigation carried out, if necessary. The details shall be submitted along with the six-monthly monitoring report.	Shoreline Changes report attached as an Annexure - III
xv	While carrying out dredging, independent monitoring shall be carried out by the Government Agency/Institute to check the impact, and necessary measures shall be taken on priority basis if any adverse impact is observed.	Not applicable as yet

xvi	Water will be received from high service reservoir near Bhachau and Narmada Canal through the pipeline of Gujarat Water supply and Sewerage Board. 5.0 KLD water will be used for various purposes during the project. Rainwater harvesting shall be followed as per local byelaw and harvested water shall be stored, treated and reused to reduce the additional water requirement since Chennai is a water deficient area, besides use of water efficient appliances.	Noted
xvii	The concerns expressed during the public hearing held by the M/s Kandla Port Authority for development of 3 remaining integrated facilities (Stage I) within the existing Kandla Port needs to be addressed during the project implementation. These would also cover socio-economic and ecological and environmental concerns, besides commitment by the management towards employment opportunities.	Noted
xviii	The Marine biodiversity impact assessment report and management plan prepared by Gujarat Institute of Desert Ecology (GUIDE), Bhuj and approved by NIO and its mitigation measures for protection of sand dune vegetation, mangroves, sea grasses, macrophytes and phytoplankton etc., as given in the EIA-EMP Report shall be complied with in letter and spirit.	Noted & Please EC& CRZ clearance - Marine biodiversity impact assessment report attached as an Annexure-II

xix	A continuous monitoring programme covering all the seasons on various aspects of the coastal environs need to be undertaken by a competent organization available in the State or by entrusting to the National Institutes/ renowned Universities/ accredited Consultant with rich experiences in marine science aspects. The monitoring should cover various physico-chemical parameters coupled with biological indices such as sand dune vegetation, mangroves, sea grasses, macrophytes and phytoplankton on a periodic basis during construction and operation phase of the project. Any deviations in the parameters shall be given adequate care with suitable measures to conserve the marine environment and its resources	Noted & Please see EC& CRZ clearance - Marine biodiversity impact assessment report attached as an Annexure-II
xx	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.	Noted
xxi	Ambient air quality shall be maintained at prescribed levels. The existing ambient air quality stations shall have a system of reporting exceedances separately to the Pollution Control Board.	Noted
xxii	The project configuration should integrate and dovetail with the State Plan and not implemented unless the state plan is prepared and dovetailing ratified.	Noted
xxlii	Marine ecology shall be monitored regularly also in terms of sea weeds, sea grasses, mudflats, sand dunes, fisheries, echinoderms, shrimps, turtles, corals, coastal vegetation, mangroves and other marine	

	biodiversity components as part of the management plan. Marine ecology shall be monitored regularly also in terms of all micro, macro and mega floral and faunal components of marine biodiversity	Noted & Please see EC& CRZ clearance - Marine biodiversity impact assessment report attached as an Annexure-II
xxiv	Spillage of fuel/engine oil and lubricants from the construction site are a source of organic pollution which impacts marine life, particularly benthos. This shall be prevented by suitable precautions and also by providing necessary mechanisms to trap the spillage.	Noted
xxv	The handling of Hazardous Cargo should follow the provisions of the MSIHC Rules 1989 as amended. An onsite management plan shall be drawn up and integrated with that offsite management plan. This shall be to the satisfaction of the state pollution control board, the Factory Department and the District Management.	Noted
xxvi	Necessary arrangements for the treatment of the effluents and solid wastes/ facilitation of reception facilities under MARPOL 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. The provisions of Solid Waste Management Rules, 2016. E - waste Management Rules, 2016, and Plastic Waste Management Rules, 2016 shall be followed	Noted
xxvii	Compliance to Energy Conservation Building (ECBC-2017) shall be ensured for all the building complexes. Solar/wind or other renewable energy shall be installed to	Not applicable as yet

	meet energy demand of 1 % equivalent.	
xxviii	All the recommendations mentioned in the rapid risk assessment report, disaster management plan and safety guidelines shall be implemented.	Noted
xxix	Measures should be taken to contain, control and recover the accidental spills of fuel and cargo handle.	Noted
xxx	Necessary arrangement for general safety and occupational health of people should be done in letter and spirit.	Noted
xxxi	KPT shall take up massive greenbelt development activities in and around Kandla and also within the KPT limits.	Noted
xxxii	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 Regional Office, MoEF&CC along with half yearly compliance report.	Noted
xxxiii	As per the Ministry's Office Memorandum F. No. 22-65/2017-IA.III dated 1st May 2018, an amount of Rs. 8.04 Crore (@0.25% of project Cost) shall be earmarked under Corporate Environment Responsibility (CER) for the activities such as drinking water, sanitation, health, education, skill development, roads, solar power, rain water harvesting, avenue plantation and plantation in the community areas. The activities proposed under CER shall be restricted to the affected area around the project. The entire activities proposed under the CER shall be treated as project and shall be monitored. The monitoring report shall be submitted to the regional office as a part of half yearly compliance report, and to the District	Not applicable as yet

	Collector. It should be posted on the website of the project proponent.	
xxxiv	The project is recommended for grant of Environmental and CRZ Clearance subject to final outcome/legal opinion on the Order dated 22nd November, 2017 of Hon'ble NGT in the Original Application No. 424 of 2016 (Earlier O.A. No. 169 of 2015) and Original Application No. 11 of 2014 in the matter of M/s. Mehdad & Anr. Vs. Ministry of Environment, Forests & Climate Change & Ors. and Shamsunder Shridhar Dalvi & Ors. Vs. Govt. of India & Ors.	Noted
B	GENERAL CONDITIONS:	
i	Appropriate measures must be taken while undertaking digging activities to avoid any likely degradation of water quality.	Noted
ii	Full support shall be extended to the officers of this Ministry/Regional Office at Bhopal by the project proponent during inspection of the project for monitoring purposes by furnishing full details and action plan including action taken reports in respect of mitigation measures and other environmental protection activities.	Noted
iii	A six-Monthly monitoring report shall need to be submitted by the project proponents to the Regional Office of this Ministry at Bhopal regarding the implementation of the stipulated conditions	Noted
iv	The Ministry of Environment, Forest and Climate Change or any other competent authority may stipulate any additional conditions or modify the existing ones, if necessary, in the interest of environment and the same shall be complied with	Noted

v	The Ministry reserves the right to revoke this clearance if any of the conditions stipulated are not complied with the satisfaction of the Ministry	Noted
vi	In the event of a change in project profile or change in the implementation agency, a fresh reference shall be made to the Ministry of Environment, Forest and Climate Change.	Noted
vii	The project proponents shall inform the Regional Office as well as the Ministry, the date of financial closure and final approval of the project by the concerned authorities and the date of start of land development work.	Date of Financial Closure intimated to DPA in March 2024
viii	A copy of this clearance letter shall also be displayed on the website of the concerned State Pollution Control Board.	Noted
7	All other statutory clearances such as the approvals for storage of diesel from Chief Controller of Explosives, Fire Department, Civil Aviation Department, Forest Conservation Act, 1980 and Wildlife (Protection) Act, 1972 etc. shall be obtained, as applicable by project proponents from the respective competent authorities	Noted
8	The project proponent shall advertise in at least two local Newspapers widely circulated in the region, one of which shall be in the vernacular language informing that the project has been accorded Environmental and CRZ Clearance and copies of clearance letters are available with the State Pollution Control Board and may also be seen on the website of the Ministry of Environment, Forest and Climate Change at http://www.envfor.nic.in . The advertisement should be made within Seven days from the date of receipt	Complied with by DPA.

	of the Clearance letter and a copy of the same should be forwarded to the Regional office of this Ministry at Bhopal. The Clearance letter shall also be displayed at the Regional Office, District Industries Centre and Collector's Office/ Tehsildar's office for 30 days.	
9	A copy of the clearance letter shall be sent by the proponent to concerned Panchayat, Zilla Parishad/Municipal Corporation, Urban Local Body and the Local NGO, if any, from whom suggestions/representations, if any, were received while processing the proposal. The clearance letter shall also be put on the website of the company by the proponent.	Noted
10	This clearance is subject to final order of the Hon'ble Supreme Court of India in the matter of Goa Foundation Vs. Union of India in Writ Petition (Civil) No.460 of 2004 as may be applicable to this project	No comments
11	Any appeal against this clearance shall lie with the National Green Tribunal, if preferred, within a period of 30 days as prescribed under Section 16 of the National Green Tribunal Act, 2010.	No comments
12	Status of compliance to the various stipulated environmental conditions and environmental safeguards will be uploaded by the project proponent in its website.	No comments
13	The proponent shall upload the status of compliance of the stipulated Clearance conditions, including results of monitored data on their website and shall update the same periodically. It shall simultaneously be sent to the Regional Office of MoEF&CC, the respective Zonal Office of CPCB and the SPCB.	Noted

14	The project proponent shall also submit six monthly reports on the status of compliance of the stipulated Clearance conditions including results of monitored data (both in hard copies as well as by e-mail) to the respective Regional Office of MoEF&CC, the respective Zonal Office of CPCB and the SPCB.	Noted
15	The environmental statement for each financial year ending 31st March in Form-V as is mandated to be submitted by the project proponent to the concerned State Pollution Control Board as prescribed under the Environment (Protection) Rules, 1986, as amended subsequently, shall also be put on the website of the company along with the status of compliance of Clearance conditions and shall also be sent to the respective Regional Office of MoEF&CC by e-mail.	Noted
16	The above stipulations would be enforced among others under the provisions of the Water (Prevention and Control of Pollution) Act 1974, the Air (Prevention and Control of Pollution) Act 1981, the Environment (Protection) Act, 1986, the public liability (Insurance) Act, 1991 and EIA Notification 1994, including the amendments and rules made thereafter	Noted

Annexure 1

CRZ RECOMMENDATION COMPLIANCE REPORT
(up to March, 2025)

Subject: Compliance of conditions stipulated in CRZ recommendations issued by GCZMA for the proposal "Development of 3 Remaining Integrated Facilities (stage I) within the existing Deendayal Port Authority (Erstwhile: Deendayal Port Trust) at Gandhidham, Kutch, Gujarat".

Ref.: Letter No. ENV-10-2015-248-E (T - Cell) dated 29/6/2016 of Director (Environment) & Member Secretary, GCZMA, Forest & Environment Department, GoG.

Sr. No.	Conditions in CRZ Recommendation Letter	Compliance
	Specific Conditions	
1	The provisions of the CRZ notification of 2011 shall be strictly adhered to by the KPT. No activity in contradiction to the Provisions of the CRZ Notification shall be carried out by the KPT.	Noted & Being Complied
2	All necessary permissions, under various laws/ Rules/ Notifications issued there under from different Government Departments/ agencies shall be obtained by M/s KPT before commencing any enabling activities for proposed project.	Noted
3	The KPT shall have to ensure that there shall not be any damage to the existing mangrove area.	Noted
4	The KPT shall effectively implement the Mangrove Development, Protection & Management Plan for control of indirect impact on mangrove habitat.	According to EC& CRZ clearance -Marine biodiversity impact assessment report attached as an Annexure-II
5	The KPT shall have to make a provision that mangrove areas get proper flushing water and free flow of water shall not be obstructed.	According to EC& CRZ clearance -Marine biodiversity impact assessment report attached as an Annexure-II

6	The KPT shall have to abide by whatever decision taken by the GCZMA for violation of CRZ Notification.	Noted
7	No dredging, reclamation or any other project related activities shall be carried out in the CRZ area categorized as CRZ I (i) and it shall have to be ensured that the mangrove habitats and other ecologically important and significant areas, if any, in the region are not affected due to any of the project activity.	Noted
8	The KPT shall participate financially in installing and operating the Vessel Traffic Management System in the Gulf of Kachchh and shall also take the lead in preparing and operationalising and regularly updating it after getting it vetted by the Indian Coast Guard.	No comments
9	The KPT shall strictly ensure that no creeks or rivers are blocked due to any activity at Kandla.	Noted
10	Mangrove plantation in an area of 50 ha. Shall be carried out by the KPT within 2 years in time bound manner on Gujarat coastline either within or outside the Kandla port Trust area and six monthly compliance reports along with the satellite images shall be submitted to the Ministry of Environment and Forest as well as to this Department without fail.	No comments
11	No activities other than those permitted by the competent authority under the CRZ Notification shall be carried out in the CRZ area.	Noted
12	No ground water shall be tapped for any purpose during the proposed expansion modernization activities.	Noted
13	All necessary permissions from different Government Departments / agencies	CTE attached as an Annexure-I , already obtained the necessary Environmental & CRZ Clearance,

	shall be obtained by the KPT before commencing the expansion activities.	Consent to Establish with validity up to 15/11/2025
14	No effluent or sewage shall be discharged into sea/creek or in the CRZ area and it shall be treated to conform to the norms prescribed by the GPCB and would be reused /recycled within the plant premises.	Noted
15	All the recommendations and suggestion given by the Mantec Consultants Pvt. Ltd. in their Comprehensive Environment Impact Assessment report for conservation/ protection and betterment of environment shall be implemented strictly by the KPT.	Noted
16	The construction and operational activities shall be carried out in such a way that there is no negative impact on mangroves and other coastal /marine habitats. The construction activities and dredging shall be carried out only under the constant supervision and guidelines of the Institute of National repute like NIOT.	Noted
17	The KPT shall contribute financially for any common study or project that may be proposed by this Department for environmental management/ conservation/ improvement for the Gulf of Kutch.	Noted
18	The construction debris and/ or any other of waste shall not be disposed of into the sea, creek or the CRZ areas. The debris shall be removed from the construction site immediately after the construction is over.	Noted
19	The construction camps shall be located outside the CRZ area and the construction labour shall be provided with the necessary amenities, including sanitation, water supply and fuel and it	Noted

	shall be ensured that the environmental conditions are not deteriorated by the construction labours.	
20	The KPT shall regularly updates its Local Oil Spill Contingency and Disaster management Plan in accordance with the National Oil Spill and Disaster Contingency Plan and shall submit the same to the MoEF, GoI and this department after having it vetted through the Indian Coast Guard.	No comments
21	The KPT shall bear the cost of the external agency that may be appointed by this Department for supervision/monitoring of proposed activities and the environmental impacts of the proposed activities.	Noted
22	The KPT shall take up massive greenbelt development activities in and around Kandla and also within the KPT limits.	Noted
23	The KPT shall have to contribute financially for talking up the socio-economic upliftment activities in this region in construction with the Forest and Environment Department and the District Collector/ District Development Officer.	Noted
24	A separate budget shall be earmarked for environmental management and socioeconomic activities and details there of shall be furnished to this Department as well as the MoEF, GOI. The details with respect to the expenditure from this budget head shall also be furnished.	Noted
25	A separate environmental management cell with qualified personnel shall be created for environmental monitoring and management during construction and operational phases of the project.	Noted

NOC/CTE COMPLIANCE REPORT
(up to March 2025)

Annexure 1

Subject: Compliance report of conditions stipulated in Consent to Establish (CTE/NOC) issued by GPCB for the proposal "**Development of 3 Remaining Integrated Facilities (stage I) within the existing Deendayal Port Authority (Erstwhile: Kandla Port Trust) at Gandhidham, Kutch, Gujarat**".

Ref.: Amendment to NOC/CTE issued by the GPCB (CTE - 89537) vide no. PC/CCA-KUTCH-1231 (2)/GPCB ID 44000/429717 dated 4/12/2017 for inclusion of the following three projects in the CTE granted for seven projects vide CTE - 74334 dated 22/12/2015. Further, DPA had obtained CTE validity extension (CTE-125870) from GPCB vide Order dated 27/04/2023 with validity up to 15/11/2025.

Annexure up to 15/11/2025.

Sr. No.	Specific Condition	Compliance		
Subject to the following Specific Conditions.				
1	You shall not commence of any construction activities of project, till obtaining EC clearance from MoEF&CC, GoI.	Noted & Being Complied		
2	You shall have to comply with the all conditions stipulated in ToR of MoEF in order of EC no. F. No. 10-9/2017-IA.III dated 6/6/2017.	Noted & Being Complied		
3	You shall have to comply with the all conditions of CRZ vide order no. ENV-10-2015-248-E (T Cell), dated 29/6/2016.	Noted & Being Complied		
3. Conditions under Water Act 1974.				
3.1	There shall be no industrial effluent generation from the loading and unloading activities at Port and other ancillary operations.	Noted		
3.2	(a) The total water consumption for shall not exceed 11 KL/day. (b) The quantity of Domestic wastewater (sewage) shall not exceed 8 KL/Day	Noted		
3.3	The quantity of sewage shall conform to the following standards: <table><tr><td>Parameters</td><td>GPCB</td></tr></table>	Parameters	GPCB	Noted
Parameters	GPCB			

		Norms	
	PH	6.5 to 9	
	BOD (5 days at 20 °C)	30 mg/L	
	Suspended solid	100 mg/L	
	Fecal Coliform	1000	
3.4	The treated domestic sewage confirming the above standards shall be utilized for plantation/gardening within premises.		Noted
3.5	The unit shall install flow meter at utilities for measuring category wise (category as given in water cess act - 1977 schedule II) consumption of water.		Noted
4	Conditions Under Air Act 1981.		
4.1	There shall be no use of fuel hence there shall be no flue gas emission from storage handling activity and other ancillary operations.		Noted
4.2	The applicant shall provide portholes, ladder, platform etc. at chimney (s) for monitoring the air emission and shall be open for inspection to and for use of Boards staff. The chimney(s) vents attached to various sources of emission shall be designed by numbers such as S-1, S-2, etc. and these shall be painted/ displayed to facilitate identification.		Noted
4.3	The concentration of the following parameters in the ambient air within the premises of the industry shall not exceed the limits specified hereunder as per national Ambient Air Quality Emission Standards issued by Ministry of Environment and Forest dated 16 th November, 2009.		Assessment of Ambient Air attached as an Annexure - IV
	Sr. No.	Pollutant	
		Time weighted Average	
		Concentration in Ambient air in µg/M³	
	1	Sulphur Dioxide (SO ₂)	50 80
	2	Nitrogen Dioxide (NO ₂)	40 80

	3	Particulate Matter (Size less than 10 μ m) OR PM_{10}	Annual 24 Hours	60 100	
	4	Particulate Matter (Size less than 2.5 μ m) OR $PM_{2.5}$	Annual 24 Hours	40 60	
3.4	<p>The concentration of Noise in ambient air within the premises of industrial unit shall not exceed the following levels:</p> <p>Between 6 A.M. and 10 P.M.: 75 dB (A)</p> <p>Between 10 P.M. and 6 A.M.: 70 dB (A)</p>				Noted
5	Conditions Under Hazardous Waste				
5.1	The applicant shall provide temporary storage facilities for each type of hazardous waste as per hazardous waste (management, handling & trans boundary movement) Rule, 2008 as amended from time to time.				Noted
5.2	The applicant shall be obtain membership of common TSDF site for disposal Hazardous waste as categorized in Hazardous waste (Management, Handling & trans boundary Movement) Rules, 2008 as amended from time to time.				Noted
6	General Conditions				
6.1	Any change in personnel, equipment or working conditions as mentioned in the consent form / order should immediately be intimated to this Board.				Noted
6.2	The waste generator shall be totally responsible for (i.e collection, storage, transportation and ultimate disposal) of the waste generated.				Noted
6.3	Records of waste generation, its management and annual returns shall be submitted to Gujarat Pollution Control Board in Form - 4 by 31 st January of every				Noted

	year.	
6.4	In case of any accident of the same shall be submitted in form - 5 to Gujarat Pollution Control Board.	Noted
6.5	Applicant shall comply relevant provision of "Public liability insurance act - 91".	Noted
6.6	Unit shall take all concrete measures to show tangible result in waste generation reduction, avoidance, reuse and recycle. Action taken in this regard shall be submitted within 03 months and also along with form 4.	Noted
6.7	Industry shall have to display on - line data outside the main factory gate with regard to quantity and nature of hazardous chemicals being handled in the plant, including wastewater and air emission and solid hazardous waste generated within the factory premises.	Noted
6.8	Adequate plantation shall be carried out all along the periphery of the industrial premises in such a way that the density of plantation is at least 1000 trees per acre of land and a green belt of 10 meters width is developed.	Noted
6.9	The applicant shall have to submit the returns in prescribed form regarding water consumption and shall have to make payment of water cess to the Board under the water (prevention & control of pollution) Cess Act-1977.	Noted

Monitoring the Implementation of Environmental Safeguards
Ministry of Environment Forest & Climate Change
Integrated Regional Office (WZ), Gandhinagar
Monitoring Report
(for the period up to 1 March 2025)

DATA SHEET

1.	Project type: River-valley/ Mining / Industry / Thermal / Nuclear / Other (specify)		:	Other – Container Terminal
2.	Name of the project		:	Tuna Tekra Container Terminal Project
3.	Clearance letter (s) / OM No. and Date		:	Letter of Award: No: Civil Engineering/Design/143/CT/2023/48 dated 14.03.2024
4.	Location		:	Tuna Tekra
	a.	District (S)	:	Kutch
	b.	State (s)	:	Gujarat
	c.	Latitude/ Longitude	:	
5.	Address for correspondence			
	a.	Address of Concerned Project Chief Engineer (with pin code & Telephone/telex/fax numbers)	:	Suresh Joseph, Vice-President Project – Ports & Terminals, Hindustan Gateway Container Terminal, Pavilion Corner, Second Floor, Plot No. 13, Ward No. 6, Gandhidham 370201
	b.	Address of Project: Engineer/Manager (with pin code/ Fax numbers)	:	Hindustan Gateway Container Terminal, Pavilion Corner, Second Floor, Plot No. 13, Ward No. 6, Gandhidham 370201
6.	Salient features			
	a.	of the project	:	54 Ha back-up area, 1650x20 meters trestle, 1100x54 meters berth length, capacity 2.19 million TEUs
	b.	of the environmental management plans	:	-
7.	Production details during the compliance period and (or) during the previous financial year			-
8.	The breakup of the project area		:	Not applicable
	a.	submergence area forest & non-forest	:	
	b.	Others	:	
9.	Breakup of the project affected Population with enumeration of Those losing houses / dwelling units Only agricultural land only, both Dwelling units & agricultural Land & landless laborers/artisan		:	Not applicable
	a.	SC, ST/Adivasis	:	
	b.	Others (Please indicate whether these Figures are based on any scientific and systematic survey carried out Or only provisional figures, it a Survey is carried out give details And years of survey)	:	
10.	Financial details		:	

	a.	Project cost as originally planned and subsequently revised estimates and the year of price reference:		
	1.	Estimated Cost of the Project	:	Rs. 4243.64 crores
	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	:	-
	d.	Whether (c) includes the Cost of environmental management as shown in the above.	:	-
	e.	Actual expenditure incurred on the project so far	:	Rs. 79.28 crores
	f.	Actual expenditure incurred on the environmental management plans so far	:	-
11.		Forest land requirement	:	Not applicable
	a.	The status of approval for diversion of forest land for non-forestry use	:	
	b.	The status of clearing felling	:	
	c.	The status of compensatory afforestation, it any	:	
	d.	Comments on the viability & sustainability of compensatory afforestation program in the light of actual field experience so far	:	
12.		The status of clear falling in Non-forest areas (such as submergence area of reservoir, approach roads), it any with quantitative information	:	Not applicable
13.		Status of construction	:	
	a.	Date of commencement (Actual and/or planned)	:	
	b.	Date of completion (Actual and/or planned)	:	
14.		Reasons for the delay if the Project is yet to start	:	No delay
15.		Details of the site visit: a) The dates on which the project was monitored by the MoEF&CC Regional Office on previous occasions (if applicable). b) Date of site visit for this monitoring report.		Not applicable
16.		Details of correspondence with project authorities for obtaining action plans/information on status of compliance to safeguards other than the routine letters for logistic support for site visit.	:	Not applicable

	(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)		
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Monitoring the Implementation of Environmental Safeguards
Ministry of Environment Forest & Climate Change
Integrated Regional Office (WZ), Gandhinagar
Monitoring Report
(for the period up to 1 March 2025)

DATA SHEET

1.	Project type: River-valley/ Mining / Industry / Thermal / Nuclear / Other (specify)	:	Other - Container Terminal
2.	Name of the project	:	Tuna Tekra Container Terminal Project
3.	Clearance letter (s) / OM No. and Date	:	Letter of Award: No: Civil Engineering/Design/143/CT/2023/48 dated 14.03.2024
4.	Location	:	Tuna Tekra
	a. District (S)	:	Kutch
	b. State (s)	:	Gujarat
	c. Latitude/ Longitude	:	
5.	Address for correspondence	:	
	a. Address of Concerned Project Chief Engineer (with pin code & Telephone/telex/fax numbers)	:	Suresh Joseph, Vice-President Project - Ports & Terminals, Hindustan Gateway Container Terminal, Pavilion Corner, Second Floor, Plot No. 13, Ward No. 6, Gandhidham 370201
	b. Address of Project: Engineer/Manager (with pin code/ Fax numbers)	:	Hindustan Gateway Container Terminal, Pavilion Corner, Second Floor, Plot No. 13, Ward No. 6, Gandhidham 370201
6.	Salient features	:	
	a. of the project	:	54 Ha back-up area, 1650x20 meters trestle, 1100x54 meters berth length, capacity 2.19 million TEUs
	b. of the environmental management plans	:	-
7.	Production details during the compliance period and (or) during the previous financial year	:	-
8.	The breakup of the project area	:	Not applicable
	a. submergence area forest & non-forest	:	
	b. Others	:	
9.	Breakup of the project affected Population with enumeration of Those losing houses / dwelling units Only agricultural land only, both Dwelling units & agricultural Land & landless laborers/artisan	:	Not applicable
	a. SC, ST/Adivasis	:	
	b. Others (Please indicate whether these Figures are based on any scientific and systematic survey carried out Or only provisional figures, it a Survey is carried out give details And years of survey)	:	
10.	Financial details	:	

(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)	
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Preliminary Report

on

Assessment of Ambient Air Quality for M/s DP World

DP World PO No. SCOHGCTKPLP03000007. Dt. 28.08.2024

Submitted by

Gujarat Institute of Desert Ecology
P.B. No. 83, Opp. Changleshwar Temple, Mundra Road
Bhuj-Kachchh, Gujarat - 370001



Submitted to

Hindustan Gateway Container Terminal Kandla Private Limited
2nd Floor, 204, Meridian House
Plot No 50, Sector 8, Gandhidham
Dist: Kachchh-370201, Gujarat



Project Team

Project Co-ordinator : Dr. V. Vijay Kumar, Director

Sr. No	Name & Designation	Role	Expertise
Scientific Personnel			
1.	Dr. K. Karthikeyan Assistant Director	Principal Investigator	Ph.D. in Environmental Sciences; Experience in water and soil studies with 17 years of experience and Environmental Monitoring and Assessment and Environmental Auditing
2.	Er. Ratansi Chaudhary Scientific Officer	Co-Investigator	B.E. in Chemical Engineering & Post Diploma in Industrial Safety. 10 years of experience in Environmental Auditing
3.	Er. Raturajsinh Sarvaiya Environmental Engineer	Co-Investigator	B.E. in Environmental Engineering & Post Diploma in Industrial Safety; 2 years and 7 months of work experience in Environmental Auditing.


Dr. V. Vijay Kumar
Director



Gujarat Institute
of Desert Ecology

Certificate

This is to state that the Preliminary report of the work entitled, "Assessment of Ambient Air Quality for DP World" has been prepared in line with the Work order issued by DP World vide No. SCOHGCTKPLPO3000007. Dt. 28.08.2024 as per the EC & CRZ Clearance accorded by the MoEF & CC. This work order is for a period of One year from September 2024 – August 2025 for the above-mentioned study.


Authorized Signatory

DIRECTOR
Gujarat Institute of Desert Ecology
Bhubaneswar



Institute Seal

1.0. Background

1.1. Profile of DP World

DP World is a multinational logistics company headquartered in Dubai, United Arab Emirates. It specializes in cargo logistics, port terminal operations, maritime services and free trade zones. Formed in 2005 by the merger of Dubai Ports Authority and Dubai Ports International, DP World handles 70 million containers that are brought in by around 70,000 vessels annually. This equates to roughly 10% of global container traffic accounted for by their 82 marine and inland terminals present in over 40 countries. Until 2016, DP World was primarily a global port operator, but since then, it has acquired other companies up and down the value chain. Our UAE heritage. From our beginnings in 1972 as a local port operator in Dubai to a global logistics provider with operations in over 69 countries and across every continent.

Dubai Ports International (DPI) was founded in 1999. Its first project was in Jeddah, Saudi Arabia, where it collaborated with a local partner on the South Container Terminal (SCT). DPI then began operations at the ports of Djibouti in 2000, Vizag, India in 2002, and Constanta, Romania in 2003. In January 2005, DPI acquired CSX World Terminals (CSX WT). In September 2005 Dubai Ports International officially merged with the Dubai Ports Authority to form DP World. The rapid expansion through acquisition continued in March 2006 when DP World purchased the fourth largest port operator in the world, P&O, for £3.9 billion.

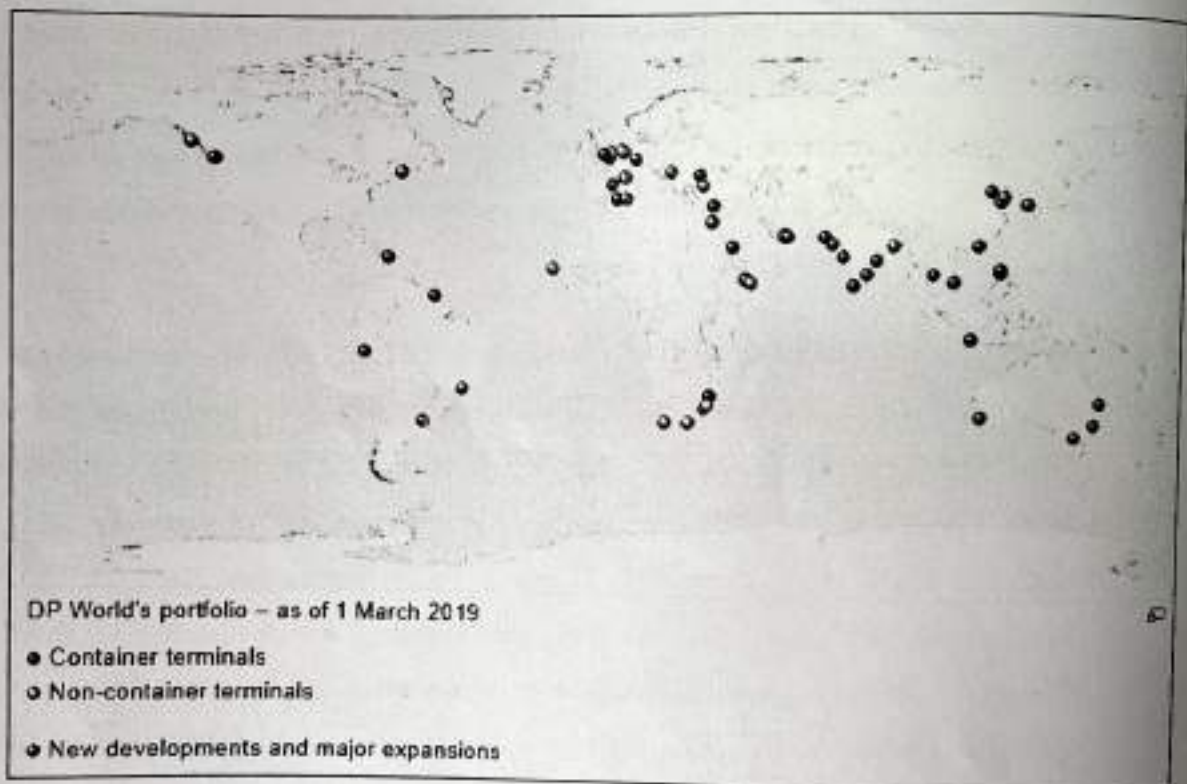
1.2 Core Services

1. **Port and Terminal Operations:** Management of 93 ports and terminals globally, including some of the world's busiest and most advanced facilities.
2. **Logistics Solutions:** Integrated end-to-end logistics, including warehousing, freight forwarding, and last-mile delivery.
3. **Marine Services:** Development and operation of free zones and business parks to facilitate trade and industrial growth.

4. **Technology & Sustainability:** Innovative technology-driven solutions to streamline global trade processes.

1.2. Global Presence

Trade powers economies, improving lives globally. With over 103,000 employees across 75 countries 6 Continents. The dedicated team from over 150 nationalities ensures the smooth flow of trade. DP World is pushing trade further and faster towards a seamless supply chain that's fit for the future.



2.0. Need of the Study

Currently, the DP World is expanding its port network. Under this, the company has decided to construct a new jetty at the Tuna port location near Tuna Village. For the construction of a new jetty at the location the EC & CRZ clearance is obtained by the company. (MoEF & CC file no. 10-9/2017-1A-III.).

For compliance with the conditions given by MoEF & CC, EC and CRZ clearance. The ambient monitoring of the site is necessary. Hence the project for ambient air quality monitoring at the premises of DP World is being provided to GUIDE.

This study on evaluation of ambient air monitoring will be carried out Three times in a year at four specified locations (Table 1) by employing the methodical investigation with special reference to the guidelines. GUIDE has received the Work order for this project with the project period being one year (September 2024 – August 2025) as given in Table 2.

2.1. Scope of Study

- To carry out "Assessment of Ambient air quality for DP World".
- To carry out seasonal monitoring of ambient air at 4 different locations during the construction process.
- Perform the analysis of ambient air quality parameters.

2.2. Selection of sampling locations for the study

The selection of a sampling location is necessary for carrying out ambient air quality monitoring. For selection of locations for monitoring our team conducted a site survey visit at Tuna Port, which was under construction. After completing the survey, the team decided to finalize four locations named: Point P1 (CH 0m), CH 300m, CH 600m, and CH 1200m. The map of the sampling locations are as shown in Plate 1 and the field visits of the team is shown in Plate 2.

Table 1: Locations of proposed sampling with Geo-coordinates

Station	Latitude (N)	Longitude (E)
Location 1 (Point P1 CH 0m)	22.915981	70.11986
Location 2 (CH 300m)	22.914103	70.121024
Location 3 (CH 600m)	22.912312	70.118826
Location 4 (CH 1200m)	22.908739	70.114428

3.0. Methodologies and Guidelines for Ambient Air Monitoring and Analysis

The sampling of ambient air is carried out by using RDS (Respirable dust Sampler) and FPS (Fine Particulate Sampler), and Gaseous sampler. The details of instruments used are given below.

3.1. Instruments Details

3.2. RDS (Respirable Dust Collector)

The sampler uses an improved cyclone with a sharper cutoff (D50 at 10 microns) to separate the coarser particulates from the air stream before filtering it on the glass microfibre filter. By using it, measurement of Respirable Particulate Matter can be done accurately and TSPM can also be assessed by collection of dust retained in the cyclone cup.

3.2.1. Special features:

- A brushless blower reduces equipment downtime and maintenance effort.
- Provision of light for flow and time reading during night.
- A Lockable casters, top cover, and gaseous attachment.
- Improved cabinet design which is sturdier and more durable with SS hardware.

It can be easily paired with a gaseous sampling attachment (for monitoring SO₂, NO_x, NH₃, Ozone, etc) as gaseous sampling requires only a few LPMs of airflow.

Table 2. Timeline showing the Work Elements of the project

Project Activities	Period			
	Sep'24 - Nov'24 -	Dec'24 - Mar'25	Apr'25 - Jun'25	Jul'25- Aug'25
Purchase of consumables and miscellaneous related to the project				
Planning and orientation for Project work				
Site Survey for selection of Ambient Air monitoring locations.				
First Season Sampling				
Analysis of samples of 1 st Season				
Submission of Preliminary Report				
Submission of First Season Report				
Second Season Sampling				
Analysis of samples of 2 nd Season				
Submission of Second Season Report				
Third Season Sampling				
Analysis of samples of Third Season				
Submission of Third Season Report				
Submission of Final Report				

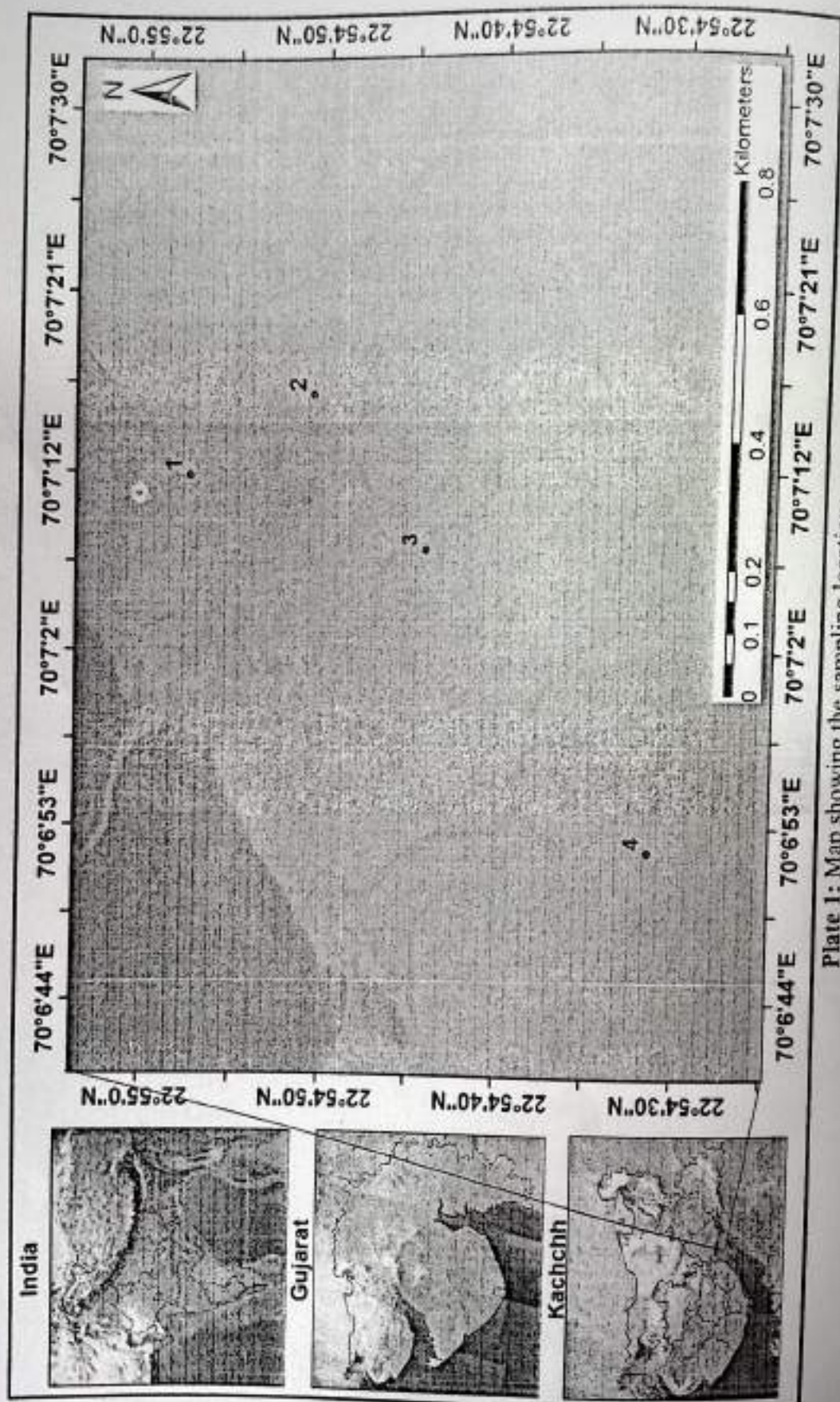


Plate 1: Map showing the sampling locations



Plate 2: Site Visit by the Team members at M/s DP world

3.3. FPS (Fine Particulate Sampler)

The manual method for sampling fine particles (PM 2.5 fraction) and is based on impactor designs standardized by USEPA for ambient air quality monitoring. Ambient air enters the sampler's system through an omnidirectional inlet designed to provide a clean aerodynamic cut-point for particles greater than 10 microns. Particles in the air stream finer than 10 microns proceed to a second impactor that has an aerodynamic cut-point of 2.5 microns. The air sample and fine particulates exiting from the PM 2.5 impactor are passed through a 47 mm diameter Teflon filter membrane that retains the fine particulate matter. The standard flow rate is set as 16.7 lpm. The standard system is supplied with a Dry Gas Meter to provide a direct measure of the total air volume sampled.

3.3.1. Sample Analysis Guidelines

Guidelines for sampling and analysis of sulphur dioxide in ambient air (Improved West and Gaeke Method)

3.3.2. Purpose

The purpose of this protocol is to provide guidelines for monitoring and analysis of Sulphur dioxide in ambient air.

3.3.3. Standard

The national ambient air quality standards for sulphur dioxide and nitrogen oxides is presented in the table 3 and 4.

Table 3: Permissible limits of Nitrogen-di-oxide in ambient air

Pollutant	Time Weighted Average	Concentration in Ambient Air	
		Industrial, Residential, Rural and other Areas	Ecologically Sensitive Area (Notified by Central Government)
Nitrogen dioxide (NO ₂), µg/m ³	Annual *	40	30
	24 Hours **	80	80

3.3.4. Principle of the method

Modified West & Gaeke Method (IS 5182 Part 2 Method of Measurement of Air Pollution: Sulphur dioxide)

Table 4. Permissible limits of Sulphur-di-oxide in ambient air

Pollutant	Time Weighted Average	Concentration in Ambient Air	
		Industrial, Residential, Rural and other Areas	Area (Notified by Central Government)
Sulphur Dioxide (SO ₂) µg/m ³	Annual *	50	20
	24 Hours **	80	80

Sulphur dioxide from air is absorbed in a solution of potassium tetrachloro- mercurate (TCM). A dichlorosulphitomercurate complex, which resists oxidation by the oxygen in the air, is formed. Once formed, this complex is stable to strong oxidants such as ozone and oxides of nitrogen and therefore, the absorber solution may be stored for some time prior to analysis. The complex is made to react with para-rosaniline and formaldehyde to form the intensely coloured pararosaniline methylsulphonic acid. The absorbance of the solution is measured by means of a suitable spectrophotometer.

3.4. Guidelines for sampling and analysis of Nitrogen dioxide in ambient air (Modified Jacob and Hochheiser Method)

3.4.1. Purpose

The purpose of this protocol is to provide guidelines for monitoring of nitrogen dioxide in ambient.

3.4.2. Standard

The national ambient air quality standard for nitrogen dioxide is presented in the table:

3.4.3. Principle of the method

Modified Jacob & Hochheiser Method (IS 5182 Part 6 Methods for Measurement of Air

Pollution: Oxides of nitrogen). Ambient nitrogen dioxide (NO_2) is collected by bubbling air through a solution of sodium hydroxide and sodium arsenite. The concentration of nitrite ion (NO_2^-) produced during sampling is determined colorimetrically by reacting the nitrite ion with phosphoric acid, sulfanilamide, and N-(1-naphthyl)-ethylenediamine di-hydrochloride (NEDA) and measuring the absorbance of the highly colored azo-dye at 540 nm.

3.5. Guidelines for sampling and analysis of Particulate Matter (PM_{10}) in ambient air (Gravimetric Method)

3.5.1. Purpose

The purpose of this protocol is to provide guidelines for monitoring and analysis of Particulate Matter PM_{10} in ambient air.

3.5.2. Standard

The national ambient air quality standards for Particulate Matter PM_{10} are presented in the table 5.

Table 5. Permissible limits of Particulate matter (PM_{10}) in ambient air

Pollutant	Time Weighted Average	Concentration in Ambient Air	
		Industrial, Residential, Rural and other Areas	Ecologically Sensitive Area (Notified by Central Government)
Particulate Matter, PM_{10} , $\mu\text{g}/\text{m}^3$	Annual *	60	60
	24 Hours **	100	100

3.5.3. Principle of the method

Air is drawn through a size-selective inlet and through a 20.3 X 25.4 cm (8 X 10 in) filter at a flow rate, which is typically 1132 L/min. Particles with aerodynamic diameters less than the cut-point of the inlet are collected, by the filter. The mass of these particles is determined by the difference in filter weights prior to and after sampling. The

concentration of PM_{10} in the designated size range is calculated by dividing the weight gain of the filter by the volume of air sampled.

3.6. Guidelines for determination of $PM_{2.5}$ in ambient air (Gravimetric Method)

3.6.1. Purpose

The purpose of this protocol is to provide guidelines for monitoring and analysis of Particulate Matter $PM_{2.5}$ in ambient air.

3.6.2. Standard

The national ambient air quality standards for Particulate Matter $PM_{2.5}$ are presented in the table 6.

Table 6. Permissible limits of Particulate matter ($PM_{2.5}$) in ambient air

Pollutant	Time Weighted Average	Concentration in Ambient Air	
		Industrial, Residential, Rural and other Areas	Ecologically Sensitive Area (Notified by Central Government)
Particulate Matter	Annual *	40	40
$PM_{2.5}$, $\mu g/m^3$	24 Hours **	60	60

3.6.3. Principle

An electrically powered air sampler draws ambient air at a constant volumetric flow rate (16.7 lpm) maintained by a mass flow / volumetric flow controller coupled to a microprocessor into specially designed inertial particle-size separator (i.e. cyclones or impactors) where the suspended particulate matter in the $PM_{2.5}$ size ranges is separated for collection on a 47 mm polytetrafluoroethylene (PTFE) filter over a specified sampling period. Each filter is weighed before and after sample collection to determine the net gain due to the particulate matter. The mass concentration in the ambient air is computed as the total mass of collected particles in the $PM_{2.5}$ size ranges divided by the actual volume

of air sampled, and is expressed in $\mu\text{g}/\text{m}^3$. The microprocessor reads averages and stores five-minute averages of ambient temperature, ambient pressure, filter temperature and volumetric flow rate. In addition, the microprocessor calculates the average temperatures and pressure, total volumetric flow for the entire sample run time and the coefficient of variation of the flow rate.

4.0. Details of the Work completed

4.1. Reconnaissance Survey

As a part of the Ambient Air Quality monitoring project of M/s DP World entrusted to Gujarat Institute of Desert Ecology, Bhuj. In this regard, Gujarat Institute of Desert Ecology, Bhuj has conducted a Reconnaissance Survey for selection of Ambient Air monitoring as the reconnaissance survey helps to identify suitable monitoring locations that accurately represent the ambient air quality. It is really important to conduct a Reconnaissance Survey in Ambient Air Monitoring in coastal areas as this is a critical initial step in ambient air monitoring, especially in coastal areas undergoing development. It also helps in identifying key factors that influence air quality and ensures that the monitoring process is effectively planned and executed. Moreover, coastal environments have unique meteorological conditions, including sea breezes, humidity, and wind patterns that influence pollutant dispersion. In addition, development activities such as construction, industrial expansion and shipping operations can introduce pollutants like particulate matter (PM), sulfur oxides (SO_x), and nitrogen oxides (NO_x) and such survey helps distinguish between natural emissions and anthropogenic pollution sources. Coastal areas experience dynamic weather conditions that affect pollutant transport and dilution. Hence, the survey assesses wind direction, humidity levels, and temperature variations to optimize monitoring strategies. Further, the study will help to identify sensitive receptors such as residential areas, marine ecosystems, and wildlife habitats that may be affected by air pollution.

Table 7: Descriptive statistical values of ambient air quality parameters with GPCB permissible limits.

S. No.	Parameters	Min	Max	Mean	SD	GPCB Limits ($\mu\text{g}/\text{m}^3$)
1	PM ₁₀ ($\mu\text{g}/\text{m}^3$)	125.49	545.00	290.69	199.30	100
2	PM _{2.5} ($\mu\text{g}/\text{m}^3$)	62.08	100.84	75.05	17.50	60
3	NO _x ($\mu\text{g}/\text{m}^3$)	9.77	23.04	15.64	5.91	80
4	SO ₂ ($\mu\text{g}/\text{m}^3$)	0.23	2.11	1.12	0.79	80

4.2. Description of the data collected during First season sampling

Among the four locations studied, Near Point P1 (CH 0 m), Near CH 300 m, Near CH 600 m and Near CH 1200 m, all the four locations recorded an above permissible limit in case of PM₁₀ and PM_{2.5} where the value of PM₁₀ ranged between 125.49 – 545 $\mu\text{g}/\text{m}^3$ in case of PM_{2.5} it was 17.5 – 100.84 $\mu\text{g}/\text{m}^3$, whereas the values of Nitrous oxide (5.91 – 23.04 $\mu\text{g}/\text{m}^3$) and Sulphur-di-oxide (0.23 – 2.11 $\mu\text{g}/\text{m}^3$) were well within the Permissible limits as prescribed by GPCB which is 100 $\mu\text{g}/\text{m}^3$ for PM₁₀ and 60 $\mu\text{g}/\text{m}^3$ for PM_{2.5} and 80 $\mu\text{g}/\text{m}^3$ for NO_x and SO₂ as shown in Table 7. The reason for higher concentration of PM₁₀ and PM_{2.5} can be attributed to various scientific reasons because coastal regions in general experience high levels of sea spray, which generates sea salt aerosols and such particles contribute significantly to PM₁₀ and to some extent PM_{2.5} due to the evaporation of water, leaving behind fine salt residues. Coastal areas often experience atmospheric transport of pollutants from inland sources due to wind patterns, leading to accumulation of particulates over time. But majorly, industrial and urban activities including shipping activities and industries located near coasts, contributing to higher emissions of fine particulates. Shipping emissions, including sulfur oxides (SO_x) and nitrogen oxides (NO_x), can lead to the formation of secondary PM_{2.5}. These combined factors make coastal regions particularly vulnerable to elevated PM₁₀ and PM_{2.5} levels, impacting air quality and human health.

Draft Report

**Shoreline Change Assessment Studies Using Satellite
Imageries for the Proposed Hindustan Gateway Container
Terminal Kandla Private Limited (HGCTKPL) Project by DP
World, Tuna, Gujarat, India**

Submitted to: -

**Hindustan Gateway Container Terminal Kandla Private
Limited (HGCTKPL), DP World**

Submitted by: -



Gujarat Institute of Desert Ecology

**P.O. Box # 83, Opp. Changleshwar Temple,
Mundra Road, Bhuj,
Kachchh-370001, Gujarat**

February-2025

Project Personnel

Project Coordinator
Dr. V. Vijay Kumar, Director

Principal Investigator
Mr. Dayesh Parmar, Project Officer
Mr. Ketan Yogi, JRF

Team Member
Mr. Chetanbhai Pandya & Team (DGPS Survey)

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1. INTRODUCTION

The shoreline is the zone where large bodies of water, such as an ocean or lake, meet the land. The coastal shoreline is a dynamic interface that undergoes changes due to various coastal processes such as wave characteristics, nearshore circulation, sediment characteristics and beach morphology. Shoreline changes result from littoral transport, which moves eroded materials along the coast via waves and currents (Misra and Ramakrishnan, 2015). Developmental activities such as port construction, beach sand mining, industrialization, urbanization, and reduction in sediment supply from rivers have significantly altered shoreline dynamics (Kannan and Malarvannan, 2016).

Sustainable development and protection of the coastal environment are crucial, as shoreline changes can have cascading effects on adjacent regions. Regular monitoring of shoreline areas is essential to alleviate risks and plan for sustainable development (Tamassoki *et al.*, 2014).

1.1. Gujarat

Gujarat is situated on the western coast of India, bordering the Arabian Sea. Among the maritime states of India, Gujarat has the longest coastline of around 1,650 km, which supports a wide variety of habitats with diverse marine flora and fauna. The state has two gulfs out of the three gulfs present in the country; the Gulf of Khambhat is located along the southern coast and the Gulf of Kachchh is located along the western coastal area of the State. The coastal area is further delineated between high rainfall area (2500 mm in southern Gujarat) and low rainfall area (250 mm in the northwest part of Kachchh). The coast experiences a different range of tides, waves, cyclones, and currents in the sea, affecting the physical as well as the biological conditions of the whole marine ecosystem.



1.1.1. Gulf of Kachchh

The Gulf of Kachchh is situated along the west coast of Gujarat in India. It is about 170 Km in length. The coastal stretch of Kachchh district constitutes the entire northern coast of the Gulf of Kachchh (GoK) which is endowed with very high biological richness and physical and chemical peculiarities. Despite its high aridity (4 on a scale of 1- 4) and poor annual mean rainfall (340 mm), the Kachchh coast has diverse ecological habitats and ecosystems like mangroves, sandy coasts, mudflats, creeks and other tidal incursions which enhance manifold its coastal landscape diversity and its natural resources.

In the late 1990s, industrial development was promoted aggressively in Kachchh due to its very rich mineral deposits, the short sea routes to Gulf countries and easy availability of land which were considered best than the other coastal regions of the state. The announcement of tax holidays during the post-earthquake in 2001 by the State government has provided further impetus for coastal industrial development. Many of these developments are anticipated to have some implications on ecological, social, and economic spheres. In addition, Kachchh coast also faces threats from climate change, desertification and land degradation along with pollution and habitat changes which are crucial for understanding the impacts on the shoreline areas.

Morphological change is responsible for the change in coastal structure or shape, which occurs due to tidal patterns. The changes can be estimated by different methods like aerial photography, field survey using GPS, Satellite Remote Sensing data, LIDAR, etc.

The shoreline changes occurring due to processes like accretion and erosion of substratum can be analysed in a Geographic Information System (GIS) by examining differences between the shoreline of different years. Shoreline proxies include the high-water line, vegetation line and dunes among many others. (Jodhani *et al.*, 2020)



1.2. About Hindustan Gateway Container Terminal Kandla Private Limited, (HGCTKPL),

DP World is a global logistics company that provides services such as Marine Services, Inland Terminals, Industrial Parks, Technology-Driven Customer Solutions, Cargo Logistics, Port Terminal Operations and Free Trade Zones.

HIPL won the bid in January, 2023 for the development of Tuna Tekra Container Terminal (TTCT) on PPP basis from Deendayal Port Authority on BOT basis for a period of 30 years. A special purpose company was formed, "Hindustan Gateway Container Terminal Kandla Private Limited" (HGCTKPL), under the Companies Act to execute the project.

ABOUT PROJECT

The components of the project as specified in the Concession Agreement (CA) are development of Berth length of 1100 meters (extendable up to 1375 meters) and width of 54 meters. Berth to be designed for handling vessels of at least up to 6000 TEUs drawing a draft of 14 meters. Depth at the approach and berth pocket shall be of 15.4 meters below CD and 16.1 in turning circle. The project encompasses a backup area of 54.2 ha. The length of the Trestle is 1650 meters and width of 20 meters. The DPA will provide two lane temporary access road for the construction phase and two-lane permanent road and also will provide a take-off point for a private railway siding to be built by the Concessionaire.

CHRONOLOGY OF EVENTS

- ✓ The CA was signed between the DPA and HGCTKPL on 25th August 2023.
- ✓ Within 6 months of signing of the CA both parties had to fulfil their respective CPs. The design consultants, Royal Haskoning was onboarded in September 2023.



- ✓ Fugro International has completed Topo and Bathymetry surveys/studies in December 2023. The CPs were fulfilled by both parties in early March 2024
- ✓ The project site of approximately 64 hectares was taken over from DPA.
- ✓ The Letter of Award of Concession was issued on 14th March 2024, signifying start of Concession Period of 30 years and three years of Construction Phase.
- ✓ The appointment of the Independent Engineer, RITES, took effect from the date of Award of Concession. Advance works under execution since May 2024.

1.3. Origin of the Study

DPA has obtained Environmental and CRZ Clearance for a waterfront development project at Tuna, Kachchh District, Gujarat, and as a part of EC/CRZ Clearance condition, HGCTKPL shall undertake "The shoreline changes in the area shall be monitored periodically and the reports to be submitted every 6 months to RO, Bhopal".

HGCTKPL had undertaken in line with the MoEF&CC Order dated 18th September, 2015 for the projects already granted Environmental Clearance and CRZ Clearance in the region so that future developments can be assessed for providing necessary approvals at a later stage. As a part of the Environmental Management Plan (EMP) compliance, HGCTKPL shall undertake a study "To map the coastal morphology (Shoreline) at least once in three years". Therefore, HGCTKPL has approached M/s. Gujarat Institute of Desert Ecology (GUIDE) to conduct the intensive monitoring of shoreline changes through high-resolution satellite imageries (LISS-IV). The present report compiles the results of shoreline change analysis by using latest high spatial resolution satellite imageries and ground truthing by highly accurate DGPS survey along 24 km stretches of Hindustan Gateway Container Terminal Kandla Private Limited (HGCTKPL). Due to the dynamic nature of shoreline

boundary, it is essential to understand the long and short-term rate of shoreline changes from a coastal vulnerabilities point of view.

1.4. Objectives of the Study

1. To map and compare decadal changes in Shoreline behavioral by using LISS IV high resolution satellite imageries of 2014 and 2024.
2. To identify the zones of high erosion and accretion using LISS-IV, high-resolution satellite imageries.
3. Collection of shoreline information using DGPS, at 200-meter interval along the coastal route at the high tide line, along the 24 km stretch around the project site.
4. Shoreline data through the ground truthing using DGPS Survey and superimposing on the latest satellite data.
5. Superimposing current shoreline on the approved CZMP in line with CRZ Notification, 2019 prepared by National Centre for Coastal Management (NCSCM).

2. STUDY AREA

2.1. Location

Tuna SEZ is to be located southwest of Deendayal Port at a distance of around 2 km from its periphery. Kandla and Tuna area is separated by Nakti creek. Land cover in the terrain is mostly sparse halophytic vegetation like scrubby mangroves, creek water and salt encrusted land mass. Major land component in the earmarked Tuna area is salt encrusted land without any vegetation and site is biologically not very productive. The surrounding environs consisting salt works, industrial establishments and port related structures on North and West creek system and mangroves as well as mudflats in the South and East.

The present study investigates shoreline changes along the coastal stretch of Tuna, extending from the western side of Vira Bandar to the eastern side of Kandla. These 24 km-long coastlines comprise two segments; a 12 km stretch to the west of the Hindustan Gateway Container Terminal Kandla Private Limited (HGCTKPL) and a 12 km stretch along the Deendayal Port Authority (DPA) side of Tuna Tekra.

The TTCT lies within the geographical coordinates of:

- Western boundary: 22°52'00"N, 70°00'00.0"E
- Eastern boundary: 23°01'00.0"N, 70°09'00.0"E

These spatial boundaries are depicted in Figure 2.1 and form the focus of this study on shoreline dynamics within the designated region.

2.2. Climate

As per the Indian Meteorological Department, Govt. of India, the highest monthly mean of daily maximum temperature of the study area is 36°C. The dry bulb temperature goes up to 47.8°C, considering max Humidity of 95%. The wind is predominantly from the south-west as well as from the west to some extent and the wind velocity is up to 65 km/hr.

Due to its arid nature, annual rainfall in Kachchh is poor, ranging from 250-350 mm which is often irregular. However, the mean annual rainfall during 1932 to 2021 was higher at Tuna (478 mm) comparing to other coastal talukas of Kachchh district. Rain during monsoon is confined to only 12-16 days and occurs as an instant downpour. Freshwater input into the near coastal waters is quite meagre and appears to influence the coastal erosion. Annual temperature fluctuation in the district is extreme, ranging from 7- 47 °C with a yearly average humidity of 60% which increases to 80% during the southwest monsoon and decreases to 50% during November-December. The phenomenon of drought is common, with 2 drought years in a cycle of 5 years (Thivakaran *et al.*, 2015).

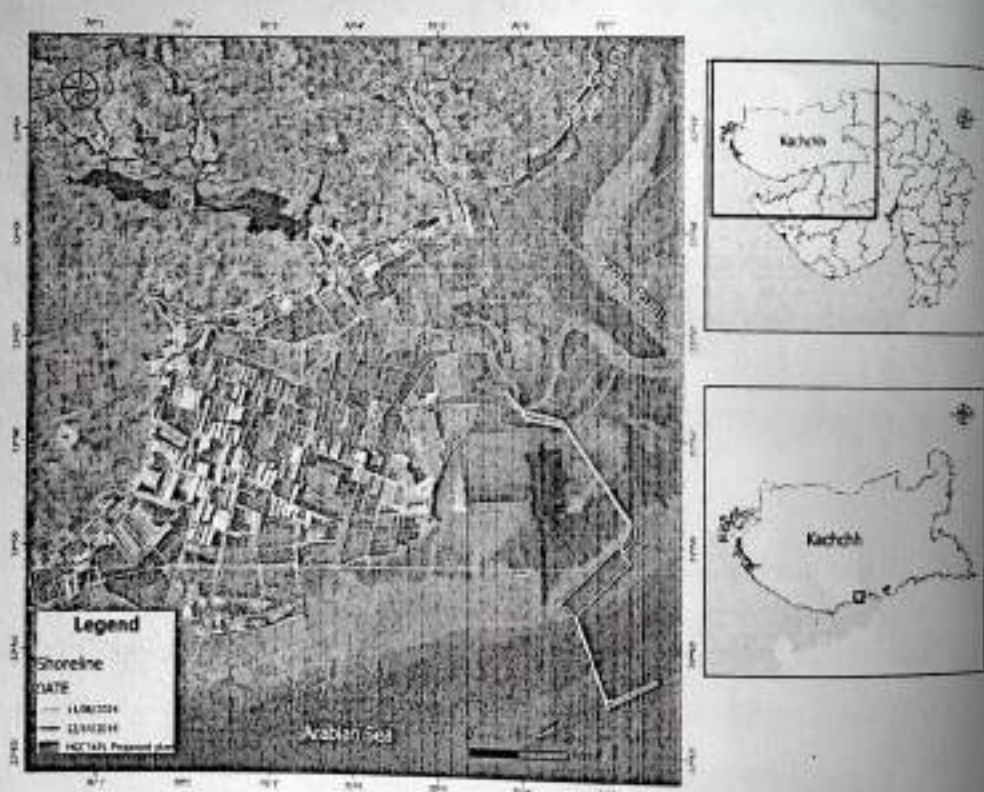


Figure 2.1: Location Map of The Study Area

2.2.1. Tidal Regime

Tides near Mundra are the mixed type, predominantly semidiurnal type with a Mean High-Water Spring (MHWS) of 6.66 m and Mean High water Neap (MHWN)

of 5.17 m. The phase difference is not uniform for successive tides in the Gulf and it varies as per tidal conditions (ICMAM, 2004).

2.2.2. Currents

The currents in the Gulf and associated creeks are largely tide induced and oscillations are mostly bimodal reversing in direction with the change in the tidal phase. The influence of wind on variations in current is minor. The current reversals are quite sharp occurring within 30 - 60 min. The maximum current speed varied from 0.5 to 1.2 m/s. The predominant direction of the current is 45° during flood and 220° during ebb.

The circulation is generally elliptical with the major axis in the east-west direction. These trajectories suggest that the excursion lengths are in the range of 10 to 15 km depending on the tidal phase (neap or spring) (NIO, 2009).

2.2.3. Salinity

Salinity is an indicator of freshwater intrusion in nearshore coastal waters as well as the excursion of salinity in inland water bodies such as estuaries, creeks, and bays. Normally seawater salinity is 35.5 ppt but may vary depending on evaporation, precipitation, and freshwater addition. Salinity largely influences several processes such as dissolution, dispersion, dilution, etc in seawater due to high dissolved salt content and high density. In the absence of freshwater inflow, the salinity varies from 35.9 to 38.0 ppt.



3. METHODOLOGY AND DATA USED

The shoreline change analysis has been carried out by using multi-date satellite images to estimate the rate of change in terms of distance of the shore eroded or accreted using a cross-shore profile in terms of area and volume. From the satellite images, the shoreline has been extracted after rectification and co-registration. The rate of shoreline changes from 2014 to 2024 has been analysed and compared with the DGPS survey and ground truthing data for which Digital shoreline change analysis system (DSAS) software that works within the Geographic Information System (ArcGIS) software was applied. DSAS computes rate-of-change statistics for a time series of shoreline vector data. It is also useful for computing rates of change for other boundary conditions that incorporate a clearly-identified feature position at discrete times (Himmelstoss *et al.*, 2018). The methodology flowchart of the present study on the shoreline change is shown in (Figure 3.1)

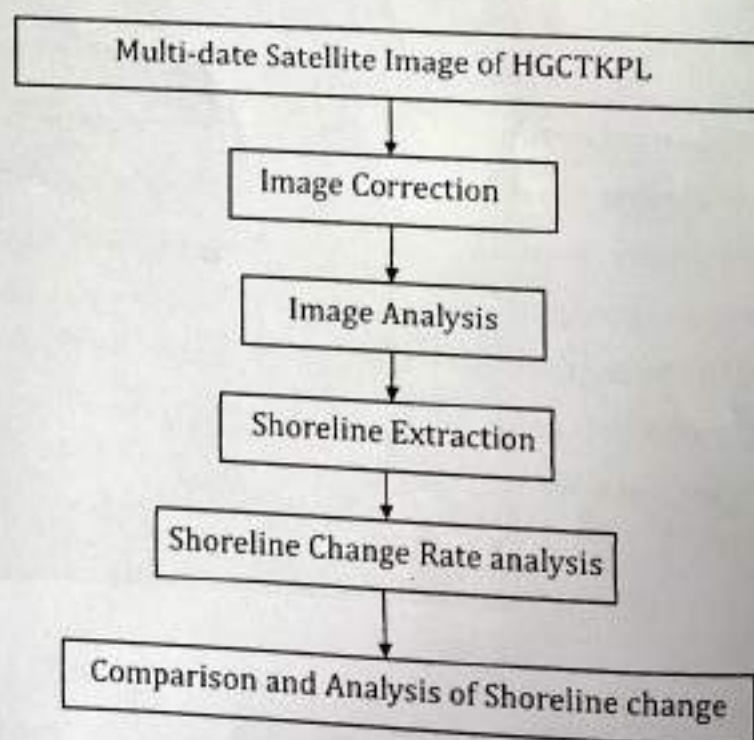


Figure 3.1: Flowchart of the Methodology Adopted

3.1. Short Term Shoreline Change Analysis

The end point rate (EPR) is calculated by dividing the distance of shoreline movement by the time elapsed between the oldest and the most recent shoreline (Figure 3.2). The major advantages of the EPR are the ease of computation and the minimal requirement of only two shoreline dates. The major disadvantage is that in cases where more data are available, the additional information is ignored.

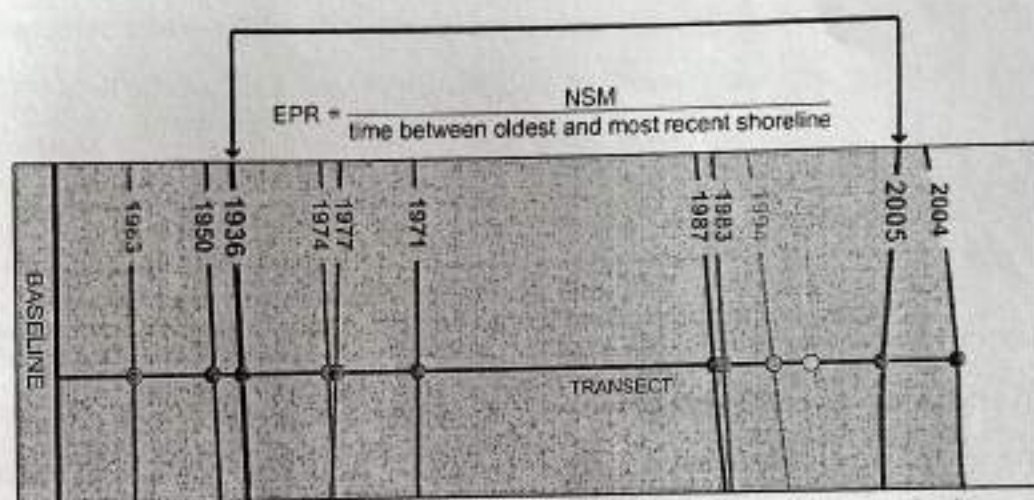


Figure 3.2: Method of Short-Term Shoreline Change Analysis
(Sample image source: (Sweet *et al.* 2017))

3.2. Long Term Shoreline Change Analysis

The linear regression rate-of-change (LRR) statistic was determined by fitting a least-squares regression line to all shoreline points for a particular transect (Figure 3.3). The regression line is placed so that the sum of the squared residuals (determined by squaring the offset distance of each data point from the regression line and adding the squared residuals together) is minimized. The linear regression rate is the slope of the line. However, the linear regression method is susceptible to outlier effects and also tends to underestimate the rate of change relative to other statistics (Sutikno *et al.*, 2017).

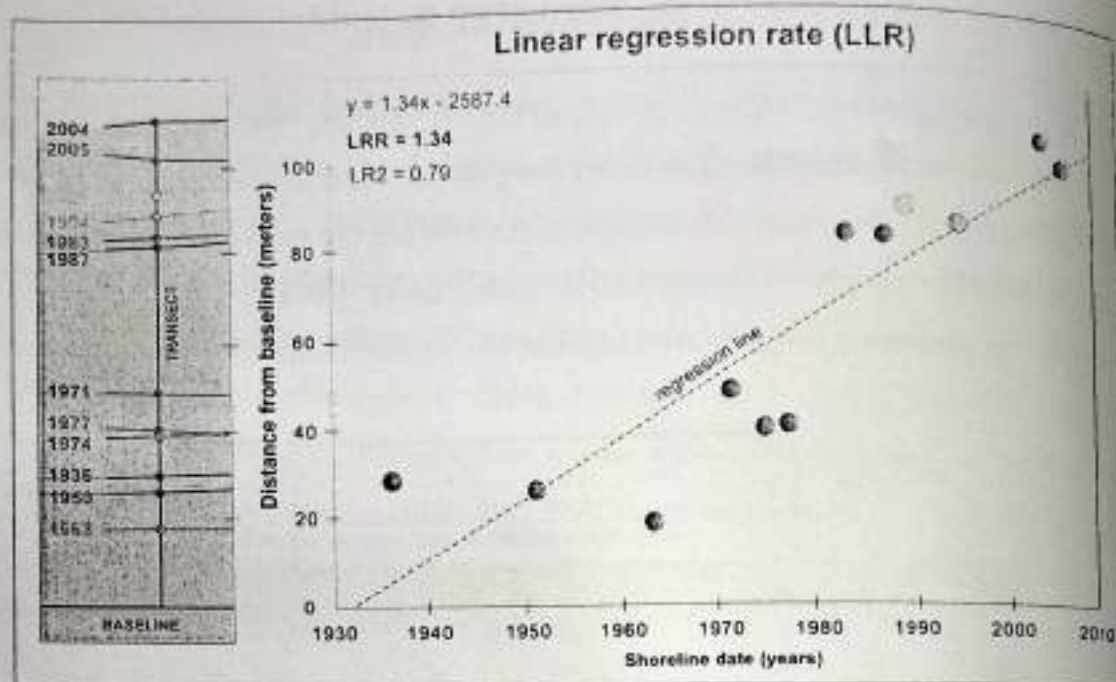


Figure 3.3: Calculation of Long Term (LRR) Shoreline Change Analysis
(Sample image source: (Sweet *et al.* 2017))

3.3. Data Used

The multi-date satellite imageries, LISS-IV was procured from NRSC, Hyderabad was used for the analysis of the present study. The details of the satellite imagery used for the present study are given below (Table 3.1).

Table 3.1: High-resolution Satellite Data for Shoreline Procured From NRSC

Satellite	Date	Sensor	Resolution (m)
IRS-R2	14 Dec 2014	LISS-IV	5.8
IRS-R2A	08 Nov 2024	LISS -IV	5.8

3.3.1. Pre-processing

Pre-processing of satellite data includes correction of geometric, atmospheric, and radiometric aspects and clipping of the area to obtain the exact imagery of the project sites. The rectification operation aims to correct distorted images to create

a more faithful representation of the original scene. It typically involves the initial processing of raw image data to correct geometric distortions.

Radiometric Correction: Radiometric correction addresses variations in the pixel intensities (DNs) that have not been caused by the object or scene scanned. These variations include differing sensitivities or malfunctioning of the detectors, topographic effects and atmospheric effects.

Geometric Correction: Geometric correction addresses errors in the relative positions of pixels. These errors are induced by sensor viewing geometry or terrain variations. A geometric correction was done based on Ground Control Points (GCPs) and the image was re-sampled using the nearest neighbourhood interpolation method.

Shoreline Extraction: Continuous shoreline positions were extracted automatically and digitized manually for two different periods *i.e.*, 2014 and 2024. Digital Shoreline Analysis System (DSAS) version 5.1, an extension of ESRI ArcGIS software was used to calculate rate of change shoreline statistics from a time series of multiple shoreline positions, which is purely a statistical approach. The shoreline positions were compiled in ArcGIS with 5 attribute fields that included Object ID (a unique number assigned to each transect), shape, shape length, ID, date (original survey year) and uncertainty values. All different shoreline features were then merged within a single line on the attribute table, which enabled the multiple coastline files to be appended together into a single shape file. The Shoreline change rate was calculated by Endpoint Rate (EPR) for the short term and Linear Regression Rate (LRR) for the long-term period. A baseline was digitized onshore by closely digitizing the direction and shape of the outer shoreline, which was used as the starting point for all transects (Figure 3.4).



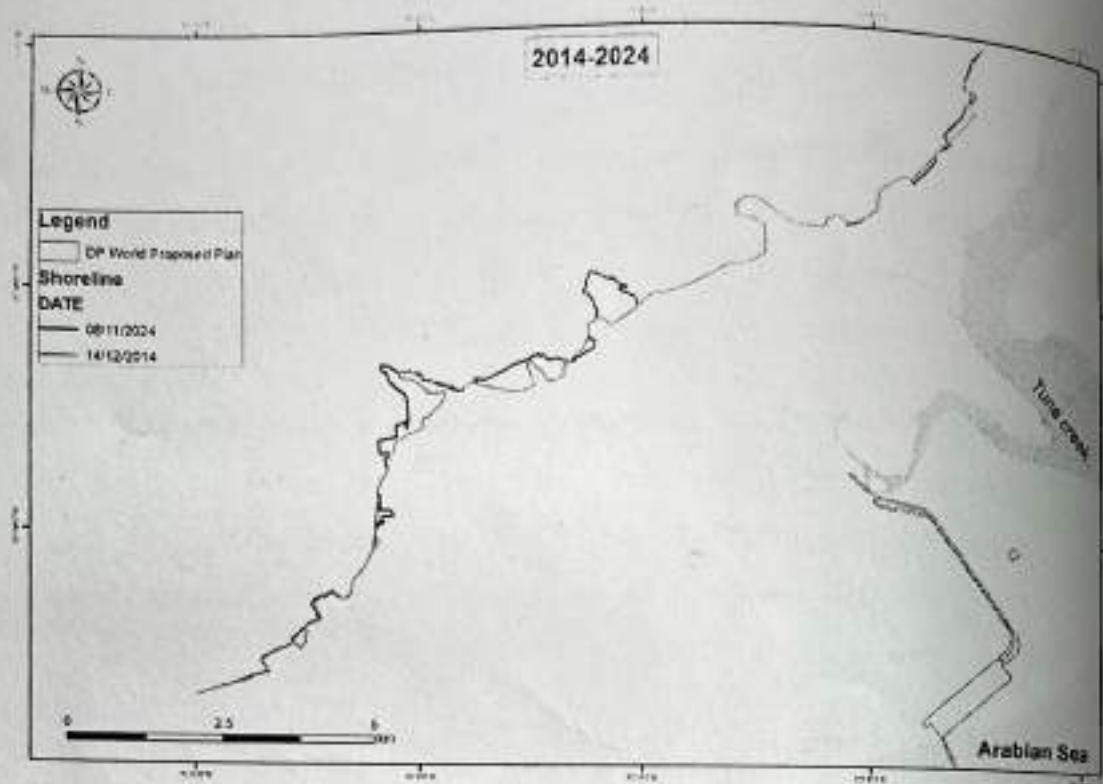


Figure 3.4: Shoreline Digitization for Different Years Using Multi-Date Satellite Imageries.

3.4. Field Work

Field investigation is a vital part of the project. Fieldwork helps to check and collect most of the ground information required for shoreline mapping. The field work was conducted during the period between 22th November 2024 and 9th January 2025 for the DGPS survey and collecting ground truthing data.

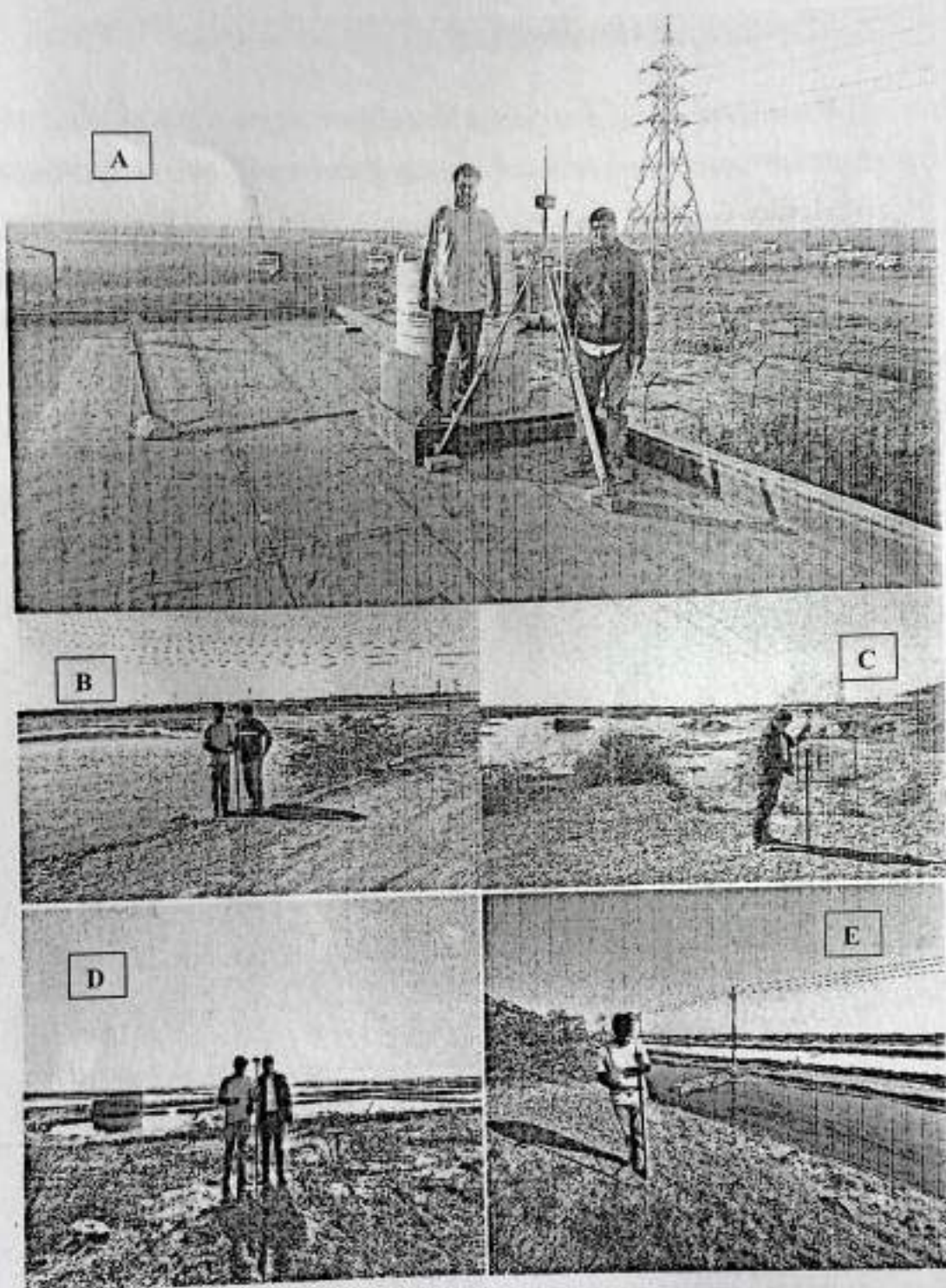


Figure 3.5: Establishing DGPS Base Station (A) Survey and Ground Truthing Data(B), (C), (D), (E) Using Rover.








4. RESULTS AND ANALYSIS

In the present study, the rate of shoreline changes statistics on a time series of multiple shoreline positions of a totally 24 km coastline stretches on either side of Hindustan Gateway Container Terminal Kandla Private Limited (HGCTKPL) has been taken in to account for the calculation by using satellite images. A total of 915 transects were generated with 10 m spacing along the shoreline. The variations in the rate of shoreline change were re-coded as N - S coast configuration. The shoreline change analysis was carried out for 2014-2024, the short-term shoreline change analysis method EPR was carried out using high-resolution images such as LISS-IV.

As a part of the MOEF & CC Compliance, the shoreline change analysis has been carried out for the years 2014-2024 to study short-term variation for the year 2014-2024 using EPR method has been carried out.

Based on the rate of change over the period, shoreline change has been categorized into seven classes National shoreline Assessment system (N-SAS, 2022).

Table 4.1: Shoreline Change Classification

Classification	Rate (m/year)	Colour Schemes
High Erosion	> -5.0	
Moderate Erosion	-5.0 to -3	
Low Erosion	-3.0 to -0.5	
Stable Coast	-0.5 to 0.5	
Low Accretion	0.5 to 3.0	
Moderate Accretion	3.0 to 5.0	
High Accretion	> 5.0	

4.1. Results For Shoreline Change Analysis From Satellite Images

The erosion and accretion are highlighted with red and blue colour respectively for better understanding. The study area is divided into two major blocks (1) West side and (2) Eastern side for accurate analysis as shown in Figure 4.1.



Figure 4.1: Study Area in Two Blocks.

4.1.1. Results for Overall Shoreline Change From 2014 to 2024

The analysis of high-resolution LISS-IV (5.8m) satellite images for the period 2014 to 2024 has revealed significant decadal changes in shoreline dynamics. The study identified substantial variations in erosion and accretion patterns across the study area, highlighting the dynamic nature of the coastline. The results indicate a high rate of accretion, with a maximum of 28.63 m/year, particularly observed in areas with favourable sediment deposition conditions. Conversely, the highest rate of erosion reached -102.48 m/year, predominantly affecting regions exposed to strong wave action and tidal influences. The shoreline's transition to stable coastal

conditions in certain segments suggests a complex interplay of natural processes and anthropogenic activities.

The eastern section of the study area, except for a few pockets with high to moderate erosion, remained relatively stable, indicating the presence of protective natural barriers or reduced exposure to erosive forces. In contrast, the western side of the proposed port exhibited significant erosion in most areas, potentially due to increased human intervention, sediment transport imbalances, and hydrodynamic changes (Figure 4.2). These findings underscore the need for targeted coastal management strategies to mitigate erosion and enhance the accretion in requisite areas.

A summary of the instantaneous rate of shoreline changes recorded from 2014 to 2024 is provided in Table 4.2. The data indicate that shoreline changes were highly dynamic, with no consistent pattern across the study sites. However, the rate of change was comparatively higher on the western side of the port over the past decade, emphasizing the need for continuous monitoring and adaptive management approaches to sustain coastal stability.

Table 4.2: Details of Average and Maximum Short Term Shoreline Changes

Period	Name of the Block	Average Shoreline Change(M/Year)	Shoreline Change(M)	
			Maximum Accretion	Maximum Erosion
2014-2024	Block A	-10.32	28.63	-102.48
	Block B	-0.94	10.78	-17.09

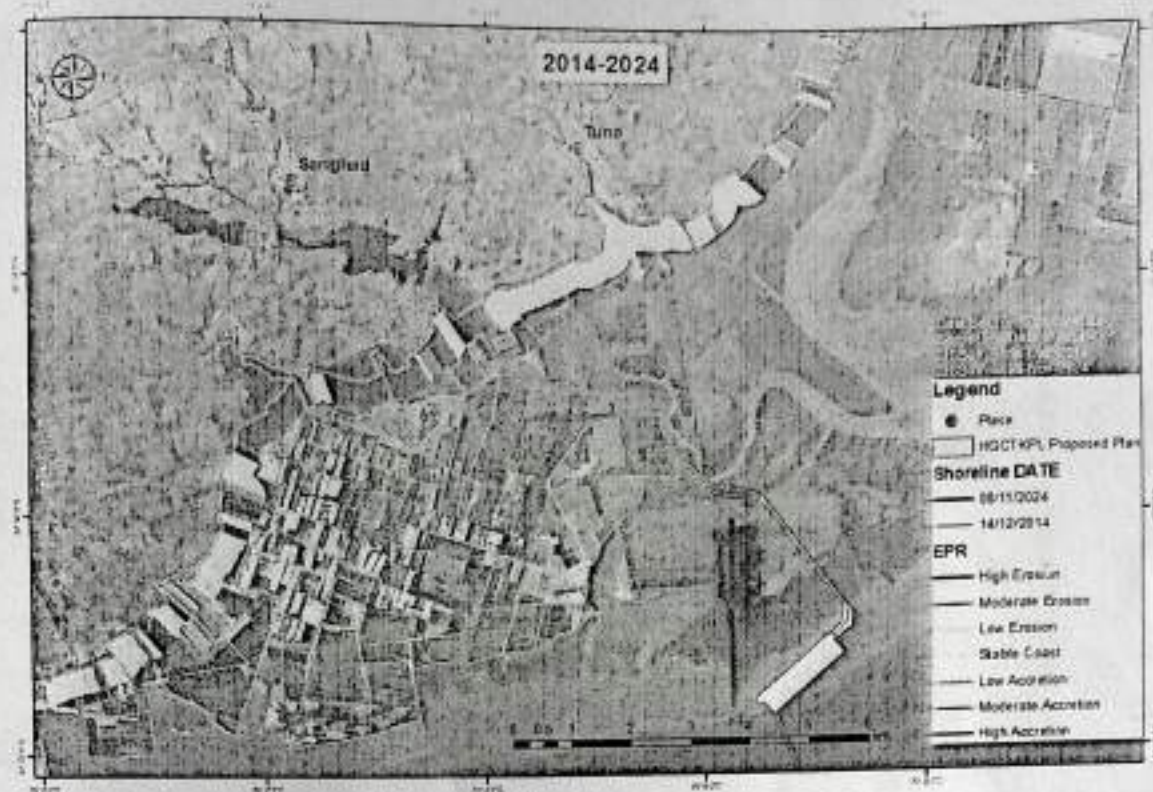


Figure 4.2: Shoreline Changes During Dec 2014 to Nov 2024

4.1.2. Zones of High Erosion and High Accretion

For the present study, shoreline changes were evaluated using a single set of high-resolution (5.8m) satellite images captured between 2014 and 2024. The analysis categorized the shoreline into distinct zones of high erosion and high accretion, the results are presented in Figure 4.3.

Based on the imagery analysis, the study area was delineated into zones to facilitate classification within the study limits. The findings indicate that a total distance of 1.59 km falls under the high accretion zone, while approximately 7.19 km of the shoreline, particularly near the downstream area of the dam near Sanghad village, is classified as a high erosion zone (Figure 4.3).

Out of the 24km stretch, 7 locations showed high erosion which is ranging from 0.09km to 3.12 in different locations.



Figure 4.3: Zones of High Erosion and High Accretion

Ground verification of the shoreline data of the 24 km coastal stretch of Hindustan Gateway Container Terminal Kandla Private Limited (HGCTKPL), using Differential GPS (DGPS) has been carried out from 8th to 9th January 2025 (**Figure 4.4: DGPS shoreline data superimposed on satellite image of 2024**

Error! Reference source not found.). The results obtained using DGPS field data is quite match the shoreline details derived from the high-resolution satellite image of LISS IV data of 2024.

The shoreline data derived from high-resolution LISS IV satellite imagery 2024 and Ground truthing data with high accurate DGPS data has been superimposed on NCSCM (National Centre for Coastal Management) approved CRZ map 2019 map (**Figure 4.4: DGPS shoreline data superimposed on satellite image of 2024**

Figure 4.5) which is quite similar with the shoreline configuration derived from the NCSCM approved CRZ map of 2019 data.



Figure 4.4: DGPS shoreline data superimposed on satellite image of 2024

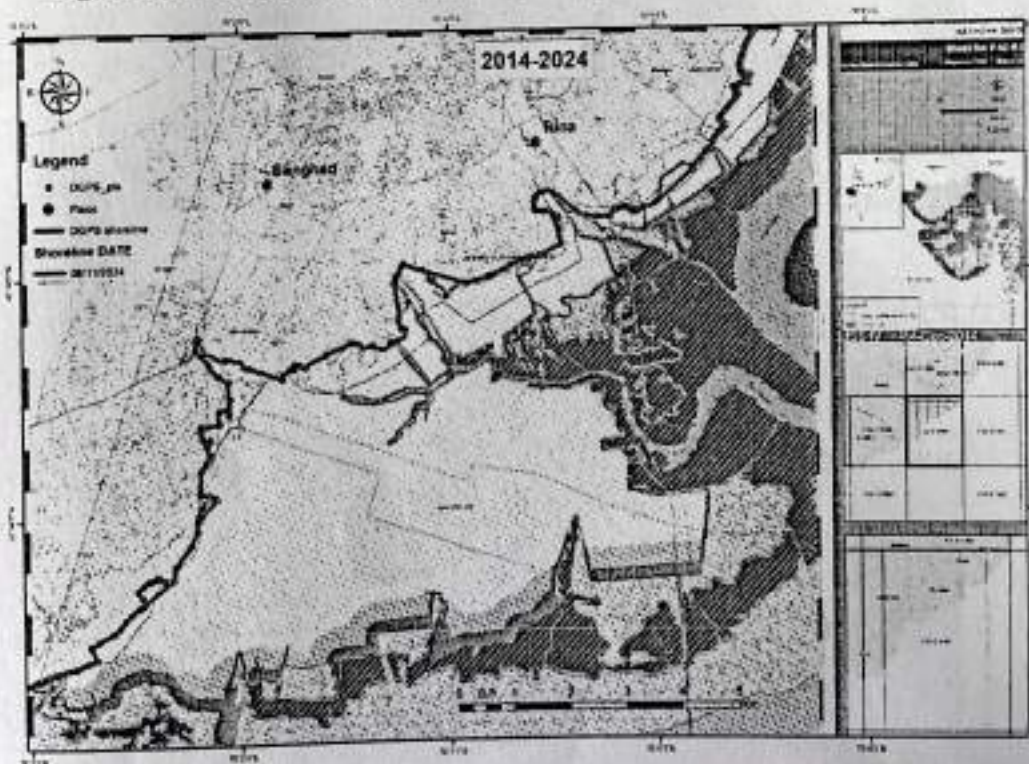


Figure 4.5: DGPS Shoreline Data and Shoreline Data of Generated from Satellite Image Of 2024 Superimposed on CZMP in Line with CRZ Notification, 2019 Prepared by (NCSCM).

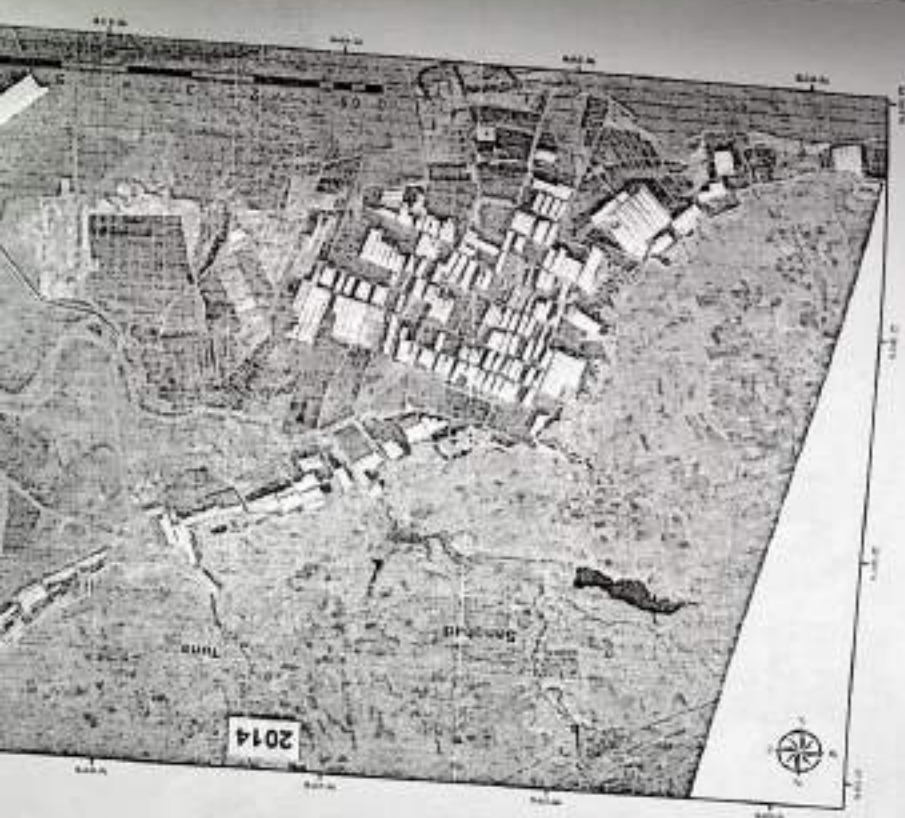
UJIAN KUALA RUMAH TERHADAP PROJEK PENGEMBANGAN
Dec 2014



UJIAN KUALA RUMAH TERHADAP PROJEK PENGEMBANGAN

SHORELINE CHANGE ASSESSMENT STUDIES USING SATELLITE IMAGES FOR THE PROPOSED DEVELOPMENT OF HINDUSTAN GATEWAY CONTAINER TERMINAL, GUJARAT, INDIA

Figure 4.6: Satellite Image of the Study Area During



SHORELINE CHANGE ASSESSMENT STUDIES USING SATELLITE IMAGES FOR THE PROPOSED DEVELOPMENT OF HINDUSTAN GATEWAY CONTAINER TERMINAL, GUJARAT, INDIA



Figure 4.7: Satelliteimage of the Study Area During Nov 2024

locations 1,2,3 and 7 showed minor area, with a length ranging from 0.09 to 0.66km, while the length of the coastal erosion area was higher in case of locations 4-6 (ranged from 1.36 to 3.12 km), and highest length of 3.12 km was recorded at location No. 4 and is followed by 1.50km in location No. 5 (Figure 4.8).

The process of erosion is highest along the edges (close to the waterfront). Erosion, either man-made or natural is a major threat to intertidal habitats in the Gulf environment due to altered hydrological regimes and other natural causes. The typical process to prevent coastal erosion is to identify the factors influencing the erosion in the area so as to provide appropriate strategies to reduce the same. Among the 7 locations, 1 to 5 and 7th locations the erosion is caused due to expansion of salt pans which significantly increased the salinity as well as alteration of natural drainage patterns of the area leading to higher erosion rates compared to unaffected regions. In the 6th location, situated along the downstream of Sanghad is caused by multiple causes such as water drainage and salt pan activities.

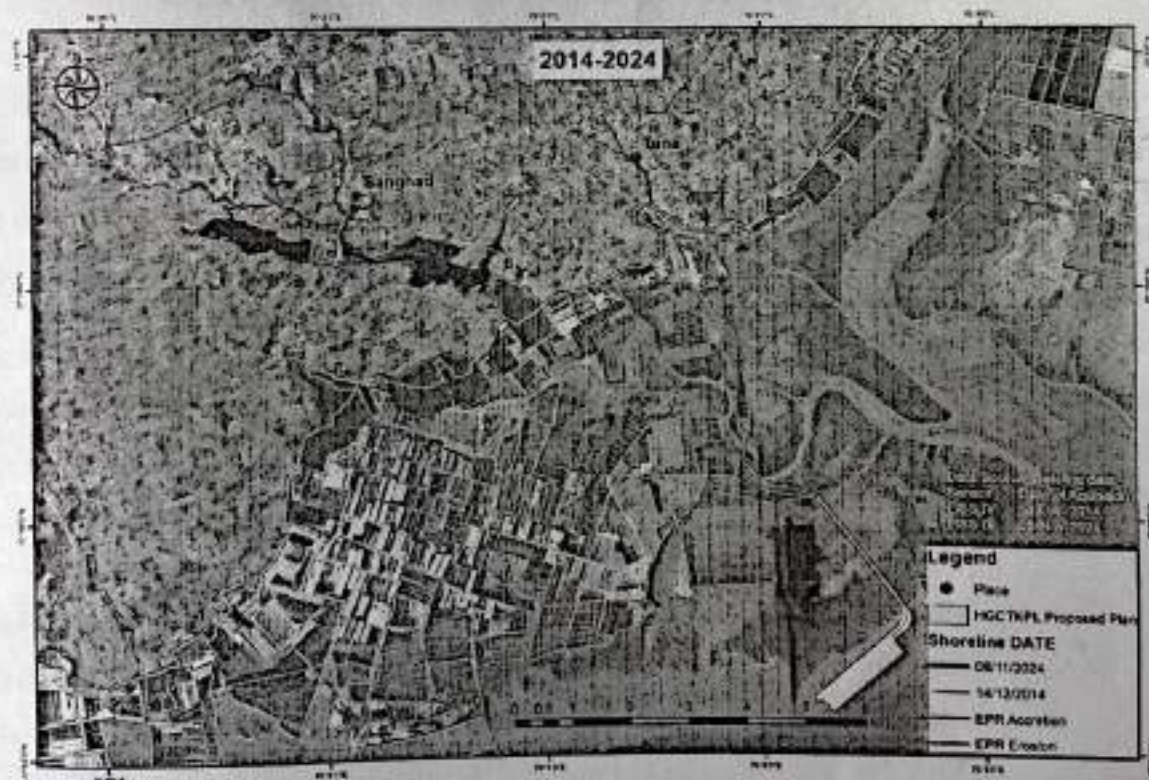


Figure 5.1: Satellite image of the High Erosion Locations (1 to 7) in the Study Area

- ❖ To control the soil erosion in the locations 1-5 and 7, it is envisaged that the implementation of strict regulations and zoning laws to regulate the salt panning activities in sensitive coastal areas. This includes designating specific zones for salt production and restricting such activities in areas prone to erosion.
- ❖ At location 6, the erosion could be controlled only by physical means, by constructing appropriate civil engineering structures. Erosion control structures or constructing embankments of stones or any suitable material along the erosion site is strongly recommended for the present problem. The proposed embankment should be an eco-engineering design with a gentle slope of appropriate angle to the tidal action that will allow natural flushing while controlling erosion.
- ❖ Further, gabion structures in the upstream at regular intervals would regulate the waterflow as well as control the silt movements from the landward side to the ocean.
- ❖ Observations carried out during the field surveys revealed that apart from the above, high tidal amplitude is another cause for erosion along the creek environments as well as some of the coastal stretches. Hence, extensive surveys are required to understand the process to recommend suitable mitigation measures and to update the status of the biodiversity as well in order to estimate the level of physiographical impacts on the shoreline.
- ❖ The artificial coastal structures help in controlling coastal erosion and provide habitats for certain species of Limpets, Crabs, Molluscs, Gastropods, Bivalves along with seaweeds and sea grass which in turn enhance the intertidal and sub-tidal biodiversity as they accelerate the reef-building process. Artificial reefs tend to last for decades supporting faunal components. Since such structures are built using natural materials (for example dead gastropods and bivalves) they are environment-friendly and in due course become natural. They attract diverse marine fauna within a short period with a high potential to enhance biodiversity. The same could be implemented in Hindustan Gateway Container Terminal Kandla Private Limited (HGCTKPL) jurisdiction in consultation with the experts.

Kandla Private Limited (HGCTKPL) observations through GIS and RS tools have to be adopted. The GIS maps may be utilized for the purpose and could serve as a base map. Changes in creek systems, shoreline configuration and other land use categories could be monitored through this exercise once in two or three years.

- ❖ Periodical monitoring, preferably once in 2 years, and comparison of results with baseline data to evaluate the changes will pave way for the formulation of mitigation and conservation efforts. Periodical monitoring of shoreline configuration and mudflats will help to assess their health and detect shoreline changes. Assessment and earlier generated data could be used to check shoreline configuration in terms of short and long-term changes and its succession patterns.
- ❖ Mudflats and mangrove conservation and restoration measures could subsequently be undertaken based on the results of the monitoring programs.
- ❖ Research needs to be undertaken to assess the economic and ecological benefits of sustainable development of shoreline configuration. Further, it is important to understand the long-term impacts of salt pan activities along the shoreline dynamics and developing innovative solutions to address these challenges.
- ❖ Awareness should be generated among local people about the shoreline configuration changes in the surrounding areas and the consequences, particularly to the fishermen community. This will help in enhance the possibilities of participatory approach for coastal protection and its management.



References

- Thivakaran, G.A.Pranav J. Pandya, G.Thirumaran, and Devi Velusamy. 2015. "CONSERVATION AND MONITORING FOR NATURAL MANGROVE STANDS AT MUNDRA."
- Himmelstoss, Emily A., Rachel E. Henderson, Meredith G. Kratzmann, and Amy S. Farris. 2018. "Digital Shoreline Analysis System (DSAS) Version 5.0 User Guide." Report 2018-1179. Open-File Report. Reston, VA. USGS Publications Warehouse. <https://doi.org/10.3133/ofr20181179>.
- Hitesh B Patel, Subhash Bhandari. 2018. "Shoreline Change Analysis along Eastern Part of Kachchh Coast, Western India." *International Journal of Creative Research Thoughts(IJCRT)* 6 (1). <https://doi.org/january2018>.
- ICMAM. 2004. "Model Integrated Coastal and Marine Area Management Plan for Gulf of Kachchh." Department of Ocean Development, Ministry of Earth Sciences, ICMAM Project Directorate, Chennai, Government of India.
- Jodhani, Keval, Pulkit Bansal, and Priyadarshna Jain. 2020. "Shoreline Change Observations in Gulf of Khambhat Using Satellite Images." *Available at SSRN* 3552461.
- Kannan, Jayakumar, and S. Malarvannan. 2016. "Assessment of Shoreline Changes over the Northern Tamil Nadu Coast, South India Using WebGIS Techniques." *Journal of Coastal Conservation* 20 (December). <https://doi.org/10.1007/s11852-016-0461-9>.
- Misra, Ankita, and Balaji Ramakrishnan. 2015. "A Study on the Shoreline Changes and LAND-Use/ Land-Cover along the South Gujarat Coastline." *Procedia Engineering* 116 (December): 381-89. <https://doi.org/10.1016/j.proeng.2015.08.311>.
- NIO. 2009. "Marine Environmental Impact Assessment for Discharge Channel of 4000 MW Ultra Mega Power Project Near Mundra, Gulf of Kachchh." National Institute of Oceanography.
- Sutikno, Sigit, Ari Sandhyavetri, Muhammad Haidar, and Koichi Yamamoto. 2017. "Shoreline Change Analysis of Peat Soil Beach in Bengkalis Island Based on GIS and RS." *International Journal of Engineering and Technology* 9 (January): 233-38. <https://doi.org/10.7763/IJET.2017.V9.976>.
- Sweet, William, Robert Kopp E., Christopher P. Weaver, J. T. B. Obeysekera, Radley M. Horton, Robert E. Thieler 1965-, and Chris Eugene Zervas 1957-. 2017. "Global and Regional Sea Level Rise Scenarios for the United States." Edited by Center for Operational Oceanographic Products and Services (U.S.), NOAA technical report NOS CO-OPS ; 83, . <https://doi.org/10.7289/v5/tr-nos-coops-083>.
- Tamassoki, E, H Amiri, and Z Soleymani. 2014. "Monitoring of Shoreline Changes Using Remote Sensing (Case Study: Coastal City of Bandar Abbas)." *IOP Conference Series: Earth and Environmental Science* 20 (June): 012023. <https://doi.org/10.1088/1755-1315/20/1/012023>.



PRELIMINARY REPORT

**"MARINE BIODIVERSITY IMPACT
ASSESSMENT OF DP WORLD TERMINAL"**

DP world Purchase Order SCOHGCTKPLPO3000007

Submitted to



DP WORLD

Hindustan Gateway Container Terminal Kandla Private Limited

2nd Floor ,204, Meridian House

Plot No 50, Sector 8, Gandhidham

Kachchh-370201

Gujarat



**Gujarat Institute
Of Desert Ecology**

P.B. No. 83, Mundra road

Opp. Changleshwar Temple

Bhuj-Kachchh, Gujarat-370001

JANUARY 2025

Project Coordinator

Dr. V. Vijay Kumar, Director
Coordinator

Project Investigators

Name	Designation	Area of Expertise
Dr. Durga Prasad Behera	Scientist	Plankton; Marine biodiversity

Team Members

Dr. Kapilkumar. N. Ingle	Project Scientist-II	Mangrove Ecology
Dr. L. Prabha Devi	Advisor	Marine Ecology
Dr. S. K. Sajan	Scientist	Avifauna
Dr. Dhara Dixit	Project Scientist-I	Halophytes & Laboratory analysis
Dr. Rupak Dey	Project Scientist-I	GIS & Remote sensing
Mr. Dayesh Parmar	Sr. Scientific Officer	GIS & Remote sensing

1. INTRODUCTION

DP World is a multinational logistics company based in Dubai, United Arab Emirates. It specialises in cargo logistics, port terminal operations, maritime services and free trade zones. Formed in 2005 by the merger of Dubai Ports Authority and Dubai Ports International, DP World handles 70 million containers that are brought in by around 70,000 vessels annually. This equates to roughly 10% of global container traffic accounted for by their 82 marine and inland terminals present in over 40 countries. Until 2016, DP World was primarily a global port operator, but since then, it has acquired other companies up and down the value chain. DP World in India has an extensive portfolio of Express & Contract Logistics Services, Ports & Terminals, Economic Zones, Inland Rail Terminals, Container Freight Stations, Cold Chain, and Freight Forwarding Services. DP World already operates five marine terminals – two in Mumbai, one each in Mundra, Cochin and Chennai – with a combined capacity of approximately 6 million TEUs and with the addition of Tuna Tekra Container Terminal DP World will have a capacity of 8.19 million TEUs. This is along with seven multimodal inland terminals connected to DP World's rail network, cold storage facilities and container freight stations. It is also developing three state-of-the-art economic zones across the country in Mumbai, Cochin and Chennai. The Gujarat is concern DP World has won a major concession to develop, operate and maintain the mega-container terminal at Deendayal port in Gujarat, on the western coast of India. The project involves the construction of a mega-container terminal at Tuna-Tekra through a Public-Private Partnership (PPP). Once complete, the terminal will include a 1,100-metre berth, and will be capable of handling vessels carrying more than 18,000 TEUs. Total capacity will be 2.19 million TEUs. So in this juncture special purpose company was formed, "Hindustan Gateway Container Terminal Kandla Private Limited" (HGCTKPL), under the Companies Act to execute the project and the contract was awarded by the Deendayal Port Authority under on a Build-Operate-Transfer (BOT) basis. This project will complement initiatives of the Government of India, such as the PM Gati Shakti Master Plan and National Logistics Policy, which has been introduced to provide greater focus on developing multimodal logistics Infrastructure promoting economic growth.

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, DP World project location comprehends a number of fragile marine ecosystems that includes a vast expanse of mangroves, mudflats, creek systems and associated biota. The project 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 has an irregular and dissected configuration with vast open water front facility, experiencing the tidal amplitude of 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 will initiate for port developmental activity.

Chronology of events of DP World

- The CA was signed between the DPA and HGCTKPL on 25 August 2023.
- Within 6 months of signing of the CA both parties had to fulfil their respective CPs.
- The design consultants, Royal Haskoning, was onboarded in September 2023.
- Fugro International completed Topo and Bathymetry surveys/studies in December 2023.
- The CPs were fulfilled by both parties in early March 2024.
- The project site of approximately 64 hectares was taken over from DPA.
- The Letter of Award of Concession was issued on 14 March 2024, signifying start of Concession Period of 30 years and three years of Construction Phase.
- The appointment of the Independent Engineer, RITES, took effect from the date of Award of Concession.
- Advance works under execution since May 2024



1.1. Rationale of the present study

The ongoing developmental activities DP World has been intended for the following.

- Development of berth of meters (extendable up to 1375 meters) and width of 54 meters.
- The berth to be designed for handling vessels of at least up to 6000 TEUs drawing a draft of 14 meters.
- The berth depth approach and berth pocket shall be of 15.4 meters below CD and 16.1 in turning circle.
- The project Back up area of 54.2 hectares.
- The Trestle length of 1650 meters and width of 20 meters.

As per the environmental clearance requirements to these developmental initiatives, by MoEF & CC, among other conditions, has specified to conduct the monitoring of the coastal environment on various aspects covering all the seasons. The 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 an 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 faunal components of marine biodiversity of the major intertidal ecosystems, the water and sediment characteristics. The study covers all the seasons as specified by specific condition of the Ministry of Environment, Forest and Climate Change (MoEF&CC). The present study is designed considering the scope of work given in the EC conditions

1.2. Study Area

The coastal belt in and around DP world port jurisdiction is characterized by a network of creek systems and mudflats which are covered by sparse halophytic vegetation like scrubby to dense mangroves, creek water and salt-encrusted landmass which forms the major land component. The surrounding environment in a radius of 10 km radius from the port includes creek, mangrove habitat (Eastern side) and port related structures on wester side of project location and extensive water front facility to words southern side of project location.



The nearest major habitation is Gandhidham town about 15 km west with a population of 2, 48,705 (as per 2011 census).

1.3. Background of the Present Study

As part of its ongoing developmental activities, DP world intend to develop berth of meters (extendable up to 1375 meters) and width of 54 meters for handling vessels of at least up to 6000 TEUs drawing a draft of 14 meters. While according environmental clearance to these developmental initiatives, MoEF & CC, among other conditions, stipulated the following: ***"Marine Ecology shall be monitored Regularly also in terms of Seaweeds, Sea grasses, Mudflats, Fisheries, Echinoderms, Shrimps, Turtles, Corals, Coastal vegetation, Mangroves and other Biodiversity components as a part of the management plan. Marine ecology shall be monitored regularly also in terms of all Micro, Macro and Mega floral and faunal components of marine biodiversity"***.

In accordance with this directive, DP world assigned the task of carrying out a holistic marine ecological monitoring study to Gujarat Institute of Desert Ecology (GUIDE), Bhuj during September 2024 . Since marine ecological components are to be studied regularly as stipulated by the Ministry, so DP World company approached GUIDE to continue the study for another three years, i.e. 2024 - 2027 for the compliance of EC and CRZ conditions by MoCC, GOI dated 1/1/2024 for the augmentation of liquid cargo handling facilities on specific condition xxv. The inception report is prepared considering the 4 months of work activity in the Project (May 2024 to August 2027). The present project is designed considering the scope of work given in the EC conditions with the specific objectives as follows

2. Scope of the 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 & 1.1.2024 with specific conditions xviii, xxiii, xv, iv and xxv respectively. A detailed holistic approach to different components of marine physico-chemical parameters of water and sediment and marine biodiversity within the DP world project area will be carried out. Based on the results obtained during the survey



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., post monsoon, monsoon and pre-monsoon as the period October 2024 to September 2025 as follows:

- Physico-chemical characteristic of water and sediment will be analysed.
- 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.
- To study the intertidal faunal composition, distribution, diversity, density and other characteristics, other mega faunal components such as mammals, reptiles and amphibians.
- To investigate the species composition, distribution, diversity, density of sub-tidal benthic fauna.
- To estimate the primary productivity selected sampling sites located in around DPT area.
- Investigate the species composition, distribution, density and diversity of phytoplankton and zooplankton.
- To study the distribution of halophytes, sea grasses, seaweeds and other coastal flora, their occurrence, distribution, abundance and diversity.
- To study the Avifaunal Density, diversity, composition, habitat, threatened and endangered species and characters.
- Fishery Resources - Common fishes available, composition, diversity, Catch Per Unit Effort (CPUE) and other socio-economic information.

This study in short attempts the following, to i) developing a strong long term monitoring of the port marine environment from the biological perspective which could be used to monitor changes in the future, and ii) formulating a management plan based on the baseline data in order to ensure long-term ecological health of the port environment. A better understanding



of the marine ecology of the port and its processes has been attempted in this study which will assist in better management and conservation decisions to promote marine environmental health within the port limits.

3. Sampling locations (2024-2025)

Table 1 Mangrove and Intertidal Sampling location

Mangrove and Intertidal	Longitude	Latitude
DPW M1	70.118892	22.927029
DPW M2	70.114561	22.924488
DPW M3	70.089989	22.911006
DPW M4	70.120403	22.964023
DPW M5	70.10856	22.952139
DPW M6	70.143865	22.952616
DPW M7	70.206583	22.97488
DPW M8	70.063466	22.912799

Table 2 Offshore Sampling location

Offshore	Longitude	Latitude
DPW S1	70.082402	22.88688
DPW S2	70.113573	22.86975
DPW S3	70.136619	22.90293
DPW S4	70.046472	22.86451
DPW S5	70.081212	22.84643
DPW S6	70.166873	22.86665
DPW S7	70.187812	22.90211
DPW S8	70.188764	22.93875
DPW S9	70.145695	22.95129
DPW S10	70.1353	22.83103
DP World Project	70.120046	22.91225

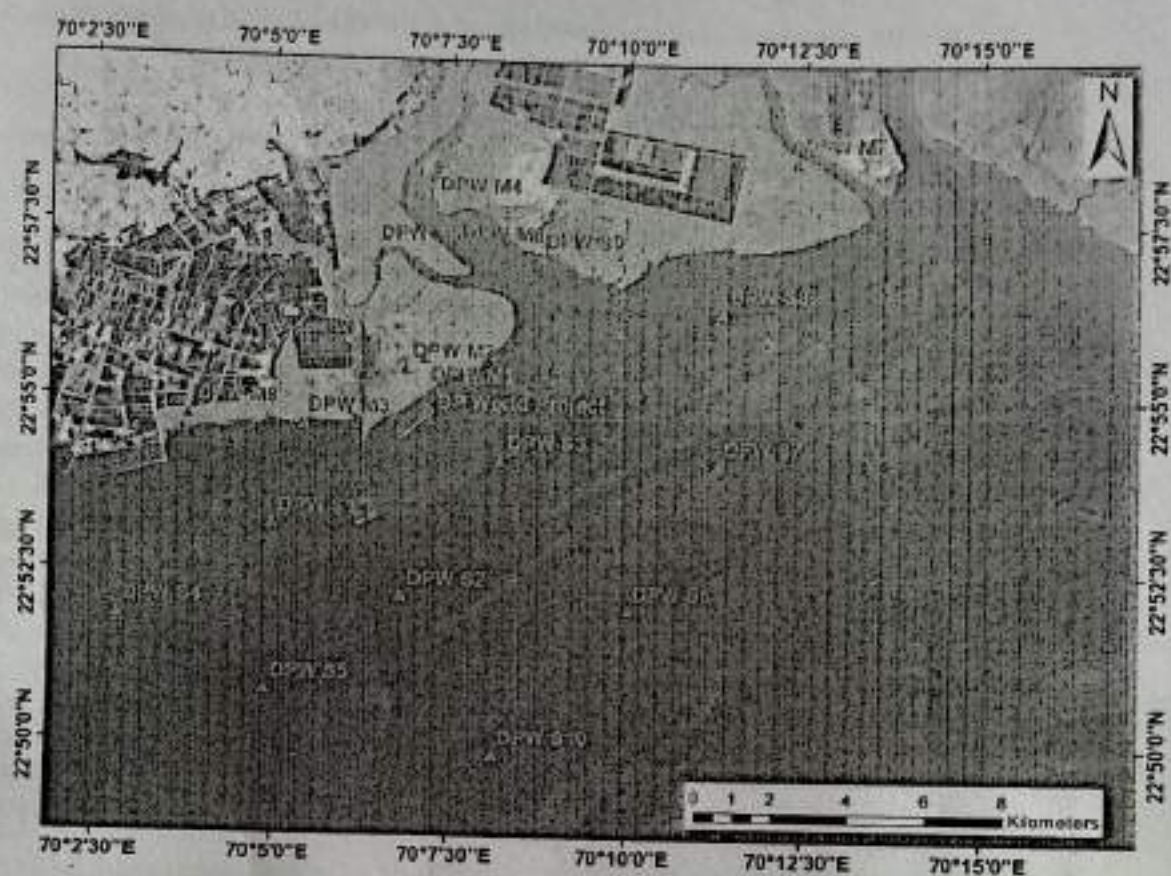


Fig.1. Maps showing the sampling location of the year 2023-2024

3.2. Timeline of the Study

1. Submission of preliminary reports
2. Details of work activity to be conducted for the First Quarter (September 2024-December 2024) :

In this first quarter of the study, The GUIDE team has visited the coastal stretches of DPA port jurisdiction for reconnaissance survey. After reconnaissance survey and permission from the above authorities, first season (post-monsoon) field work will be conducted and the sampling will be undertaken as per the standard protocols and first season (post-monsoon) report will be submit.



3. Details of work activity to be conducted for the Second Quarter (January 2025- April 2025)

During the second quarter, the field work will be conducted during the post monsoon season between February 2025 and January 2025. The samples will be collected as per standard protocols. The samples analyzed and validate the data based on the standard references. All the data will incorporated and submitted the second seasonal report (Pre-monsoon) to the DP World office.

4. Details of work activity to be conducted for the third quarter during (May 2025 to August 2025)

During the third quarter, the analysis of samples collected during the season 3monsoon as per standard protocols. The data will be analyzed and validated based on the standard references.

5. Final Report

All three seasonal data (monsoon, post-monsoon and pre-monsoon) will be pooled together and incorporated to prepare the annual report will be submitted to the DP world by the end of the year as Final report.

Table 2: Timeline - Organization of work (Yearly)

Project Activities	1 st Quarter (September 2024- December 2024)	2 nd Quarter (January 2025- April 2025)	3 rd Quarter (May 2025- August 2025)
<ul style="list-style-type: none"> Review of literature related to study Permission related to field work Planning and orientation of project objectives Initiation of inception study Post-monsoon sample collection Submission of Preliminary report 			
<ul style="list-style-type: none"> Sample analysis Post-monsoon report Submission 			
<ul style="list-style-type: none"> Pre-monsoon season sample collection Sample analysis Pre-monsoon report Submission 			
<ul style="list-style-type: none"> Monsoon sample collection Sample analysis Monsoon report Submission 			
<ul style="list-style-type: none"> Final Draft Report Submission 			
<ul style="list-style-type: none"> Final Report Submission 			

4. Sampling Parameters

Sampling will be carried water for physical and chemical characteristics of coastal water in the proposed developmental site. Similarly, physical and chemical characteristics of sediment in the proposed site will be analyzed. Biological parameters (benthic and pelagic fauna & flora, productivity) will also be included. The following table shows the parameters planned to be gathered.

Table 1: Parameters to be study

Parameters		
Water Quality	Mangrove	Intertidal fauna
<ul style="list-style-type: none"> pH Temperature Salinity (ppt) Petroleum Hydrocarbon-PHC DO Total Suspended Solids (TSS) Total Dissolved solids (TDS) 	<p>Mangrove- vegetation structure including density, diversity, height, canopy and other vegetation characteristics.</p> <p>Halophytes: occurrence, distribution, and diversity</p> <p>Sea grasses, seaweeds: occurrence, distribution, and diversity.</p>	<p>Intertidal faun: composition, distribution, diversity, density and other characteristics, other mega faunal components such as mammals, reptiles and amphibians.</p> <p>Avifauna: Density, diversity, composition, habitat, threatened and endangered species and characters</p>
Nutrients		
<ul style="list-style-type: none"> Nitrate (NO₃) Nitrite (NO₂) Total phosphate Silicate 		
Sediment Quality		
<ul style="list-style-type: none"> Texture Total organic carbons (TOC) Total Nitrogen Total Phosphorus Petroleum Hydrocarbon-PHC 		
Biological Parameters		
<ul style="list-style-type: none"> Phytoplankton - Species, abundance, diversity and biomass Productivity-Chlorophyll a Zooplankton - Species, abundance, diversity and biomass Macrobenthos - Species, abundance, diversity Fishery Resources - Common fishes available, composition, diversity, Catch Per Unit Effort (CPUE) 		

5. Working Methodology

5.1. Water Quality

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

5.2. Temperature: Temperature will be recorded using a mercury thermometer with an accuracy of 0.1°C.

5.3. pH: pH will be measured on a microprocessor controlled pH analyzer. The instrument has been calibrated with standard buffers before use.

5.4 Suspended Solids (SS): A known volume of water will be filtered through a pre-weighed 0.45 micron membrane filter paper (Millipore), dried and weighed again.

5.5. Turbidity: Turbidity will be measured in a calibrated Nephelometer (Hanna make) and the results will be expressed in Nephelometer Turbidity Unit (NTU).

5.6 Salinity: A suitable volume of the sample will be titrated against silver nitrate (25g/l) with potassium chromate as an indicator. Standardization of silver nitrate was done using standard seawater (IAPSO, OSIL, UK).

5.7. Dissolved oxygen (DO): DO will be determined by Winkler's method.

5.8. Phosphate: Acidified molybdate reagent will be added to the sample to yield a phosphomolybdate complex that will be reduced with ascorbic acid to a highly coloured blue compound, which was measured at the wavelength of 690 nm in spectrophotometer (Shimadzu UV 5040).

5.9. Total phosphorus: Phosphorus compounds in the sample will be oxidized to phosphate with alkaline potassium per sulphate at high temperature and pressure. The resulting phosphate will be analyzed and described as total phosphate.

5.10. Nitrite: Nitrite in water sample will be allowed to react with sulphanilamide in acid solution. The resulting diazo compound has reacted with N-1-Naphthylethylenediaminedihydrochloride to form a highly coloured azo-dye. The light absorbance will be measured at the wavelength of 543 nm in spectrophotometer (Shimatzu UV 5040).

5.11. Nitrate: Nitrate will be determined as nitrite (as mentioned above) after its reduction bypassing the sample through a column packed with amalgamated cadmium.

5.12. Ammonia: Ammonium compounds (NH_3 , NH_4^+) in water will be reacted with phenol in presence of hypochlorite to give a blue colour of indophenol. The absorbance will be measured at the wavelength of 630 nm.

5.13. Total nitrogen: Nitrogen compounds in the sample will be oxidized to nitrate by autoclaving with alkaline per sulphate. The solution will be neutralized and nitrate will be estimated and described as total nitrate.

5.14. Silicate: The method is based on the reaction between silicate ions and excess ammonium molybdate reagent to give a yellow silico-molybdic complex. This complex is then reduced to the heteropoly blue compound by means of ascorbic acid. Absorbance values are measured at 830 nm, and are stable for more than 2 h.

5.15. Petroleum Hydrocarbons (PHs): Water sample (2.5 l) will be extracted with hexane and the organic layer will be separated, dried over anhydrous sodium sulphate and reduced to 10 ml at 30°C under low pressure. Fluorescence of the extract will be measured at 360 nm (excitation at 310 nm) with Saudi Arabian crude residue as a standard. The residue will be obtained by evaporating lighter fractions of the crude oil at 100°C.

6. Sediment Quality

Sediment analyses will be carried out using standard methodologies. Sediment samples will be collected in prefixed stations in using a Van Veen grab or by a non-metallic plastic spatula.

In each location (grid), sediment samples will be collected from the three different locations and will be pooled together to make it composite sample, representative of a particular site. Collected samples will be stored in a sterile, black polythene bag at 4°C in an icebox to avoid possible bio leaching of metals by microbes. The collected samples will be in air dried and used for further analysis.

6.1. Sediment Texture

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

6.2. Total Phosphorus

The phosphate in sediment solution reacts with ammonium molybdate and form molybdophosphoric acid, which gets reduced to a complex of blue colour in the presence of stannous chloride. The absorption of light by this solution was measured at 690 nm to calculate the phosphate concentration.

6.3. Total Nitrogen

Total Nitrogen present in the sediment samples will be measured following the Kjeldah Method.

6.4. Organic carbon

Percentage of organic carbon in the dry sediment was determined by oxidizing organic matter in the sample by chromic acid and estimating excess chromic acid by titrating against ferrous ammonium sulphate with ferroin as an indicator.

6.5. Petroleum Hydrocarbon-PHC

For estimating Petroleum hydrocarbon (PHC) in sediment, the sample will be reflexed with KOH-Methanol mixture and extracted with hexane. After removal of excess hexane, the residue will be subjected to silica gel chromatography and PHC and the florescence will be estimated at 360 nm.

7. Mangrove assessment

Total fifteen (15) sites will be primarily considered which will be widely distributed and covered the entire DPT jurisdiction. The mangrove sites will be named Tuna, Jangi, Kandla, Phang creek, Vira coast and Navlakhi based on the nearest location to their respective creek system. The vegetation structural attributes of all the mangrove stands will be based on Point Centered Quadrature Method (PCQM). The methodology and measurement accuracy of Cintron & Novelli (1984) will be adopted to study both measurements of density, height variations and basal area at each stand. A transect of a maximum of 200 m will be laid out either perpendicular or parallel to the creek and sampling points at an interval of 10 m will be fixed to record the vegetation structure of the stand. Along the transects, sub-plots of $1 \times 1 \text{ m}^2$ and $2 \times 2 \text{ m}^2$ will be laid randomly to enumerate regeneration and recruitment class, respectively. Seedlings with a height of $< 50 \text{ cm}$ will be considered as regeneration class, while recruitment class will be well-established saplings $> 50 \text{ cm}$ in height.

8. Intertidal Fauna, Marine Mammals and Reptiles: Sample collection and assessment of intertidal communities will be done in the intertidal zone during the low tide period. At each site, 1 m^2 quadrates will be placed randomly and all visible macro-faunal organisms encountered inside the quadrate will be identified, counted and recorded. At each site along the transects which ran perpendicular to the waterfront, three to six replicate quadrate samples will be assessed for the variability in macro-faunal population structure and the density will be averaged for the entire intertidal belt. Organisms, which could not be identified in the field, will preserved in 5% formaldehyde, bring to the laboratory and identified using standard identification keys (Abott, 1954; Chapgar, 1957; Apte, 1998). Average data at each site will be used to calculate the mean density (No/m^2).

9. **Subtidal Macro Benthic Fauna:** For studying the benthic organisms, triplicate samples will be collected at each station using Van Veen grab which covered an area of 0.04m^2 . The wet sediment will be passed through a sieve of mesh size 0.5 mm for segregating the organisms. The organisms retained in the sieve will be fixed in 5-7% formalin and stained further with Rose Bengal solution for the ease of spotting at the time of sorting. The number of organisms in each grab sample will be expressed as No. / m^2 . All the species will be sorted, enumerated and identified by following available literature. The works of Fauvel (1953), Day (1967) were referred for polychaetes; Barnes (1980) and Lyla *et al.* (1999) for crustaceans; SubbaRao *et al.* (1991) and Ramakrishna (2003) for molluscs. Further, the data will be treated with following univariate statistical methods in PRIMER (Ver. 6.) statistical software (Clark & Warwick, 2001).

10. **Phyto and Zooplankton:** Plankton samples will be collected from prefixed 15 sampling sites from DPT location. Plankton samples will be collected using standard plankton net with a mesh size of $51\mu\text{m}$ and $200\mu\text{m}$ and a mouth area of 0.1256 m^2 (20 cm radius). The net fitted with a flow meter (Hydrobios) will be towed from a motorized boat at 2 nautical miles/hr. Plankton adhering to the net will be concentrated in the net bucket by splashing seawater. The plankton retained will be transferred to a pre-cleaned and rinsed container and preserved with 5% neutralized formaldehyde and appropriately labelled indicating the details of the collection and transferred to the laboratory for further analysis.

The Quantitative analysis of phytoplankton (cell count) will be carried out using a Sedgewick-Rafter counting chamber. Exactly 1 ml of the well mixed sample added to a Sedgwick counting chamber will be observed under an inverted compound microscope. The number of cells present in individual cells of the counting chamber (1/1000) will be noted and identified up to species level. Several observations were made to represent the entire quantity of the soup (generally >30 times) and the recorded data will be used for further calculations with which density and diversity of the plankton in 1 liter of the seawater will be calculated.

The density (No/l) will be calculated using the formula: $N = n \times v / V$

[Where, N is the total no/liter, n is average no of cells in 1 ml, v is the volume of concentrate; V is the total volume of water filtered.

11. Marine Fishery: Fishery resources and diversity will be assessed in the sampling sites. Samples of finfish and shell fish will be collected using a gill net with 10 mm mesh size. The net will operated onto the water from the canoe or by a person standing in waist during the high tide start. For effective sampling, sampling points were fixed at regular distance in 15 sites close to areas where parameters such as plankton and subtidal fauna will be investigated. In each sampling point, the gill net will be deployed 5 times and the CPUE (Catch Per Unit Effort) was estimated per hour. The collected specimens will be segregated into groups, weighed and preserved in 10% neutralized formalin solution. Finfishes will be identified following Fischer & Bianchi (1984), Masuda *et al.* (1984), de Bruin *et al.* (1995) and Mohsin & Ambiak (1996). Relevant secondary information pertaining to fishery resources of Deendayal Port creek systems has been gathered through technical reports, district fisheries department, Government gazette and other research publications

12. Halophytes: To quantify and document the halophytes at Deendayal Port region, quadrat method will be followed. At each sampling location quadrates of various sizes will be laid in each season. For trees, the quadrates of 10 x 10 m will be laid. Quadrates of 5 x 5 m and 1 x 1 m will be laid within each tree quadrat to record shrubs and herbs, respectively (Misra, 1968; Kershaw, 1973; Bonham, 1989). Four quadrates each for shrubs and herbs will be laid in each tree quadrat to assess the halophytes in the study area. To enrich the species inventory, areas falling outside the quadrates will be also explored and the observed species will be recorded and photographed. Specimens of species will be collected to know more information on habitat and for preparation of herbarium specimens. The species will be identified using standard keys.

13. Avifauna: The mangrove habitat along the Gulf of Kachchh will be delineated into 15 major sites based on the subjective magnitude of anthropogenic pressure. In each project site creeks will be of varying length from 2 to 5 km. These creeks will be surveyed by using boat and adopting "line transect" method. A total of 12 transect (one at each site) will be

placed to count the birds. Survey will be done in both terrestrial habitats like natural mangrove and plantation adjoining the mudflats and wasteland, and aquatic habitats like creek area, rivers and wetland.

14. Data Analysis

Data collected *in situ* and through laboratory analysis of samples were subjected to descriptive statistical analysis (PAST) for mean, range and distribution of different variable.

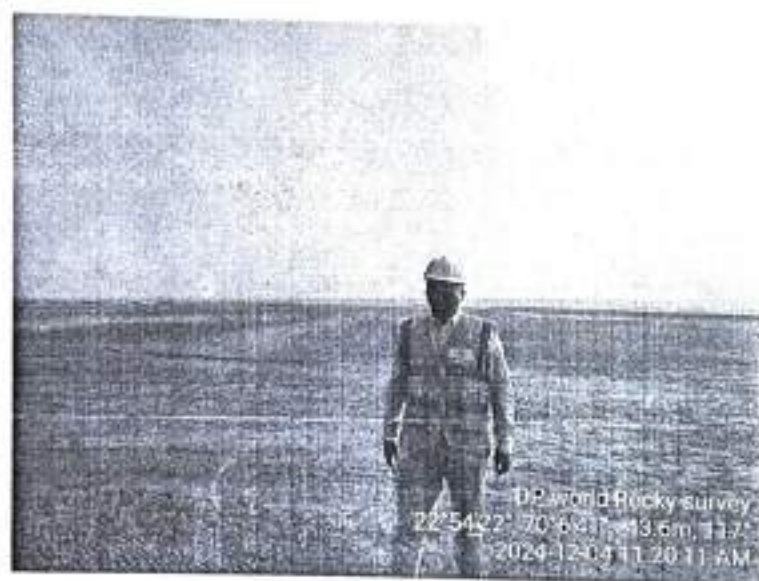
15. Brief Seasonal report covering post-monsoon study conducted during October 2024 to January 2025

S. No	Components of the Study	Remarks
1	Duration of the project	One year (2024-2025)
2	Period of the survey carried	First Year Post-Monsoon (October 2024 to January 2025)
3	Survey area within the port limit	All major and minor creek systems from Tuna to and Vira coastal area.
4	Number of sampling locations	Ten sampling locations in and around the World port jurisdiction
5	Components of the report	
5a	Mangroves	Among the 10 sampling locations, the overall average density of tree class mangroves was found to be 2523 trees / hectare during the survey. Notably, the highest average density was observed in M-7 and M-3. Conversely, quadrat M-5 and M-4 exhibited the lowest average density.
5b	Mudflats	The highest TOC value (3.0%) was recorded at DPW-5 followed by DPW-4 and lowest TOC value was reported at site DPW-1. dependent on the living life forms and variations in the living object in the mudflats. The bulk density of mangrove soil at DP WORLD region ranged from 1.18 g/cm ³

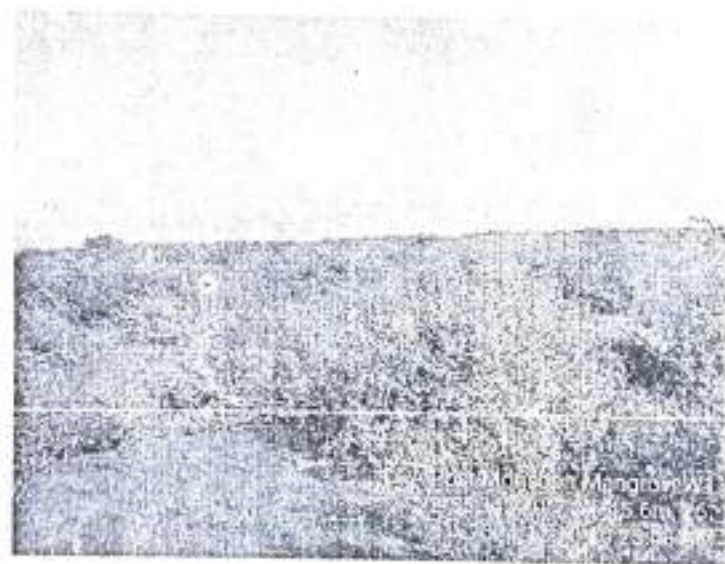
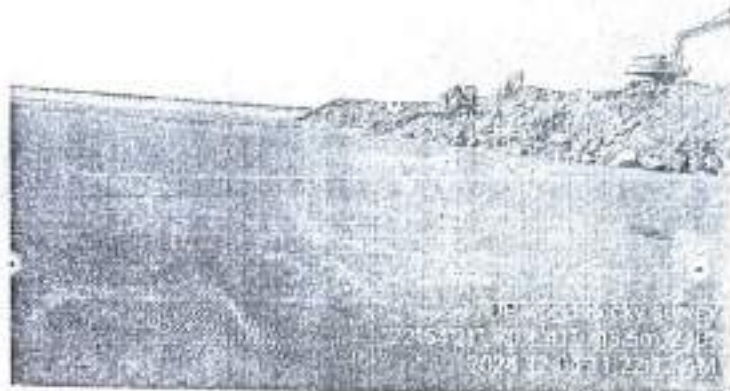
		to 1.67 g/cm ³ . The highest bulk density was recorded at DPW7 followed by DPW5. The lowest bulk density was recorded at DPW1 located at Tuna creek.
5c	Phytoplankton	The phytoplankton density varied from 6,000 No/L to 17,600 No/L with the average 10,906 No/L. The highest phytoplankton density was observed at station S9(17,600 No/L) followed by S-10(17,500 No/L), whereas the lowest at S3. <i>Schroderella delicatula</i> , <i>Nitzschia</i> sp. <i>Grammatophora marina</i> , <i>Thalassionema</i> , <i>Nitzschia paradoxaw</i> which are distributed at all the stations.
5d	Zooplankton	The zooplankton identified from the 10 stations falls under 10 phyla and 27 genera belonging to the 15 groups. Zooplankton population density during the Post-monsoon at the 10 sampling sites ranged from 3110 No/L to 15,360 No/L with an overall average of 7,438 No/L.
5e	Intertidal Fauna	The species diversity of the invertebrate phyla showed the maximum for phylum Mollusca (7 species), which is followed by Arthropoda (6 species). The overall percentage composition of the three groups of intertidal fauna at the 8 station. i.e., Arthropoda (55.8%), Mollusca (34.8%), and Chordata (9.4%),
5f	Sub-tidal Macrobenthos	Macro benthic species of the various groups recorded DPW port environment includes Mollusca (11) and Annelida (5) Arthropoda (6). The percentage composition of the three phyla that occurred during the Post-monsoon. The phylum Annelida is represented by maximum (53.8%) share of the subtidal Fauna, followed by Mollusca (30.9%), Arthropoda (15.3%).

5g	Seaweeds	Nil
5h	Seagrass	Nil
5i	Marine reptiles	Nil
5j	Marine mammals	Nil
5k	Halophytes	Nil
5l	Avifauna	During the filed survey the filed team documented 77 species across 10 orders and 34 families. Among them, 40 species were aquatic, 37 were terrestrial, one was vulnerable and two were categorized as near threatened under the IUCN 2024 Red List. Migrant species composition include 18 species were identified as migrants, with four as Resident migrants and 55 as breeding Resident.
5m	Physicochemical	This is purely dynamic varies according to tidal current and condition gulf environment and influence to entire creek system.

Photographs during the Reconnaissance Survey







Annexure -B

Annexure 1**COMPLIANCE REPORT (for the period October, 2024 to March, 2025)**

Subject: Compliance of conditions stipulated in CRZ recommendations issued by GCZMA for the proposal "Development of 3 Remaining Integrated Facilities (stage I) within the existing Deendayal Port Authority (Erstwhile: Deendayal Port Trust) at Gandhidham, Kutch, Gujarat".

CRZ Recommendations: **Letter No.** ENV-10-2015-248-E (T - Cell) dated 29/6/2016 of Director (Environment) and Member Secretary, GCZMA, Forest and Environment Department, GoG.

Sr. No.	Conditions in CRZ Recommendation Letter	Compliance
	Specific Conditions	
1	The provisions of the CRZ notification of 2011 shall be strictly adhered to by the KPT. No activity in contradiction to the Provisions of the CRZ Notification shall be carried out by the KPT.	<p>For Project at Sr. No. 1 which is under construction, kindly refer compliance submitted by M/s HGCTKPL (concessionaire of the project) placed at Annexure A.</p> <p>The Projects at Sr. No. 2 and 3 of the EC and CRZ Clearance have already been completed.</p>
2	All necessary permissions, under various laws/Rules/Notifications issued there under from different Government Departments/agencies shall be obtained by M/s KPT before commencing any enabling activities for proposed project.	DPA obtained CTE/NOC from the GPCB vide No. PC.CCA-KUTGH-1231(2) I GPCB ID 44000 dated 4/12/2017 (Copy of the same has been communicated with the last compliance report submitted). Further, DPA had obtained CTE validity extension (CTE-125870) from GPCB vide Order dated 27/04/2023 with validity up to 15/11/2025 (A copy of the same has already been submitted along with compliance report submitted on 17/09/2024). MoEFandCC, GoI accorded EC and CRZ Clearance for the subject proposal of DPA dated 18/2/2020.
3	The KPT shall have to ensure that there shall not be any damage to the existing mangrove area.	<p>For Project at Sr. No. 1 which is under construction, kindly refer compliance submitted by M/s HGCTKPL (concessionaire of the project) placed at Annexure A.</p> <p>The Projects at Sr. No. 2 and 3 of the EC and CRZ Clearance have already been completed.</p> <p>Further, DPA has already prepared a mangrove preservation plan for the entire Kandla area.</p>
4	The KPT shall effectively implement the Mangrove Development, Protection and Management Plan for control of	DPA has undertaken Mangrove Plantation in an area of 1600 Hectares since the year 2005. The copy of the details has already been communicated with the earlier compliance reports submitted.

	indirect impact on mangrove habitat.	<p>Further, the Study on the present Status, Conservation and Management Plan for Mangroves of Kandla Port region submitted by M/s GUIDE, Bhuj, had already been communicated to the GCZMA and to the MoEFandCC, GoI.</p> <p>In addition to the above, DPA appointed M/s GUIDE, Bhuj for "Regular Monitoring of Mangrove Plantation carried out by DPA" (period 15/9/2017 to 14/9/2018 vide work order dated 1/9/2017 and 24/5/2021 to 23/5/2022 vide work order dated 3/5/2021). The final report submitted by M/s GUIDE, Bhuj, for the years 2017 to 2018 and 2021 to 2022 has already been communicated with the six monthly compliance submitted.</p> <p>Further, vide work order dated 10/06/24 DPA appointed M/s GUIDE, Bhuj, for "Regular Monitoring of Mangrove Plantation carried out by DPA" (Period 10/06/2024 to 09/06/2025) (A copy of the same has already been submitted along with compliance report submitted on 17/09/2024)</p>
5	The KPT shall have to make a provision that mangrove areas get proper flushing water and free flow of water shall not be obstructed.	It is hereby assured that necessary provisions will be made so that mangrove areas get proper flushing water and free flow of water shall not be obstructed.
6	The KPT shall have to abide by whatever decision taken by the GCZMA for violation of CRZ Notification.	Point noted
7	No dredging, reclamation or any other project related activities shall be carried out in the CRZ area categorized as CRZ I (i) and it shall have to be ensured that the mangrove habitats and other ecologically important and significant areas, if any, in the region are not affected due to any of the project activity.	<p>For Project at Sr. No. 1 which is under construction, kindly refer compliance submitted by M/s HGCTKPL (concessionaire of the project) placed at Annexure A.</p> <p>The Projects at Sr. No. 2 and 3 of the EC and CRZ Clearance have already been completed.</p> <p>DPA had authorised the work to M/s GUIDE, Bhuj for continuous monitoring of Marine Ecology since the year 2017 and the final reports are being submitted from time to time to the Regional Office, MoEFandCC, GoI, Gandhinagar and to the MoEFandCC, GoI, New Delhi along with six monthly compliance reports submitted.</p> <p>The final report for the year 2023-24 has already been submitted along with compliance report submitted on 17/09/2024.</p>

		In continuation to the same, DPA issued a work order to M/s GUIDE vide its letter no. EG/ WK/ 4751/ Part (Marine Ecology Monitoring) /72 dated 10/06/2024 for the period of 2024-27 (A copy of the same has already been submitted along with compliance report submitted on 17/09/2024)
8	The KPT shall participate financially in installing and operating the Vessel Traffic Management System in the Gulf of Kachchh and shall also take the lead in preparing and operational sing and regularly updating it after getting it vetted by the Indian Coast Guard.	Deendayal Port Authority had already contributed Rs. 41.25 crores for installing and operating the VTMS in the Gulf of Kachchh.
9	The KPT shall strictly ensure that no creeks or rivers are blocked due to any activity at Kandla.	For Project at Sr. No. 1 which is under construction, kindly refer compliance submitted by M/s HGCTKPL (concessionaire of the project) placed at Annexure A . The Projects at Sr. No. 2 and 3 of the EC and CRZ Clearance have already been completed.
10	Mangrove plantation in an area of 50 ha. Shall be carried out by the KPT within 2 years in time bound manner on Gujarat coastline either within or outside the Kandla port Trust area and six monthly compliance reports along with the satellite images shall be submitted to the Ministry of Environment and Forest as well as to this Department without fail.	As per the directions of the GCZMA and MoEFandCC, GoI, till date, DPA has undertaken Mangrove Plantation in an area of 1600 Hectares since the year 2005, which includes 50 Hectares mangrove plantation as per stipulated condition. Further, DPA appointed M/s GUIDE, Bhuj for "Regular Monitoring of Mangrove Plantation carried out by DPA" (period 15/9/2017 to 14/9/2018 vide work order dated 1/9/2017 and 24/5/2021 to 23/5/2022 vide work order dated 3/5/2021). The final report submitted by M/s GUIDE, Bhuj, for the years 2017 to 2018 and 2021 to 2022 have already been submitted in the six monthly compliance communicated vide letter 06/07/2022. In continuation of the same, DPA issued a work order to M/s GUIDE vide its letter no. EG/ WK/ 4751/ Part (Marine Ecology Monitoring) /72 dated 10/06/2024 for further period of 2024 – 27 (A copy of the same has already been submitted along with compliance report submitted on 17/09/2024)
11	No activities other than those permitted by the competent authority under the CRZ Notification shall be carried out in the CRZ area.	For Project at Sr. No. 1 which is under construction, kindly refer compliance submitted by M/s HGCTKPL (concessionaire of the project) placed at Annexure A .

		<p>The Projects at Sr. No. 2 and 3 of the EC and CRZ Clearance have already been completed.</p> <p>However, no activities other than those permitted by the competent authority under the CRZ Notification shall be carried out in the CRZ area.</p>
12	No ground water shall be tapped for any purpose during the proposed expansion modernization activities.	Water requirements will be met through procurement from GWSSB or private tankers. It is hereby assured that no groundwater shall be tapped.
13	All necessary permissions from different Government Departments / agencies shall be obtained by the KPT before commencing the expansion activities.	DPA has already obtained the necessary Environmental and CRZ Clearance for three project activities dated 18/2/2020. Further, Consent to Establish from GPCB had already been obtained from GPCB (CTE – 89537) vide no. PC/CCA-KUTCH-1231 (2)/GPCB ID 44000/429717 dated 4/12/2017. Further, DPA had obtained CTE validity extension (CTE-125870) from GPCB vide Order dated 27/04/2023 with validity up to 15/11/2025 (A copy of the same has already been submitted along with compliance report submitted on 17/09/2024).
14	No effluent or sewage shall be discharged into sea/creek or in the CRZ area and it shall be treated to conform to the norms prescribed by the GPCB and would be reused /recycled within the plant premises.	DPA already has a Sewage Treatment Plant capacity of 1.5 MLD. The treated wastewater is utilized for plantation/gardening purposes. Further, BOT Operator will provide necessary arrangements for a sewage treatment facility.
15	All the recommendations and suggestion given by the Mantec Consultants Pvt. Ltd. in their Comprehensive Environment Impact Assessment report for conservation / protection and betterment of environment shall be implemented strictly by the KPT.	<p>DPA has installed Mist Canon at the Port area to minimize the dust.</p> <p>Further, to control dust pollution in other area, regular sprinkling through tankers on roads and other staking yards is being done.</p> <p>For monitoring of environmental parameters, DPA has been appointing NABL Accredited laboratory and reports are being submitted from time to time to the GPCB, IRO, MoEFandCC, GoI, Gandhinagar. Recently, DPA appointed GEMI, Gandhinagar for regular monitoring of environmental parameters vide Work Order dated 15/02/2023. The work is in progress and the latest environmental monitoring report submitted by GEMI, Gandhinagar is attached herewith as Annexure B.</p> <p>For ship waste management, DPA issued Grant of License/Permission to carry out the work of collection and disposal of "Hazardous</p>

		<p>Waste/Sludge/ Waste Oil” and “Dry Solid Waste (Non- Hazardous)” 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 Swachh Sagar portal.</p> <p>Further, DPA has appointed GEMI, Gandhinagar for the work of “Preparation of Plan for Management of Plastic Wastes, Solid Waste, including CandD waste, E-waste, Hazardous waste, including Biomedical and Non-Hazardous Waste in the Deendayal Port Authority” vide Work Order dated 24/01/2023. The work is completed. Final report submitted herewith is attached as Annexure C.</p> <p>DPA assigned work to M/s GUIDE, Bhuj, for regular monitoring of Marine Ecology since the year 2017 (From 2017 – 2021), and final reports of the same are being submitted regularly to the Regional Office, MoEFandCC, GoI, Gandhinagar as well as to the MoEFandCC, GoI, New Delhi along with compliance reports submitted.</p> <p>The final report for the year 2023-24 has already been submitted along with compliance report submitted on 17/09/2024.</p> <p>In continuation to the same, DPA issued a work order to M/s GUIDE vide its letter no. EG/ WK/ 4751/ Part (Marine Ecology Monitoring) /72 dated 10/06/2024 for the period of 2024-27 (A copy of the same has already been submitted along with compliance report submitted on 17/09/2024)</p> <p>As already informed, 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). The work is completed.</p> <p>Further, DPA has appointed the Gujarat Institute of Desert Ecology (GUIDE) for “Green belt development in Deendayal Port Authority and its Surrounding Areas, Charcoal site' (Phase-I)” vide Work Order No.EG/WK/4757/Part [Greenbelt GUIDE, dated 31st May 2022. The final report submitted by GUIDE, Bhuj have already been</p>
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		<p>communicated with the earlier six monthly compliance reports submitted via letter dated 13/03/2024.</p> <p>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.</p> <p>For dredged material management, DPA has been assigning work to M/s GUIDE, Bhuj for analysis of dredged material since the year 2017 and the reports are being submitted from time to time along with compliance reports submitted.</p> <p>The final Report submitted by M/s GUIDE, Bhuj for the period 2022-2023 has already been submitted along with compliance report submitted on 17/09/2024.</p> <p>Further, Dredged Material will be disposed of at designated location as identified by the CWPRS, Pune.</p> <p>For energy conservation measures, DPA is already generating 20 MW of Wind energy. In addition to it, DPA has commissioned a 45 kWp Solar Plant at Gandhidham. Further, it is relevant to mention that, two out of four Nos. of Harbour Mobile Crane (HMC) made electric operated. Balance 02 Nos. shall be made electric operated by 2023-2024. Four Nos. of Deisel operated RTGs converted to e-RTGs. Retrofitting of hydrogen fuel cell in Tug Kalinga and Pilot Boat Niharika to be done as a pilot project under the guidance of MoPSW. Also, 14 Nos. of EV cars to be hired in this year and 03 Nos. EV Bus to be procured by the year 2023-24.</p> <p>Further, for Oil Spill Management, DPA is already having Oil Spill Contingency Plan in place and Oil Response System as per the NOS-DCP guidelines.</p>
16	The construction and operational activities shall be carried out in such a way that there is no negative impact on mangroves and other coastal /marine habitats. The construction activities and	<p>For Project at Sr. No. 1 which is under construction, kindly refer compliance submitted by M/s HGCTKPL (concessionaire of the project) placed at Annexure A.</p>

	dredging shall be carried out only under the constant supervision and guidelines of the Institute of National repute like NIOT.	The Projects at Sr. No. 2 and 3 of the EC and CRZ Clearance have already been completed. Further, DPA has already prepared a mangrove preservation plan for the entire Kandla area.
17	The KPT shall contribute financially for any common study or project that may be proposed by this Department for environmental management / conservation / improvement for the Gulf of Kutch.	Point noted.
18	The construction debris and / or any other of waste shall not be disposed of into the sea, creek or the CRZ areas. The debris shall be removed from the construction site immediately after the construction is over.	For Project at Sr. No. 1 which is under construction, kindly refer compliance submitted by M/s HGCTKPL (concessionaire of the project) placed at Annexure A . However, the construction debris and/ or any other waste will not be disposed of into the sea and the debris will be removed from the construction site after construction is over. 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 has already been communicated with the last compliance report submitted).
19	The construction camps shall be located outside the CRZ area and the construction labour shall be provided with the necessary amenities, including sanitation, water supply and fuel and it shall be ensured that the environmental conditions are not deteriorated by the construction labours.	For Project at Sr. No. 1 which is under construction, kindly refer compliance submitted by M/s HGCTKPL (concessionaire of the project) placed at Annexure A . However, construction camps with necessary amenities will be located in the already nearby developed areas. Further, due care shall be taken so that the environmental conditions are not deteriorated by the construction labours.
20	The KPT shall regularly updates its Local Oil Spill Contingency and Disaster management Plan in accordance with the National Oil Spill and Disaster Contingency Plan and shall submit the same to the MoEF, GoI and this department after having it vetted through the Indian Coast Guard.	Point noted. <ul style="list-style-type: none"> ▪ Deendayal Port already has an updated Disaster Management Plan (A copy of the Plan has already been submitted with the earlier compliances). ▪ Further, the Local Oil Spill Contingency Plan is already available with Deendayal Port Authority. ▪ DPA has also executed MOU with Oil Companies, i.e., IOCL, HPCL, BPCL etc., for combating the Oil Spill at Kandla
21	The KPT shall bear the cost of the external agency that may be appointed by this Department for	Agreed with the condition

	supervision/monitoring of proposed activities and the environmental impacts of the proposed activities.	
22	The KPT shall take up massive greenbelt development activities in and around Kandla and also within the KPT limits.	<p>DPA has planted about one lakhs trees in roadside dividers, colony areas at Kandla and Gopalpuri, in the greenbelt area of Gandhidham and Adipur Township, Sewage Treatment Plants at Gopalpuri and Kandla and extensive green belt development plans initiated at different locations in Township areas.</p> <p>DPA entrusted work of greenbelt development in and around the Port area to the Forest Department, Gujarat, at the cost of Rs. 352 lakhs (Area 32 hectares), and the work is completed.</p> <p>Further, DPA has appointed the Gujarat Institute of Desert Ecology (GUIDE) for "Green belt development in Deendayal Port Authority and its Surrounding Areas, Charcoal site' (Phase-I)" vide Work Order No.EG/WK/4757/Part [Greenbelt GUIDE, dated 31st May 2022. The final report submitted by GUIDE, Bhuj has been submitted in the last compliance report.</p> <p>Further, DPA assigned work to GUIDE, Bhuj vide work order dated 23/06/2023 for "Green belt development in Deendayal Port Authority and its Surrounding Areas (Phase II) (10000 plants). The work is completed and final report is attached herewith as Annexure D.</p>
23	The KPT shall have to contribute financially for taking up the socio-economic upliftment activities in this region in construction with the Forest and Environment Department and the District Collector/District Development Officer.	<p>For Project at Sr. No. 1 which is under construction, kindly refer compliance submitted by M/s HGCTKPL (concessionaire of the project) placed at Annexure A.</p> <p>Already CSR works are being attended by DPA. The details of CSR activities undertaken/to be undertaken by DPA are placed in Annexure E.</p>
24	A separate budget shall be earmarked for environmental management and socioeconomic activities and details there of shall be furnished to this Department as well as the MoEF, GOI. The details with respect to the expenditure from this budget head shall also be furnished.	The allocation made under the "Environmental Services and Clearance of other related Expenditure" during RBE 2024-25 is Rs. 585 Lakhs.

25	A separate environmental management cell with qualified personnel shall be created for environmental monitoring and management during construction and operational phases of the project.	<p>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. In addition, it is relevant to submit here that, DPA has appointed Manager (Environment) on contractual basis for the period of 3 years and further extendable to 2 years (Copy of the details has already been communicated with the last compliance report submitted).</p> <p>Further, for monitoring of environmental parameters, DPA has been appointing NABL Accredited laboratory and reports are being submitted from time to time to the GPCB, IRO, MoEFandCC, GoI, Gandhinagar. Recently, DPA appointed GEMI, Gandhinagar for regular monitoring of environmental parameters vide Work Order dated 15/02/2023. The work is in progress and the latest environmental monitoring report submitted by GEMI, Gandhinagar is attached herewith as Annexure B.</p>
26	An Environmental reports indicating the changes, if any, with respect to the baseline environmental quality in the coastal and marine environment shall be submitted every year by the KPT to this Department as well as to the MoEFandCC, GOI.	<p>For monitoring of environmental parameters, DPA has been appointing NABL Accredited laboratory and reports are being submitted from time to time to the GPCB, IRO, MoEFandCC, GoI, Gandhinagar. Recently, DPA appointed GEMI, Gandhinagar for regular monitoring of environmental parameters vide Work Order dated 15/02/2023. The work is in progress and the latest environmental monitoring report submitted by GEMI, Gandhinagar is attached herewith as Annexure B.</p> <p>DPA has been submitting the environmental monitoring report along with the six-monthly compliance report to IRO, MoEFandCC, GoI.</p>
27	The KPT shall have to contribute financially to support the National Green Corps Scheme being implemented in Gujarat by the GEER Foundation, Gandhinagar, in construction with Forests and Environment Department.	Point noted.
28	A six monthly reports on compliance of the conditions mentioned in this letter shall have to be furnished by the KPT on	DPA has been regularly submitting six monthly compliance reports of the stipulated conditions to GCZMA and the Regional Office, MoEFandCC, GoI.

	regular basis to this department/MoEF, GOI.	
29	Any other condition that may be stipulated by this department from time to time for environmental protection/management purpose shall also have to be complied with by the KPT.	Point noted.

Annexure -C

List of CSR Works for the Oct 2024 to Till March-2025		
Sr.No	Name of work	Approved cost (Rs in Lakhs)
1	Request for construction of relocatable of sports arena at Gandhidham Military Station,HQ 98 Artillery Brigade Military Station Gandhidham	₹ 28.00
2	Proposal for construction of Police Community Hall at Police Headquarters Shinay.Office of the Superintendent of Police, East – Kutch Gandhidham.	₹ 100.00
3	Proposal for providing AWG system at their check posts located in the Runn of Kutch,Commandant BSF Station Gandhidham	₹ 82.70
4	Proposal for providing 4000 pieces of Tripal/Tarpaulin,Matri Sena Charitable Trust	₹ 32.00
5	Proposal for Upgrading Satellite Eye Hospital at Bhuj.1.Request for financial support for the addition of cornea and retina outpatient departments (OPD), a spectacle dispensing unit, and a medicine counter as part of our OPD activities, & equipment purchase.	₹ 35.08
6	Proposal for financial assistance for purchase of C Arm and OT table to start Orthopedic at St. Joseph's Hospital Gandhidham,ST. Joseph's Hospital Trust, Gandhidham.	₹ 28.78
7	Proposed to establish a women empowerment center, through Ujjas Mahila Sangh,Gandhidham	₹ 119.48
8	CSR fund for extension of building of pre- primary unit of S.H.N. Academy School being managed by Indian Institute of Sindhology at Adipur	₹ 71.55
9	CSR Grant for 'Strengthening of School Ecosystem at Primary School Level in Kachchh District,Ladies Environment Action Foundation (LEAF), Gandhinagar	₹ 50.00
Total Amount		₹ 547.59

Annexure -D

Monsoon Report
(June to September, 2024)

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

Submitted to



DEENDAYAL PORT AUTHORITY
મુંદરા બંદર (મુંદરા જિલ્લો) ગુજરાત રાજ્ય

Submitted by



Gujarat Institute of Desert Ecology
Mundra Road, Bhuj 370 001, Kachchh, Gujarat
E-mail: desert_ecology@yahoo.com
www.gujaratdesertecology.com

Project Coordinator
Dr. V. Vijay Kumar, Director

Principal Investigator		
Dr. Durga Prasad Behera	Scientist	Phytoplankton & Zooplankton, Physico-chemical parameters, Intertidal, Seaweed, Seagrass & Marine
Team Member		
Dr. KapilKumar Ingle	Project Scientist	Mangrove Ecology
Dr. L. Prabha Devi	Advisor	Management Plan
Dr. S.K Sajan	Scientist	Avifauna
Dr. Dhara Dixit	Project Scientist	Halophytes & Nutrient
Mr. Dayesh Parmar	Project officer	GIS & Remote sensing
Mr. Rupak Dey	Project Scientist	GIS & Remote sensing
Mr. Viral. D. Vadodariya	Project Fellow	Avifauna

Monsoon (June 2024 to September 2024)

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. (v) EC& CRZ clearance granted by MoEF CC , GOI dated 1/1/2024 augmentation of liquid cargo handling facility specific condition no XXV
2	Deendayal Port letter sanctioning the project	DPA work Order: WK/4751/Part/ (Marine Ecology Monitoring)/72
3	Duration of the project	Three years-from 2024-2027
4	Period of the survey carried	First Year Monsoon season (June 2024 to September 2024)
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	Among the 15 sampling locations, Tuna Creek had the highest mean plant density with 2535 trees/ha, followed by Kharo Creek with 2486 trees/ha. However, in Kharo creek only one station is located. Regarding individual sample locations, the S-6 had the highest tree density (3,673 trees/ha), followed by S-1 (3,522 trees/ha). The S-15 (1,027 trees/Ha) and S-11 (1,221 trees/Ha) had the lowest average tree density.
7b	Mudflats	The highest TOC value (3.1%) was recorded at S-13 followed by S-1 and lowest TOC value was reported at site S-10 dependent on the living life forms and variations in the living object in the mudflats. The bulk density of mangrove soil at

Abstract

		Deendayal Port Authority coastal region ranged from 1.30 g/cm ³ to 1.61 g/cm ³ . The highest bulk density was recorded at S-13 sites followed by S-14. The lowest bulk density was recorded at S-5 located at Janghi creek.
7c	Phytoplankton	The phytoplankton density varied from 11,200 No/L to 20,480 No/L with the average 15,019 No/L. The highest phytoplankton density was observed at station S-13 (20,480 No/L) followed by S-14 (19,480 No/L), whereas the lowest 11,200 No/L at S-12. <i>Dictylum</i> , <i>Nitzschia</i> , <i>Pseudonitzschia</i> , <i>Pleurosigma</i> , <i>Rhizosolenia</i> , <i>Synedra</i> , <i>Thalassionema</i> , <i>Thalassiothrix</i> , <i>Navicula</i> , <i>Gyrosigma</i> which are distributed at all the stations.
7d	Zooplankton	The zooplankton identified from the 15 stations falls under 7 phyla and 28 genera belonging to the 13 groups. Zooplankton population density v during the Monsoon 2024 at the 15 sampling sites ranged from 8,400 No/L to 14,420 No/L with an overall average of 10,491 No/L. 12 zooplankton genera that exhibited 100% of occurrence.
7e	Intertidal Fauna	The species diversity of the invertebrate phyla showed the maximum for phylum Mollusca (8 species), which is followed by Arthropoda (4 species). The overall percentage composition of the three groups of intertidal fauna at the 15 station ie Arthropoda (67.09%), Mollusca (22.11%), and Chordata (10.8%),
7f	Sub-tidal Macrobenthos	macro benthic species of the various groups recorded (Fig.20) & Table 6 from the DPA port environment includes Mollusca (10) and Annelida (4) Arthropoda (2). The percentage composition of the three phyla that occurred during the monsoon. The phylum Mollusca is represented by maximum (65%) share of the subtidal Fauna, followed by Annelida (25.5%), Arthropoda (9.8%)
7g	Seaweeds	NO
7h	Seagrass	NO.
7i	Marine reptiles	NO
7j	Marine mammals	NO
7k	Halophytes	The halophytes sp <i>Salicornia brachiata</i> as measure dominance
7l	Avifauna	A total of 53 species (32 species terrestrial and 21 aquatic bird) representing 9 order, 22 families and 37 genera were recorded during the study period
7m	Physicochemical	This is purely dynamic varies according to tidal current and condition gulf environment and influence to entire creek system.

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1. Introduction

Deendayal Port is located at Kandla in the Kachchh district of Gujarat state, operated by Deendayal Port Authority (DPA) (constituted under the major port Authority Act and the administrative control of ministry of ports shipping & water way GOI)is India's busiest major port in recent years and is gearing to add substantial cargo handling capacity with private participation. DPA being one of the 12 major ports in India is situated at latitude 22°59'4.93N and longitude 70°13'22.59 E on the Kandla creek at the inner end of Gulf of Kachchh (GoK). 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 viz. chemicals, edible oil, crude oil and other petroleum products etc. DPA has handled 132.3 MMTPA during the year 2023-2024. Presently, the Port has total 1-16 dry cargo berths for handling dry cargo, 7 oil jetties, and one barge jetty at Bunder basin, dry bulk terminal at Tuna Tekra, barge jetty at Tuna and two SPMs (2 local & 1 Nayara energy Limited and two product berths-Nayara energy Limited) at Vadinar for handling crude oil & petroleum product. Regular expansion or developmental activities such as the addition of jetties, allied SIPC and ship bunkering facilities oil jetty No 8 and container terminal at Tuna Tekra are underway in order to cope with the increasing the 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 shape 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 (Stage I) with in existing Kandla port – specific condition no. xxiii.
- (iii) EC & CRZ clearance granted by the MoEF &CC, GoI dated 19/2/2020 Dev. integrated facilities (Stage II-5 (1)Setting of oil jetty No7 (2) Setting up barrage jetty at jafarawadi (3) Setting up barrage port at Veera (4) Admirative office building at Tuna Tekra (5) Road connecting from Veera barrage jetty to Tuna gate by M/s DPA -specific condition no. xv.
- (iv) EC & CRZ clearance granted by the MoEF &CC, GoI dated 20/11/20 – expansion of port by creation of water front facilities (Oil jetty 8,9,10 and 11) and development of land area 554 acres for associated facilities for storage at old



Regular Monitoring of Marine Ecology in and Around the Deendayal Port Authority and Continuous Monitoring Programme (Monsoon)

Kandla , Gandhidham, Kachchh by Ms.Dpa Para VIII Marine Ecology, specific condition iv.

(v)Development of 7 integrated facilities (Stage I) within the existing Kandala port CRZ clearance MoEFcc ,GOI dated 19/12/2016-Specific condition (ii),(iii) and (iv) the project proponent ensure that ,not damage the mangrove patch without disturbing creek water circulation ,there is no blocking of creek or rivers of project area and shoreline also not damaged and it periodically monitored .

(vi) EC& CRZ clearance granted by MoEF CC , GOI dated 1/1/2024 augmentation of liquid cargo handling facility specific condition no XXV.

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 all 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 an 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 faunal 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 and further extended to another 3 years i.e from May 2024 to May 2027 with specific condition XXV for augmentation of liquid cargo handling facility . The study covers all the seasons as specified by specific condition of the Ministry of Environment, Forest and Climate Change (MoEF&CC). The present study is designed considering the scope of 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 & 1.1.2024 with specific



conditions xviii, xxiii, xv, iv and xxv respectively. A detailed holistic approach to different components of 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 the period May 2024 to May 2025 as follows:

- Physico-chemical characteristic of water and sediment will be analysed.
- 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.
- To study the intertidal faunal composition, distribution, diversity, density and other characteristics, other mega faunal components such as mammals, reptiles and amphibians.
- To investigate the species composition, distribution, diversity, density of sub-tidal benthic fauna.
- To estimate the primary productivity selected sampling sites located in around DPT area.
- Investigate the species composition, distribution, density and diversity of phytoplankton and zooplankton.
- To study the distribution of halophytes, sea grasses, seaweeds and other coastal flora, their occurrence, distribution, abundance and diversity.
- To study the Avifaunal Density, diversity, composition, habitat, threatened and endangered species and characters.
- Fishery Resources - Common fishes available, composition, diversity, Catch Per Unit Effort (CPUE) and other socio-economic information.

This study in short attempts the following, to i) developing a strong long term monitoring of the port marine environment from the biological perspective which could be used to monitor changes in the future, and ii) formulating a management plan based on the baseline data in order to ensure long-term ecological health of the port environment. A



better understanding of the marine ecology of the port and its processes has been attempted in this study which will assist in better management and conservation decisions to promote marine environmental health within the port limits.

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 (Table1) .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 (Fig1). 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).

Locations	GPS coordination	
	Latitude	Longitude
S-1	22.9410	70.1358
S-2	22.9616	70.1244
S-3	22.9876	70.2345
S-4	23.0285	70.2331
S-5	23.0804	70.2245
S-6	23 9'19.99	70 24'1.47
S-7	22.9771	70.2125
S-8	23.0378	70.4070
S-9	22.9960	70.3932
S-10	23.1007	70.2961
S-11	23.1608	70.4948
S-12	22.9446	70.1062
S-13	23° 6'58.69"	70°21'8.77"
S-14	22.89590	70.07450
S-15	23.0654	70.2172

Table 1 . Sampling locations (2024-2025)

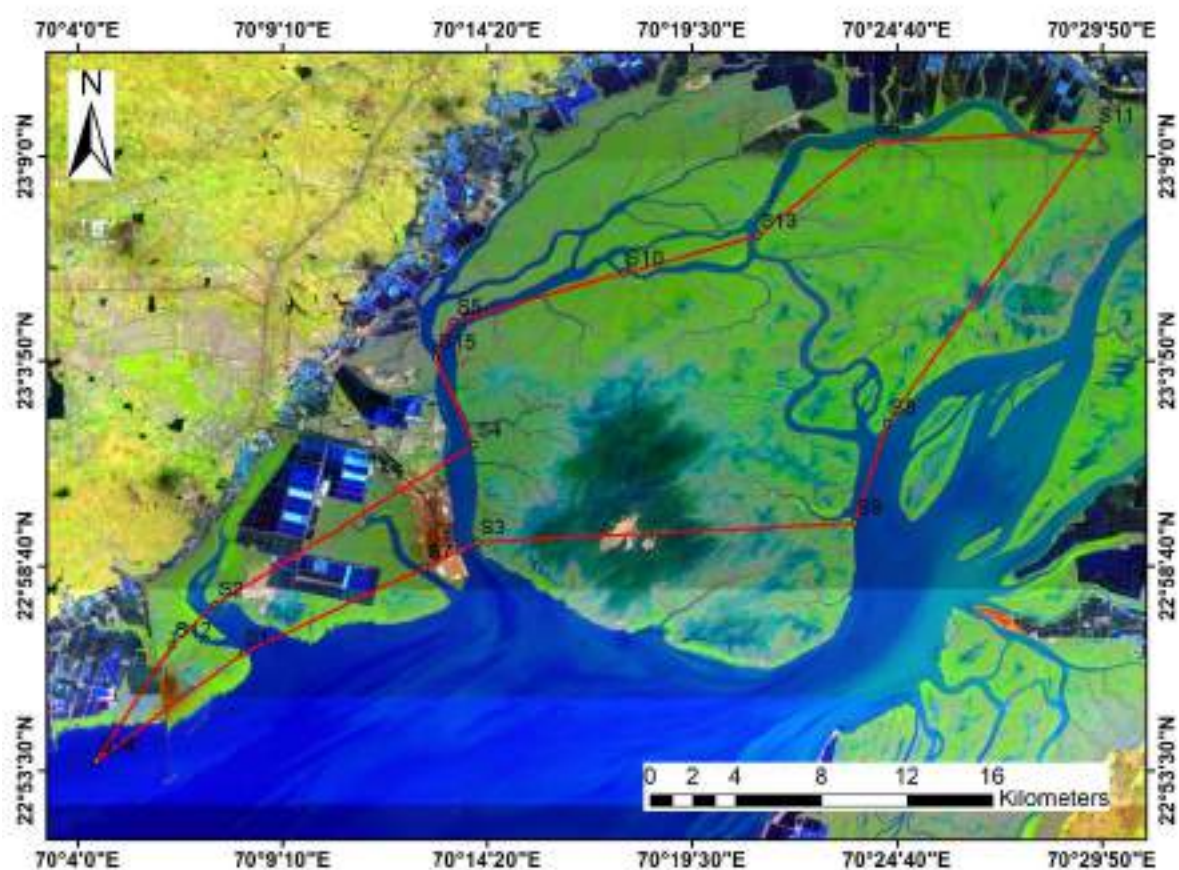


Figure 1. Sampling location of Study area

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.2).

Table 2: Physico-chemical and biological parameters analysed

Parameters	
Water	Mangrove & Other Flora
pH	Mangrove
Temperature	Vegetation structure, density
Salinity (ppt)	Diversity
Dissolved oxygen	Height
Total Suspended Solids (TSS)	Canopy and other vegetation characteristics
Total Dissolved solids (TDS)	Halophytes:
Turbidity	Percentage of distribution and cover
Nutrients	Diversity
Nitrate (NO ₃)	Seagrass and Seaweed
Nitrite (NO ₂)	Occurrence, distribution, and diversity
Phosphate	Intertidal fauna
Silicate	Composition, distribution, diversity, density and other characteristics
Petroleum Hydrocarbon (PHs)	Mammals
Sediment	Avifauna
Texture	Density, diversity, composition, habitat,
Bulk density	Threatened and endangered species and characters
Total organic carbon (TOC)	
Biological Parameters	
Phytoplankton- Genera, abundance, diversity and biomass	
Productivity-Chlorophyll a	
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 the 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

Methodology

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

Silicate

The determination of dissolved silicon compounds in natural waters is based on the formation of a yellow silicomolybdic acid when an acid sample is treated with a molybdate solution. It is Spectrophotometrically measured by absorbance (810 nm for maximum absorbance and 660 for about 40% by adopting method of Grasshoff et al. 1999).

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 sampling

Sediment samples were collected from the prefixed stations by using a Van Veen grab having a mouth area of 0.04m² 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 passed through sieves of different mesh size as per Unified Soil Classification System (USCS). Cumulative weight of the fraction 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).



2.2. 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 through the process of photosynthesis in which CO₂ is used and O₂ 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 the 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 m² (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 m² 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.

Intertidal Fauna

Intertidal faunal assemblages were studied for their density, abundance and frequency of occurrence during Monsoon 2024 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 m² 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; Naderloo 2017; Ravinesh *et al.* 2021; Edward *et al.*, 2022). Average data at each site were used to calculate the mean density (No/m²).

Sub tidal 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 0.04m². 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. /10cm². All the species were sorted, enumerated and identified by following the available literature. The works of Day (1967), Hartman (1968, 1969), Rouse

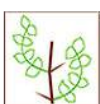


Regular Monitoring of Marine Ecology in and Around the Deendayal Port Authority and Continuous Monitoring Programme (Monsoon)

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 (2017), Ravinesh *et al.* (2021) and Edward *et al.*, (2022) for molluscs. Statistical analyses such as diversity indices and Univariate measures such as Shannon-Wiener diversity index (H'), Margalef's species richness (d), Simpson's dominance (D) were determined using Paleontological Statistics Software Package for Education and Data (PAST) version 3.2.1 (Hammer *et al.*, 2001).



Plate 1: Estimation of intertidal fauna by the quadrat method



Regular Monitoring of Marine Ecology in and Around the Deendayal Port Authority and Continuous Monitoring Programme (Monsoon)



Plate 2: Collection of Plankton and macrobenthos in subtidal habitat



2.3. Mudflats

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





Plate 3. Sediment sample collection at mangrove and mudflat areas

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.

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 H₂SO₄. 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).

2.4. Mangrove assessment

Mangroves are widely distributed on the Deendayal Port Authority jurisdiction area along the Kandla coast. The 15 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 closeness of the location to the respective creek system. The Point Centered Quadrate Method (PCQM) was used for the collection of data of the mangrove vegetation structure. The data included, measurements of density of plants, height variations, canopy and basal girth 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 to the 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 m² for regeneration and 2×2 m² were laid randomly for recruitment class of the mangrove sites.



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



2.5. Halophytes

To quantify and document the halophytes at Deendayal Port Authority region, quadrature method was followed. At each sampling location quadrates of various sizes have been laid during every seasonal sampling. For recording the plant density at each transect, a quadrature 1 x 1m² 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 each tree quadrature to assess the halophytes and the percentage cover in the study area. To enrich the species inventory, areas falling outside the quadrates were also explored and the observed species were recorded and photographed and identified using standard keys. Specimens of the various species were collected to know more information on habitat and for the preparation of herbarium.



Plate 5: Assessment and percentage cover of halophyte



2.6. 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 (Plate 6). For effective sampling, points were fixed at distances within the 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

2.7. Avifauna

The Avifauna population was determined along DPA mangrove strands for which the area was demarcated into fifteen major stations. In each station, creeks of varying lengths from 2 to 5 km are available. These creeks were surveyed by using boat and adopting “line transect” method. A total of fifteen boat transect (one in each site) survey was conducted in the Monsoon season (June- September, 2024). 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.

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

3. Results

Water quality assessment

The data on the mean water quality parameters measured at the time of sampling of the biological components from the 15 study sites are presented in Table 3.

Temperature (°C) and pH

The water temperature at the sampling sites ranged from 23°C to 30°C. The maximum temperature of seawater was reported at S-7 and the minimum at S-6 in Janghi creek. The pH of seawater ranged from 7.7 to 8.1. The highest pH reported from majority of the stations was 8.0 to 8.1 and the lowest value 7.7 was noticed at S-8 S-11 in Navlaki creek & Janghi. The overall temperature fluctuation minimum which might be due to monsoon water but the pH of the water did not show remarkable variations among the sampling locations.

Salinity (ppt)

Salinity of the water strongly influences the abundance and distribution of marine biota in coastal and marine environments. The salinity ranged from 34 ppt to 42 ppt with the average value of 38 ppt. Minimum salinity was observed at S-3 and maximum at S-8 & S-10 also.

Dissolved oxygen (DO)

Dissolved oxygen is the amount of oxygen dissolved in water and is a fundamental requirement of all biota and chemical processes in the aquatic environment. The concentration varies mainly due to photosynthesis and respiration by plants and animals in water. Generally, the coastal waters are having high level of dissolved oxygen due to the dissolution from the atmosphere through diffusion process on the surface layer (CCME, 1999). The dissolved oxygen in the coastal waters of Deendayal port authority area ranged from 2.9 mg/L to 8.2 mg/L. The highest DO concentration was observed at station S-4 and lowest value reported at S-7.

Suspended Solids (TSS)

The total suspended solids (TSS) concentration at the 15 sampling sites ranged from 205 mg/L to 729 mg/L with the average of 419 mg/L. The highest TSS values were reported at S-6 followed by 658 mg/L in S-3 opposite oil jetty. The minimum TSS value 205 mg/L was recorded at S-13.



Total Dissolved solids (TDS)

The total dissolved solids (TDS) in the water consist of inorganic salts and dissolved materials which mostly comprises of anions and cations. The TDS of the samples varied from 26,876mg/L to 1,39,862mg/L with an average of 84,352 mg/L. The maximum value was reported from S-10.

Turbidity

The turbidity of the water samples from the study sites ranged between 20 NTU and 160 NTU with the average of 59 NTU. The lowest value was noticed at S-8 and the highest value at S-6 followed by S-7 (142 NTU).

Dissolved nutrients (Nitrate, Nitrite, Total Phosphorus and Silicate)

The nutrients influence growth, metabolic activities and reproduction of biotic components in the aquatic environment. The distribution of nutrients mainly depends upon tidal conditions, season and fresh water influx from land. The nitrate concentration ranged from 0.001 mg/L to 0.003 mg/L with an average of 0.002 mg/L.. There was no remarkable variation in the concentration of nitrate among the study stations. Similarly, nitrite values varied between 0.001 mg/L to 0.173 mg/L. The highest concentration was observed at station S-9 and lowest value at station S-14. The Total phosphorus values among the study station ranged from 36 mg/L to 73 mg/L with an average of 54 mg/L. The highest phosphorus concentration was observed at station S-6 near Janghi creek and lowest at station S-3 opposite to oil jetty . During this season the highest concentration over limit might be due to leaching of phosphatic fertilizer while handling in the cargo port area and other cargo discharge . Likewise, the silicate concentration varied from 0.012 mg/L to 0.058 mg/L with the average of 0.035 mg/L. The highest concentration of Silicate was observed at S-15 and lowest value at S-14. The variations in the concentration of silicate is correlated with the production of diatoms and siliceous planktonic species which are involved in the export of carbon from surface of open sea towards creek system of Kandla and the particulate matter to the bottom sediment.



Petroleum Hydrocarbons (PHs)

Petroleum Hydrocarbons (PHs) are widely recognized as the most extensively utilized fossil fuels in commercial applications (Kuppusamy et al., 2020). PHs serve as crucial raw materials across various industries and function as primary sources of energy (Varjani, 2017). However, their pervasive use has led to their identification as a major concern in terms of environmental contamination, posing significant threats to ecosystems due to their inherent stability and resilience. The category of PHs encompasses diverse components, including Polycyclic aromatic hydrocarbons (PAHs), alkanes, paraffin, cycloalkanes, organic pollutants, and non-hydrocarbon elements such as phenol, sulfur compounds, thiol, metalloporphyrin, heterocyclic nitrogen, naphthenic acid and asphaltene. The introduction of PHs into an ecological niche or ecosystem promptly alters its composition, leading to a decline in overall functionality and inducing weathering processes. This weathering, in turn, initiates various influences, encompassing chemical reactions (auto-oxidation/photo-oxidation), physical changes (dispersion), physico-chemical alterations (sorption, dissolution, evaporation), and biological transformations (microbial and plant catabolism of hydrocarbons) (Truskewycz et al., 2019). The presence of PHs significantly impacts marine organisms, with bioaccumulation of harmful PHs in the aquatic food chain persisting for extended periods. This, in consequence, affects primary producers, primary consumers, and secondary consumers. Notably, approximately 90% of PH discharges are attributed to anthropogenic activities, particularly oil spills, occurring in both terrestrial and marine environments. Reports indicate an alarming annual discharge of around 8.8 million metric tonnes of oil into aquatic environments (Periathamby and Dadrasnia, 2013).

In the current study, the presence of PHs in water samples collected along all the 15 sampling locations were detected and estimated. The PHs ranged from 1.2 µg/L to 10.1 µg/L. The highest concentration of the PHs was noticed at S-4 (in front of oil jetty) (10.1 µg/L) while the lowest was noted at S-5 (1.2 µg/L) (Phang creek) with average variation of 4.6 2 µg/L among the different station. Overall the PHs in all station little higher which might be due to cargo handling activity.



Table 3: Physico-chemical& Biological characteristics of the waters at the study sites during Monsoon 2024

Parameter	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) (Water)	24	25	25	25	26	23	30	25	25	24	29	24	25	26	23
pH	8.1	8.0	8.1	8.0	8.0	8.1	8.1	7.7	7.9	7.9	7.7	8.0	8.1	8.1	8.0
Salinity (ppt)	36	38	34	39	37	36	41	42	38	42	38	36	40	38	36
Dissolved oxygen (mg/L)	4.3	6.2	5.5	8.2	7.6	7.4	2.9	7.2	6.4	7.0	5.2	5.8	4.1	3.6	5.3
(TSS) (mg/L)	302	599	658	467	346	729	503	329	365	390	346	468	205	259	323
(TDS) (mg/L)	56812	138585	88083	59045	116696	77160	83011	47680	98899	139862	89974	26876	96345	87131	59128
Turbidity (NTU)	58	45	58	74	42	160	142	20	47	60	44	47	31	28	33
Nitrate (NO ₃) (mg/L)	0.003	0.002	0.002	0.002	0.002	0.003	0.001	0.002	0.003	0.003	0.002	0.002	0.002	0.002	0.003
Nitrite (NO ₂) (mg/L)	0.050	0.038	0.031	0.053	0.050	0.064	0.079	0.061	0.173	0.018	0.062	0.094	0.083	0.001	0.052
Silicate (mg/L)	0.043	0.039	0.030	0.034	0.037	0.028	0.022	0.021	0.053	0.047	0.054	0.027	0.018	0.012	0.058
Total Phosphorus (mg/L)	48.24	61.18	36.18	68.53	62.94	73.24	46.18	51.18	37.06	53.82	42.35	46.18	53.53	67.35	62.94
PHs (µg/L)	7.15	6.35	3.49	10.1	1.2	6.5	2.05	7.85	8.7	2.75	1.75	3.9	3.45	1.4	2.45
TOC	3.12	2.55	2.88	2.715	3.03	2.82	2.91	2.955	2.7	2.43	2.775	2.85	2.67	2.52	2.73
(Biological) Chlorophyll a (mg/L)	0.18	0.27	0.13	0.00	0.04	0.11	0.46	0.89	0.59	0.00	0.21	0.47	0.17	0.20	0.08



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.2. There were noticeable variations in the soil fractions, sand, silt and clay, among the stations. In the present study the highest percentage of clay was reported at S-1 followed by S-4. The highest percentage of sand was observed at S-14 followed by S-11. As per the observations, the percentage of silt content showed wide fluctuations between stations when compared to the clay and sand. The nature of soil texture was characterized by the proportion of clay, sand and silt fractions. The Soil texture revealed the dominance of clay-sandy type while the sandy type substratum was very much dominated as compared to silt. This feature of the bottom sediment might be attributed to the activity of sediment transport in the creek 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.

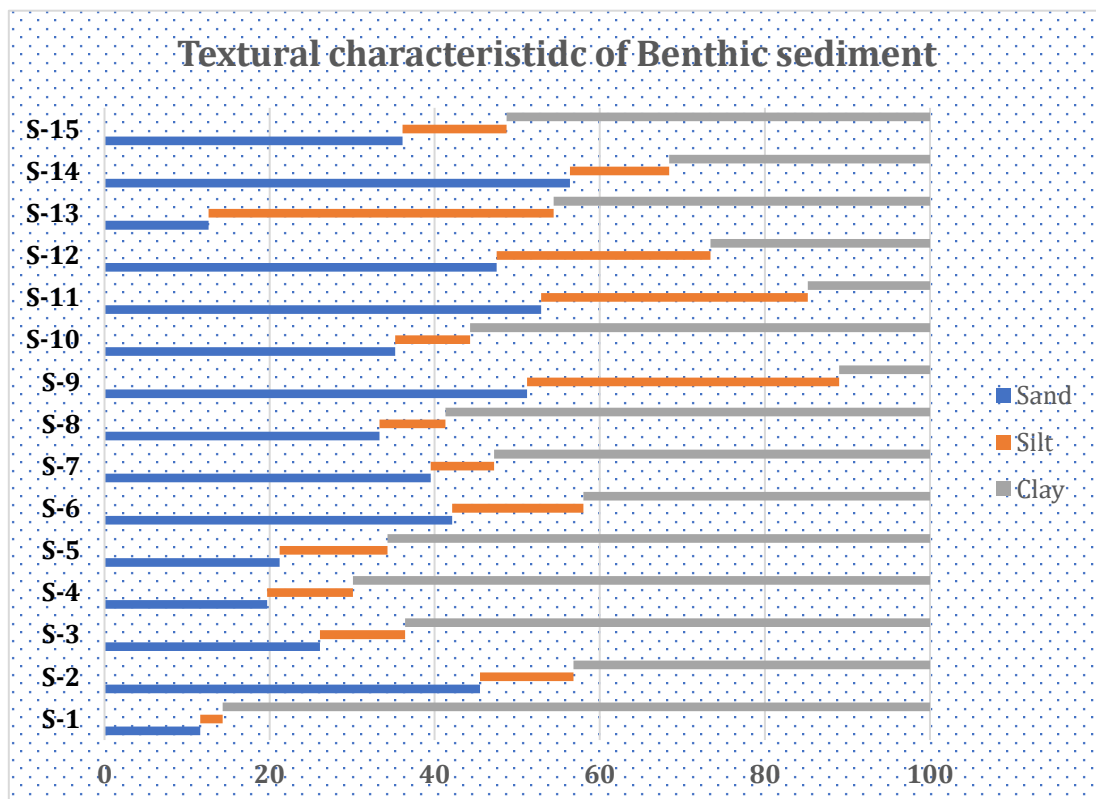


Figure 2: Characteristics of sediment at the study stations in Monsoon 2024

Total Organic Carbon (TOC)

In the present study, the total organic carbon content varied from 2.4% to 3.1% (Fig.3). The highest values of TOC were reported at S-1 followed by S-5 & S-8. The lowest TOC value was recorded at S-10. The distribution of total organic carbon closely followed the distribution of sediment type in general i.e., sediment low in clay content contained relatively low organic carbon. But in the Kandla creek system is associated with Mangroves which holds the organic particles derived from the plants and the fauna undergo decomposition and mixed with the sediment during the the mixing process which would have facilitated the adherence of particulate matter in the soft substratum as most of the stations showed more organic carbon load during monsoon .

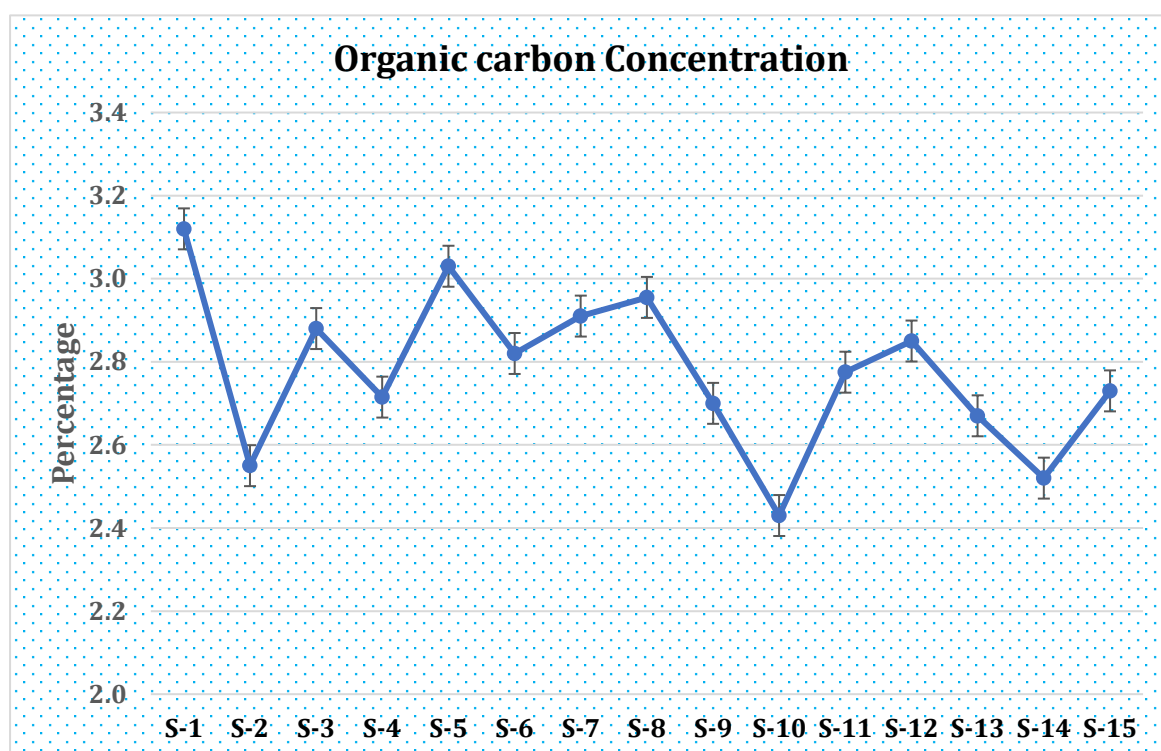


Figure 3: Total Organic Carbon content (%) in the sediment during Monsoon 2024

3.3. Biological characteristics

Primary productivity

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

At present, the Chlorophyll 'a' concentration ranged from 0.01 mg/L to 0.89 mg/L with average variation among the station was 0.26 mg/L. The highest concentration 0.89 mg/L was reported at S-8 (Fig.4) followed by S-9 (0.59mg/L). The photosynthetic pigment chlorophyll a which is a measure of the population density of phytoplankton during the monsoon period showed minor variations among the sites. The Chlorophyll 'a' content was very low at S-4 (Table 2).

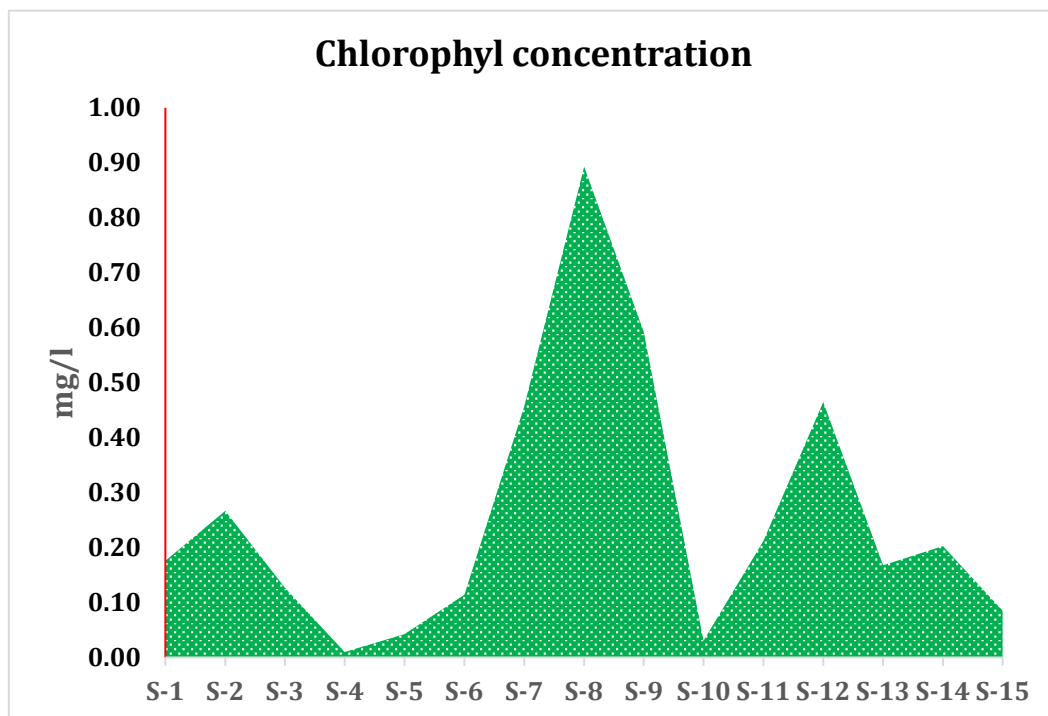


Figure 4: Chlorophyll 'a' concentration at the study stations in Monsoon 2024

3.4. Phytoplankton

Phytoplankton are a key component of the ocean and freshwater ecosystems and provide many ecosystem services including oxygenation through photosynthesis which is estimated to be about half of the Earth's oxygen. Thus, they are important component of the functioning of ecosystems and climate regulation (Jacqueline et al.,2018). The carbon assimilation during photosynthesis by the phytoplankton enables the transfer of atmospheric carbon dioxide into the biomass which is stored in the cells and later pass on to the food chains and being cycled through the food webs. These microscopic producer community has been influenced by the negative impact from human developments and activities, and hence the service provision afforded by them should be accounted for in marine management processes (Jacqueline et al.,2018). Phytoplankton growth depends on the availability of carbon dioxide, sunlight, and nutrients. Phytoplankton, like land plants, require nutrients such as nitrate, phosphate, silicate, and calcium at various levels depending on the species. Some phytoplankton can fix nitrogen and can grow in areas where nitrate concentrations are low. They also require trace amounts of iron which limits phytoplankton growth in large areas of the ocean because iron concentrations are very low. Other factors influence phytoplankton growth rates, including water temperature and salinity, water depth, wind, and what kinds of predators are grazing on them (Lindsey and Scott,2010).

The numerous species of phytoplankton are the primary producers form the basis of marine food-webs, supporting production of higher trophic levels (a provisioning ES), and act as a sink of carbon dioxide. The spatial distributions of phytoplankton and rates of primary productivity are generally subject to bottom-up control, due to the tight coupling between light, temperature and nutrients. understanding of the spatial and temporal variability in phytoplankton parameters are accounted in marine management as these are correlated with physical and chemical factors of the water. The diatoms form the bulk of phytoplankton and the dinoflagellates are scarce. The phyto-plankton in the Gulf of Kachchh shows a primary peak in September and secondary peaks in January or June are instances of local blooms of more than one genus and species of diatoms. The detailed genera and percentage of phytoplankton presented in table -4.



Generic Status

There were four groups of phytoplankton occurred during monsoon along the DPA, Kandla coast and its peripheral creek system which include Diatom (Pennales, Centrales), and Cyanophyceae. The number of genera recorded during the monsoon period was 17 to 22 at the sampling stations with variations in respect to the composition. The maximum number (22) genera were observed at S-13 and the minimum from S-12 representing 17 genera. As far as generic status is concerned the Pennales diatom contributed a smaller number of genera (13) followed by Centrales (9) (Fig.5 & Table 4). Among the 4 groups of phytoplankton, the genera *Pleurosigma*, *Thalassionema*, *Coscinodiscus* and *Odontella* was highly dominated.

Percentage composition of phytoplankton

The cumulative percentage composition of the five groups of phytoplankton from all the study sites is presented in Fig.6. The percentage composition varied from 0.14 % to 14.35 % of which the pennales and centrales are the dominant constituting 65% and 34% 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 is constituted by Cyanophyceae (1%) during the monsoon 2024.

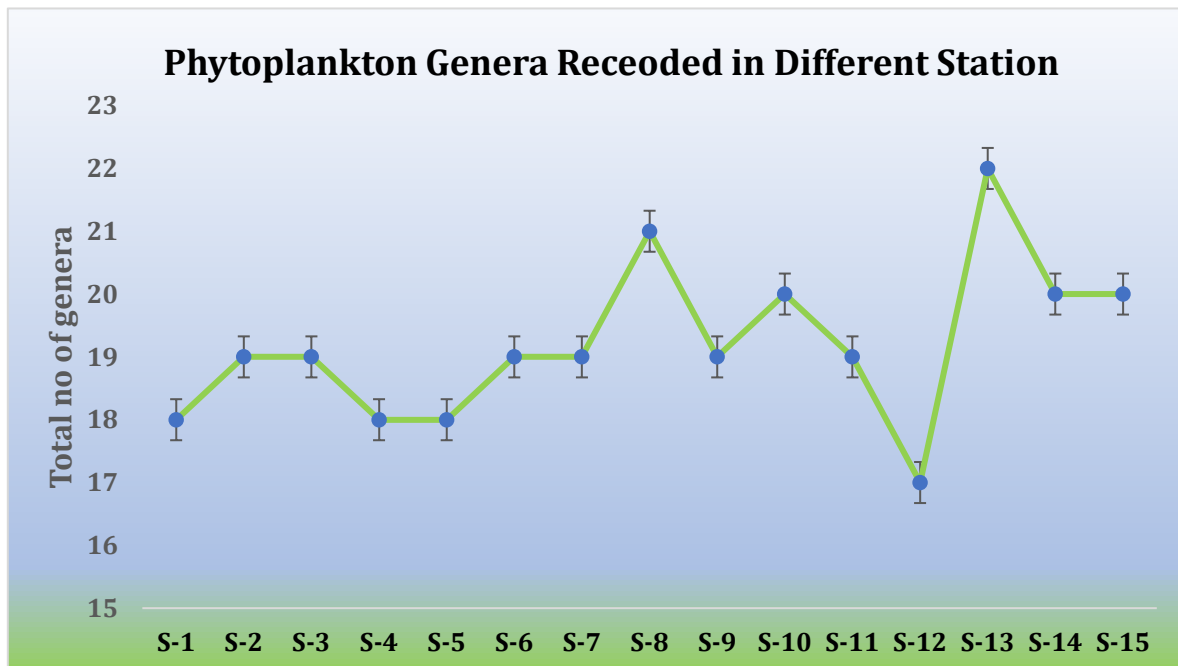


Figure 5: Number of Phytoplankton genera in Monsoon 2024

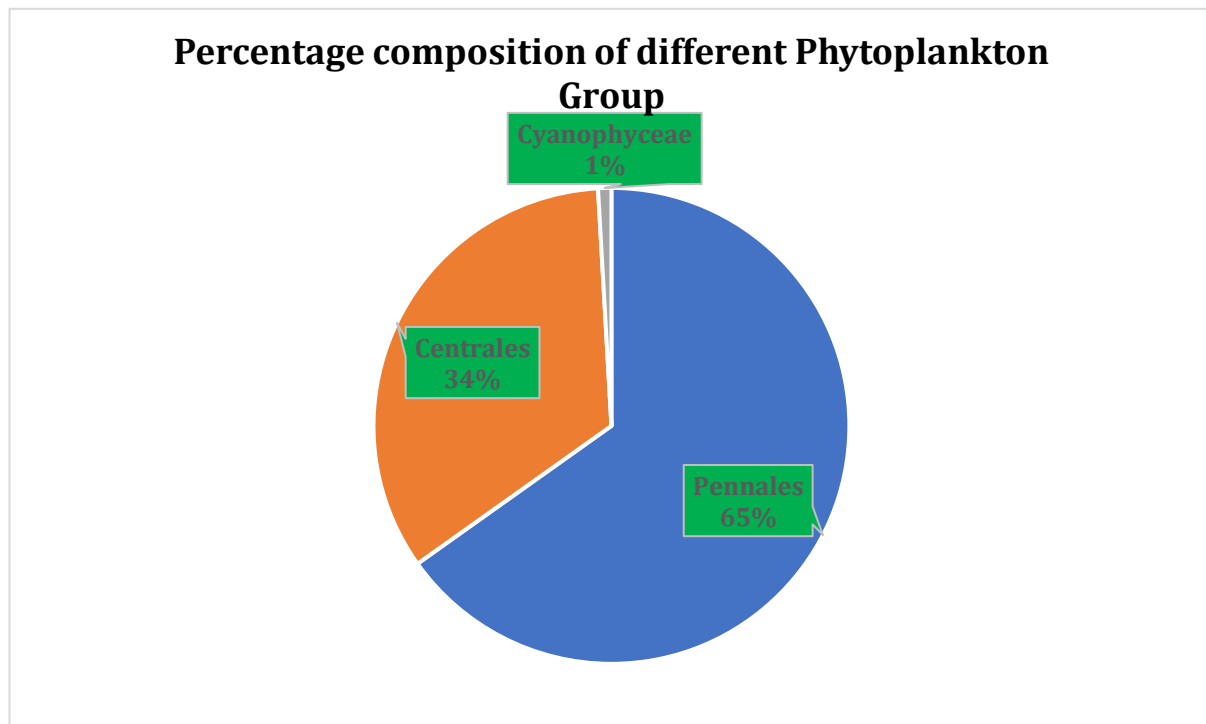


Figure 6: Percentage composition of phytoplankton groups in Monsoon 2024

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 83%. i.e 15 genera of diatoms occurred at all the stations i.e *Dictylum*, *Nitzschia*, *Pseudonitzschia*, *Pleurosigma*, *Rhizosolenia*, *Synedra*, *Thalassionema*, *Thalassiothrix*, *Navicula*, *Gyrosigma* (fig 7) followed by *Triceratium* and *Noctiluca* (73%) during the monsoon season.

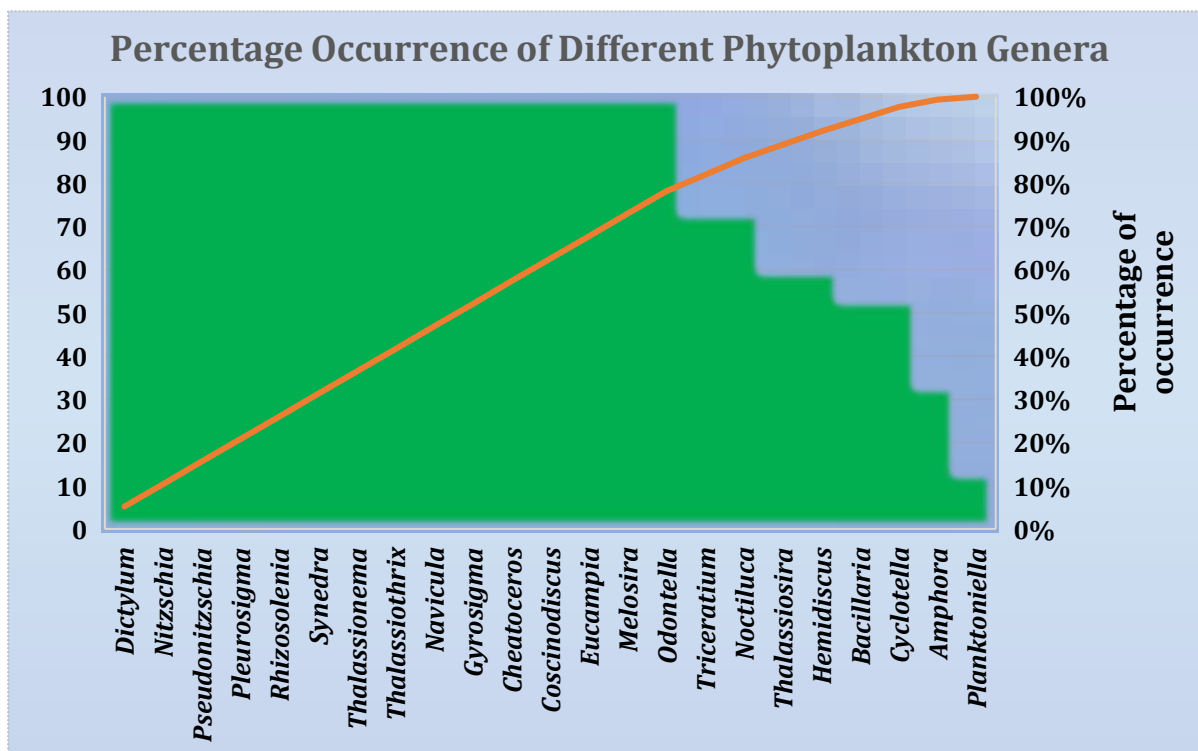


Figure 7: Percentage occurrence of phytoplankton genera in Monsoon 2024

Phytoplankton density and diversity

The density signifies the abundance of plankton which is measured as cell/ individual/L. The phytoplankton density varied from 11,200 No/L to 20,480 No/L with the average 15,019 No/L. The highest phytoplankton density was observed at station S-13 (20,480 No/L) followed by S-14 (19,480 No/L), whereas the lowest 11,200 No/L at S-12 (fig.8). Diversity indices have become part of standard methodology in the ecological studies particularly, impact analysis and biodiversity monitoring of the environments (PEET,1974). Biodiversity indices reflects the biological variability which can be used for comparison with space and time. Various species diversity indices respond differently to different environmental and behavioral factors of biotic communities. Among the different stations, the phytoplankton taxa varied from 17 to 22 (Table-3). During monsoon the Margalef and Menhinik richness indices were maximum as(2.1& 0.2). The Shannon diversity index was maximum 2.7 and minimum 2.5 a. The Simpson index clearly reflexes the species dominance (genera) at all station (fig 9).



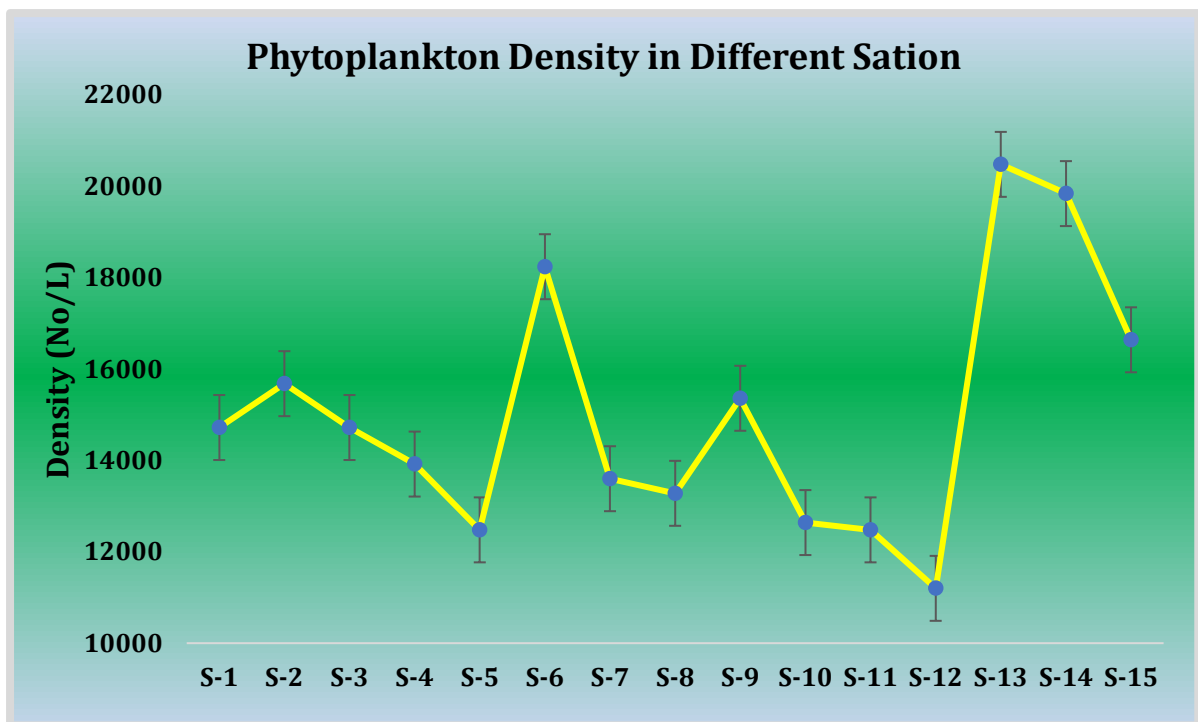
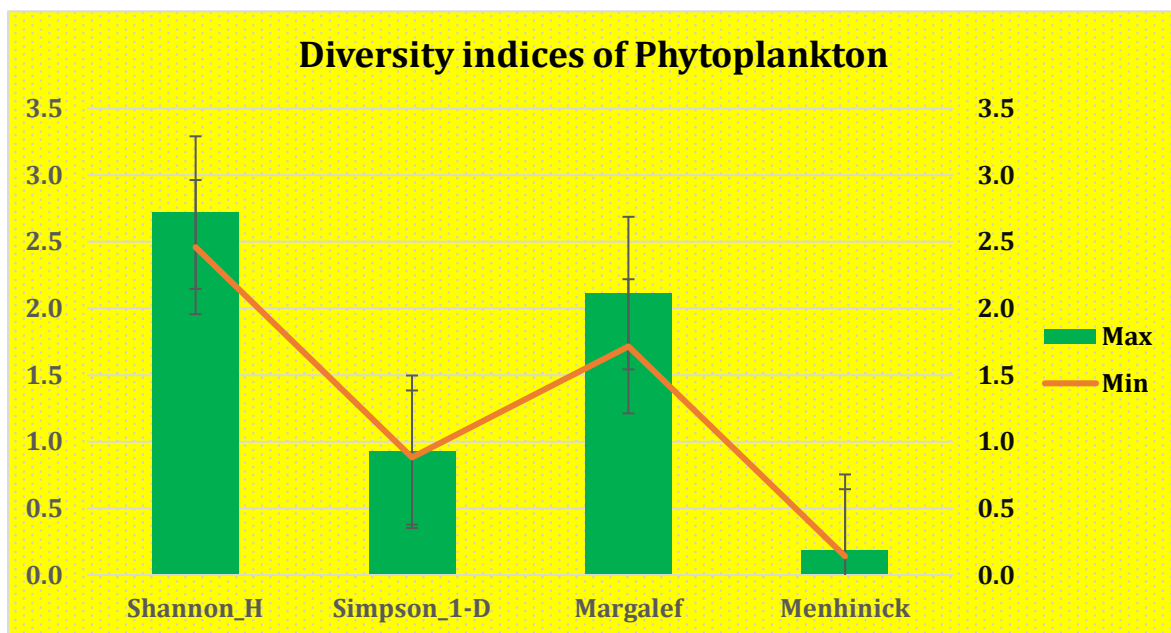


Figure 8: Phytoplankton density in Monsoon 2024



**Figure 9: Different diversity indices a. Shannon Index b. Menhinick Index
c. Margalef Index d. Simpson Index**

Regular Monitoring of Marine Ecology in and Around the Deendayal Port Authority and Continuous Monitoring Programme (Monsoon)

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 the cargo movements. Accordingly, species diversity decreases at sites with poor water quality. As presumed from the Shannon diversity index values between 2.60 to 2.93 representing the moderate quality of environmental status dominated by majority of the genera such as *Dictylum*, *Nitzschia*, *Pseudonitzschia*, *Pleurosigma*, *Rhizosolenia*, *Synedra*, *Thalassionema*, *Thalassiothrix*, *Navicula*, *Gyrosigma* which are distributed at all the stations. A community dominated by relatively few species indicates environmental stress (Plafkin *et al.*, 1989). However, during the monsoon period the many genera appeared and flourish due to the suitable environmental condition in the water. According to Staub *et. al* (1970) species diversity index value between 3.0 to 4.5 represents slightly polluted and the lightly polluted environment shows the index value between 2.0-3.0, and the 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. Which might be due to the industrial development and salt pan activity along the periphery environment of DPA port authority.

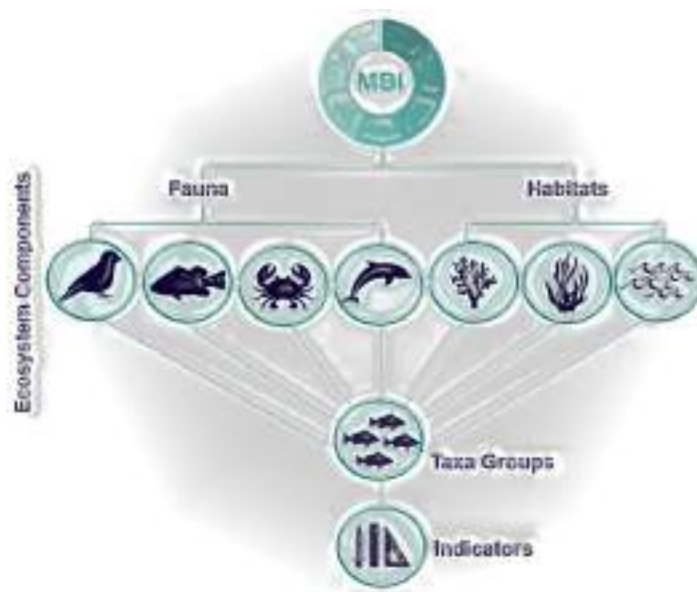


Table 4: Phytoplankton density, percentage composition and occurrence during Monsoon 2024

Group	Genera	Station															PC	PO
		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		
Pennales	<i>Amphora</i>	0	0	0	0	0	160	0	0	160	0	0	160	160	0	160	0.36	33
	<i>Bacillaria</i>	160	0	0	160	0	0	0	160	160	160	0	0	160	160	160	0.57	53
	<i>Dictylum</i>	480	320	160	480	320	320	160	320	480	640	800	480	320	480	960	2.98	100
	<i>Nitzschia</i>	1280	1440	1120	480	960	1440	1280	480	800	480	640	480	640	480	800	5.68	100
	<i>Pseudonitzschia</i>	480	640	800	480	800	480	640	480	800	480	480	320	640	960	480	3.98	100
	<i>Pleurosigma</i>	320	480	640	800	480	1440	1600	1920	1440	480	1280	1440	3360	3040	1760	9.09	100
	<i>Rhizosolenia</i>	1120	480	640	960	480	1280	480	1120	960	480	800	480	1440	1120	1440	5.89	100
	<i>Synedra</i>	1920	2400	2400	1440	1280	1920	320	320	320	480	640	640	2880	1920	480	8.59	100
	<i>Thalassionema</i>	1280	1440	1760	1920	1600	2880	3360	480	2400	2560	1440	1120	2080	4320	3680	14.35	100
	<i>Thalassiothrix</i>	480	1120	1440	480	1120	1440	480	1280	800	960	480	640	480	320	160	5.18	100
	<i>Navicula</i>	800	1280	480	640	800	480	640	1280	1120	960	480	640	800	480	1280	5.40	100
	<i>Gyrosigma</i>	480	320	480	320	160	480	320	320	480	160	160	480	320	160	160	2.13	100
	<i>Thalassiosira</i>	160	160	320	0	320	0	160	160	320	0	0	0	160	320	0	0.92	60
Centrales	<i>Cheatoceros</i>	800	640	480	320	480	800	480	640	800	1120	1440	480	800	480	640	4.62	100
	<i>Coscinodiscus</i>	2880	1440	1600	1920	1280	1920	1440	1920	2240	1440	1600	320	2400	3200	640	11.65	100
	<i>Cyclotella</i>	0	0	0	160	0	0	160	160	0	160	320	0	160	160	320	0.71	53
	<i>Eucampia</i>	320	320	480	640	320	480	320	640	480	320	640	320	480	640	800	3.20	100
	<i>Melosira</i>	480	480	320	480	640	800	480	160	320	480	320	640	480	320	800	3.20	100
	<i>Odontella</i>	960	1120	960	1920	960	1280	800	800	1120	640	480	2240	2080	960	1760	8.03	100
	<i>Planktoniella</i>	0	0	0	0	0	160	0	0	0	160	0	0	0	0	0	0.14	13
	<i>Triceratium</i>	320	160	320	160	160	320	320	160	0	0	160	320	160	0	0	1.14	73
	<i>Hemidiscus</i>	0	1280	160	0	0	160	160	320	0	160	160	0	320	160	0	1.28	60
Cyanophyceae	<i>Noctiluca</i>	0	160	160	160	320	0	0	160	160	320	160	0	160	160	160	0.92	73
Total Density (No/L)		14720	15680	14720	13920	12480	18240	13600	13280	15360	12640	12480	11200	20480	19840	16640		
Total Genera		18	19	19	18	18	19	19	21	19	20	19	17	22	20	20		

PC: Percentage of Composition

PO: Percentage of Occurrence



3.5. Zooplankton

These are the primary consumers that depends on phytoplankton for their feeding and constitute a second trophic level in food chain of marine ecosystem. The size of the zooplankton members varies greatly from microscopic to macroscopic occupying different depths in the pelagic realm. They constitute the primary food for several higher trophic level organisms which includes fishes, crustaceans and mollusks. Zooplankton provides the required amount of protein to the cultured fishes and crustaceans (Koli and Mule, 2012) as well. The zooplankton species quickly respond to the environmental changes and thus are used as bio-indicators for the assessment of aquatic environments (Sharma et al., 2007). Thus, zooplankton are of great ecological significance as they play important role of transferring organic matter from primary producer to secondary consumers like fishes (Kehayias et al., 2013). Zooplankton in the Gulf of Kachchhis dominated by copepods (Saravanakumar et al., 2017) while the microzooplankton is represented by Cilio-phora and Forminifera (Patel et al., 2017). Ramaiah (1997) stated that studies on zooplankton communities, especially copepods are of key importance in assessing the health of coastal ecosystems. The distribution of living organism is controlled by the variation in salinity of water and its variation caused by dilution and evaporation is most likely to influence the fauna in the coastal ecosystem (Sridhar et al. 2006). The density of zooplankton was found to be high during postmonsoon and premonsoon period, bimodal distribution, the primary peak occurring either in October or April and the secondary peak in March or December (Bhaskaran and Gopalakrishnan, 2011). Similarly, there occurs gradual increase in number of organisms towards the offshore area with concomitant increase in diversity. The larval forms of echinoderms, cephalopods and brachiopods are usually confined to the offshore (Govindan et al., 1980). The detailed genera and percentage of phytoplankton presented in table- 5

Phylum, group and generic status

The zooplankton identified from the 15 stations falls under 7 phyla and 28 genera belonging to the 13 groups (Table 5). The phylum Arthropoda was the predominant, represented with 20 genera including copepods, crabs, shrimps and their larva. The phylum Arthropoda dominated in the samples with major groups Calanoida, Harpacticoida, Cyclopoida, (Copepoda) Decapoda, and the larval forms of crustaceans. There were 9 genera of copepods in the samples. Among copepods, the Calanoida ranked

first in terms of generic representation particularly *Acartia* sp, *Acrocalanus* sp, *Calanopia* sp. and *Calanus* sp. (figure-10).

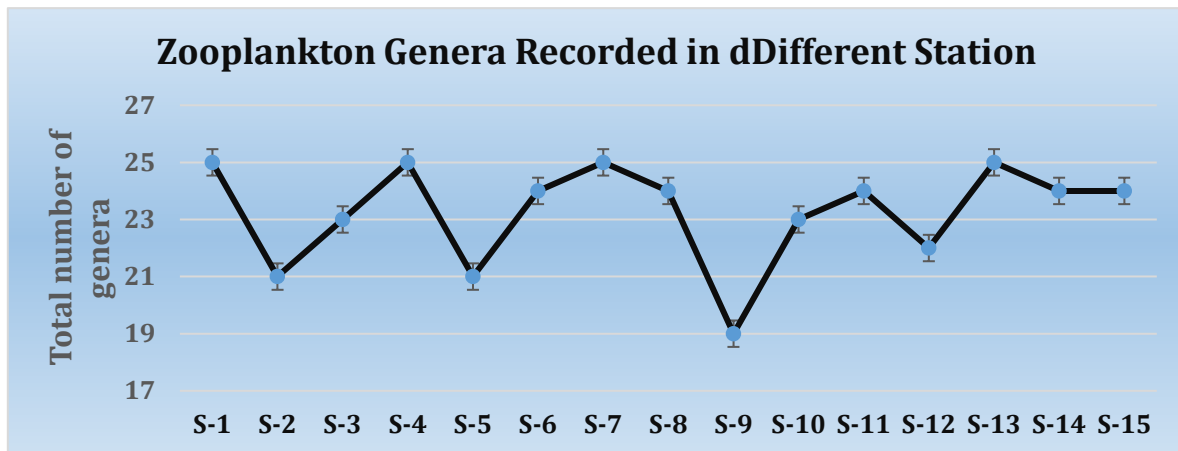


Figure 10: Generic status of zooplankton during Monsoon 2024

Percentage composition

The overall percentage of the various groups of zooplankton varied from 0.4% to 25.8%. The highest percentage was due to the calanoid copepods (25.8%) followed by *Malacostraca* (Brachyuran larvae) (19.9%) and Tintinnida (12.7%). (Fig.11). Among the zooplankton groups calanoid group predominated at all sites.

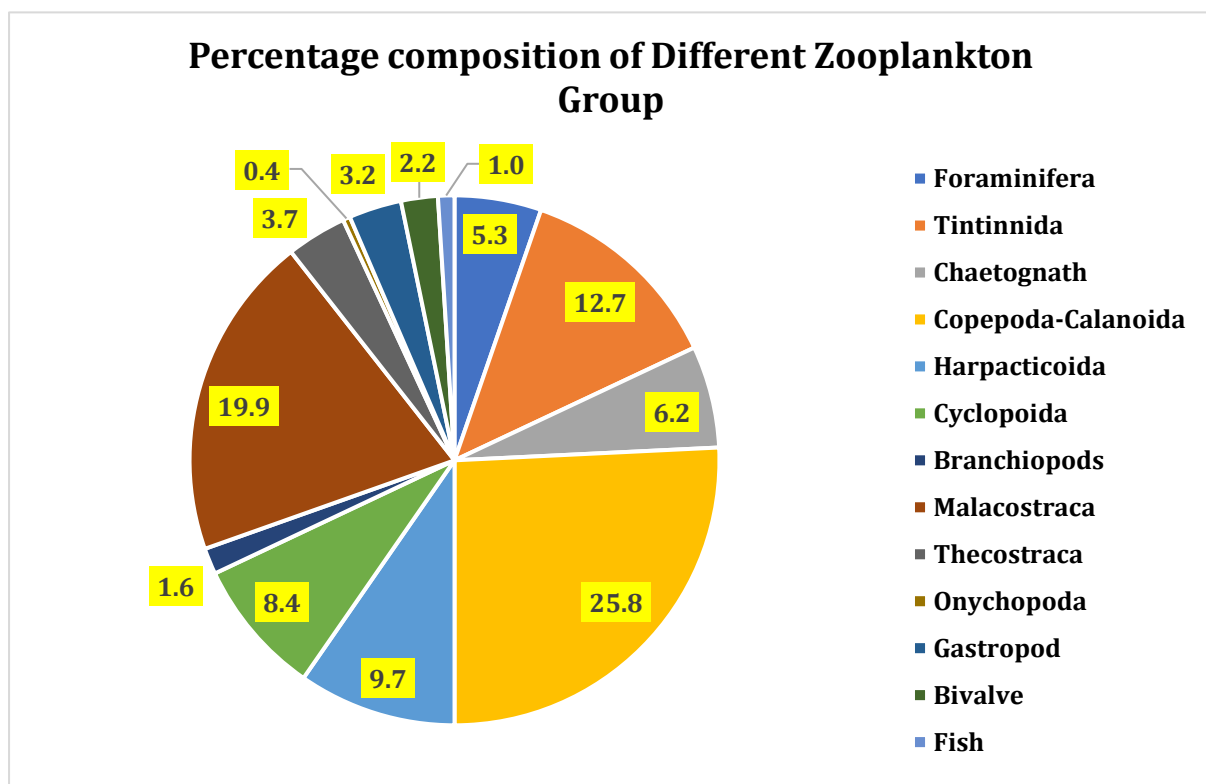


Figure 11: Percentage composition of zooplankton during Monsoon 2024

Percentage occurrence of zooplankton

The percentage occurrence of zooplankton communities (genera) varied from 33% to 100%. There were 12 zooplankton genera that exhibited 100% of occurrence (Fig.12) followed by the *Euterpina*, *Oithona* and *Oncaea* (93%) and *Calanopia*, *Nannocalanus* (87%) from the study sites (Table 5).

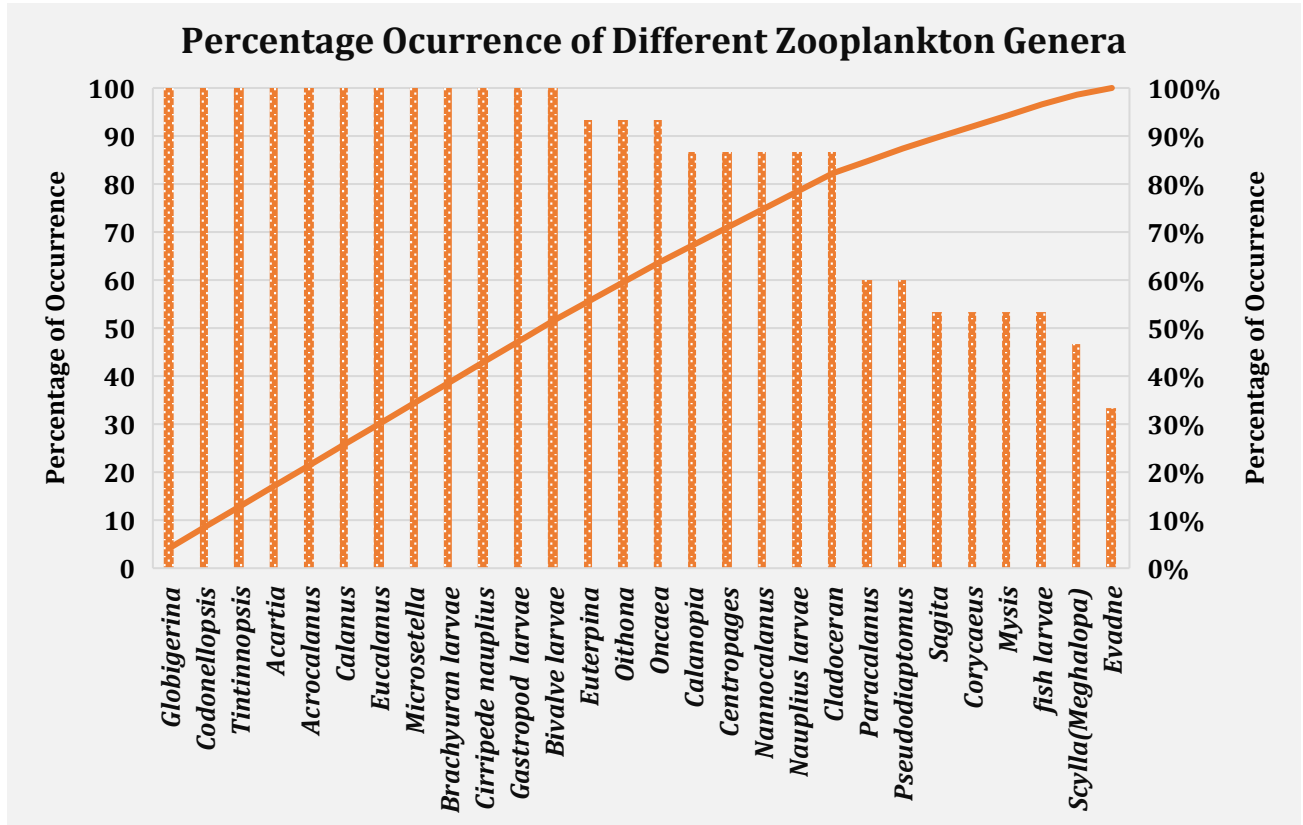


Figure 12: Percentage occurrence of Zooplankton groups during Monsoon 2024

Density of zooplankton

Zooplankton population density during the Monsoon 2024 at the 15 sampling sites ranged from 8,400 No/L to 14,420 No/L with an overall average of 10,491 No/L (Table 5). Station-wise, the highest density of 14,420 No/L was recorded in S-1 followed by S-6 (12,320 No/L) and lowest density was reported at S-11 (8,400 No/L) (Figure 13).

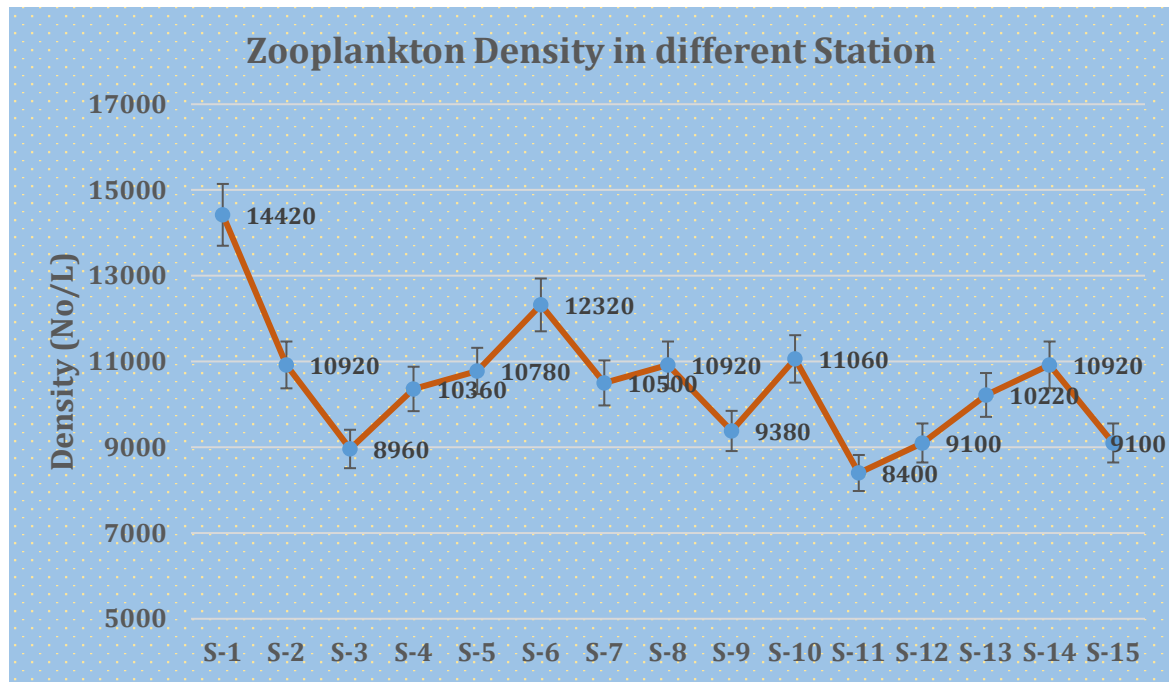


Figure 13: Zooplankton Density in the different stations during Monsoon 2024

Diversity Index

The Shannon diversity index of the zooplankton ranged between 2.44 to 3.01. Similarly, Margalef and Menhinick species richness index also varied from 2.60 to 1.97 and 0.20 to 0.26 respectively representing the moderate quality of the environment. (fig.14).

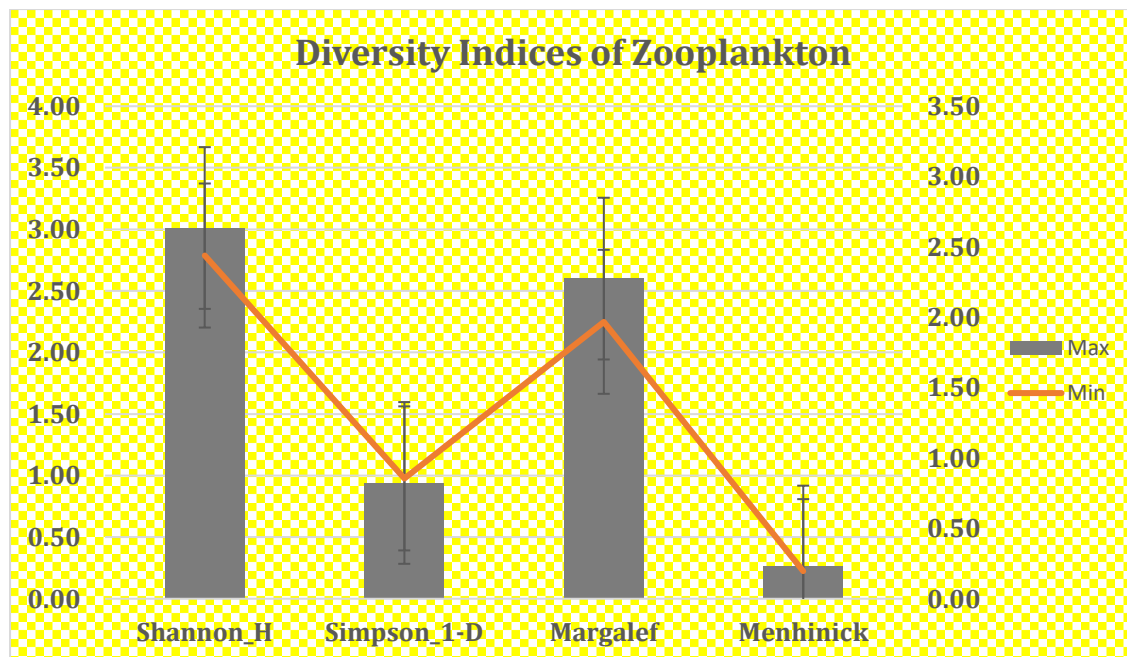


Figure 14: Zooplankton Density indices Monsoon 2024

Table 5: Zooplankton generic status during Monsoon 2024 in Deendayal Port Authority area

Groups	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
Foraminifera	Globigerina	980	1120	280	420	560	800	420	1120	420	700	420	280	420	280	140	5.31	100
Tintinnida	Codonellopsis	420	700	980	420	560	480	280	700	420	280	420	560	980	840	420	5.38	100
	Tintinnopsis	1120	420	700	980	420	800	560	420	1120	420	140	1400	420	1260	980	7.09	100
Chaetognath	Sagita	2800	0	980	1680	2100	1280	700	140	0	0	140	0	0	0	0	6.24	53
Copepoda-Calanoida	Acartia	280	420	140	280	140	640	280	140	140	420	560	280	140	420	560	3.08	100
	Acrocalanus	420	560	280	560	700	480	280	140	420	140	280	560	420	280	140	3.60	100
	Calanopia	420	280	0	280	0	320	140	420	280	420	280	700	980	280	420	3.32	87
	Calanus	700	420	980	420	560	800	420	280	140	420	280	140	420	280	140	4.07	100
	Centropages	420	280	0	140	420	320	420	280	0	140	420	280	560	420	140	2.69	87
	Eucalanus	700	420	280	140	280	960	700	980	420	560	420	280	420	280	560	4.70	100
	Nannocalanus	140	280	560	280	420	160	140	0	0	140	140	280	420	280	140	2.15	87
	Paracalanus	0	140	280	0	0	0	140	140	0	140	280	140	0	140	280	1.07	60
	Pseudodiaptomus	280	140	0	280	0	160	140	0	140	280	0	0	140	0	280	1.17	60
Harpacticoida	Corycaeus	0	0	420	0	0	320	0	420	560	0	0	140	700	280	420	2.07	53
	Euterpina	560	280	420	560	280	480	560	280	420	980	0	140	140	280	420	3.69	93
	Microsetella	840	980	420	420	280	160	420	280	140	280	420	560	280	420	280	3.93	100
Cyclopoida	Oithona	280	0	140	280	420	160	420	700	560	280	420	140	420	280	140	2.95	93
	Oncaea	280	420	140	140	420	320	140	140	0	280	140	140	280	420	140	2.16	93
	Nauplius larvae	140	0	140	280	420	320	140	280	140	0	140	140	280	140	140	1.72	87
	Mysis	140	0	140	0	140	160	140	0	0	0	140	280	140	0	0	0.81	53
	Scylla (Meghalopa)	280	140	140	140	0	0	0	140	0	0	140	0	140	0	0	0.71	47
Branchiopods	Cladoceran	280	140	280	140	140	0	280	140	140	280	140	0	280	140	140	1.60	87
Malacostraca	Brachyuran larva	1680	2940	420	1260	1680	1760	2380	2940	3080	3780	1820	1540	1260	2660	2100	19.89	100
Thecostraca	Cirripede naupliu	420	280	560	420	280	480	560	280	420	280	700	420	280	280	140	3.69	100
Onychopoda	Evadne	0	0	0	140	0	0	140	0	0	140	140	0	0	140	0	0.44	33
Gastropod	Gastropod larvae	280	280	140	280	420	320	280	420	280	420	280	420	280	560	420	3.23	100
Bivalve	Bivalve larvae	420	280	140	280	140	320	420	140	140	140	0	280	140	420	280	2.25	100
Fish	fish larvae	140	0	0	140	0	320	0	0	0	140	140	0	280	140	280	1.00	53
Total Density (No/L)		14420	10920	8960	10360	10780	12320	10500	10920	9380	11060	8400	9100	10220	10920	9100		
Total Genera		25	21	23	25	21	24	25	24	19	23	24	22	25	24	24		

PC:

Percentage of Composition PO: Percentage of Occurrence



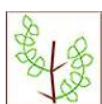
3.6. Intertidal Fauna

The intertidal zone, the interface between terrestrial and marine environments, represents one of the most dynamic and ecologically multifaceted ecosystems. Globally, the increasing utilization of the littoral zone for several developmental projects and human activities have contributed increasing level of habitat transformation and consequently degradation of this fragile ecosystem. Such degradation is manifested in the rapid loss of biodiversity, which poses a significant threat to the ecosystem's products and services (Liang et al 2024).

The intertidal zone is often referred as the littoral zone is the area where the land is submerged temporarily due to the tidal water inundation, and where the benthic region of the ocean begins and below this zone is the sublittoral (shelf) zone, extending from the low tide mark to the shelf break, is permanently submerged. The Intertidal zone can include rocky ledges, sandy beaches, mudflats, salt marshes, and mangrove swamps and the benthic region has a variety of physical conditions, including depth, light penetration, and pressure. The intertidal zone is a marine habitat that experiences extreme and rapidly changing environmental conditions such as water Temperature, salinity, tidal amplitude, turbidity, along with substratum composition and organic matter and carbon content and the vegetation characteristics which are very much correlated with the fauna population density and distribution along the intertidal zone.

Faunal composition of intertidal macrobenthos

The intertidal ecological survey has been conducted at the prefixed 15 locations within the vicinity of the Deendayal port Authority. The species diversity of the invertebrate phyla showed the maximum for phylum Mollusca (8 species), which is followed by Arthropoda (4species). The phylum Chordata was represented by one species (Table 6& Fig.15).Among the station the intertidal genera varied from 4 to 9 number higher number of genera recorded at S-6, S-10 and S-13 (9) and least number of genera recoded at S-15 .



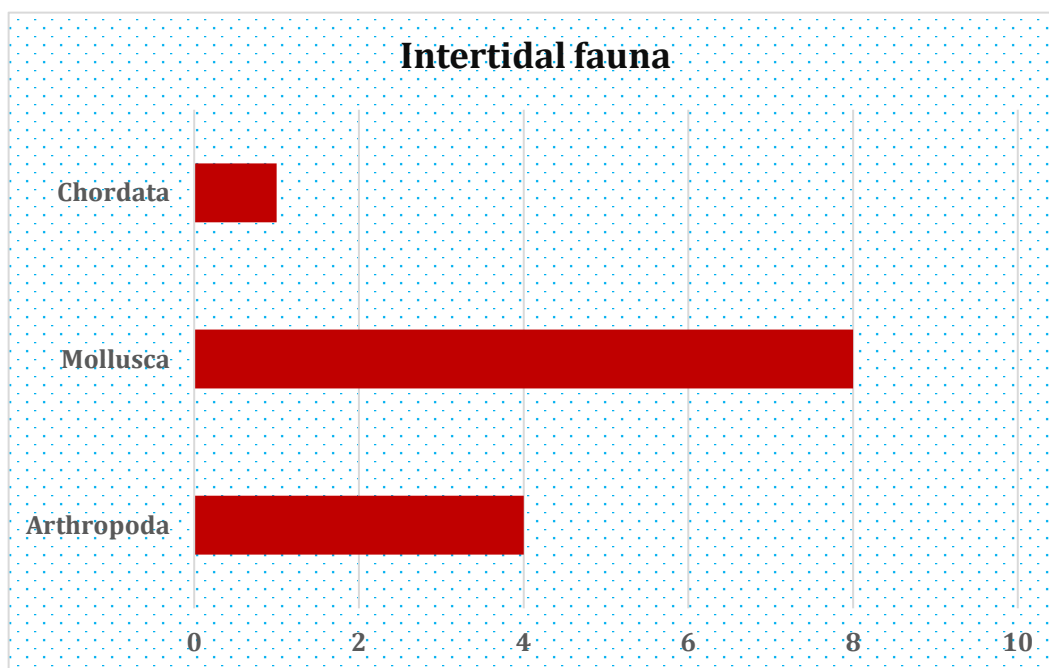


Figure 15: Number of genera of intertidal fauna during in Monsoon 2024

Percentage composition of Intertidal Fauna

The overall percentage composition of the three groups of intertidal fauna at the 15 station ie Arthropoda (67.09%), Mollusca (22.11%), and Chordata (10.8%), as shown in figure 16&17. The cumulative percentage of intertidal fauna varied from 0.1% to 23.5%.

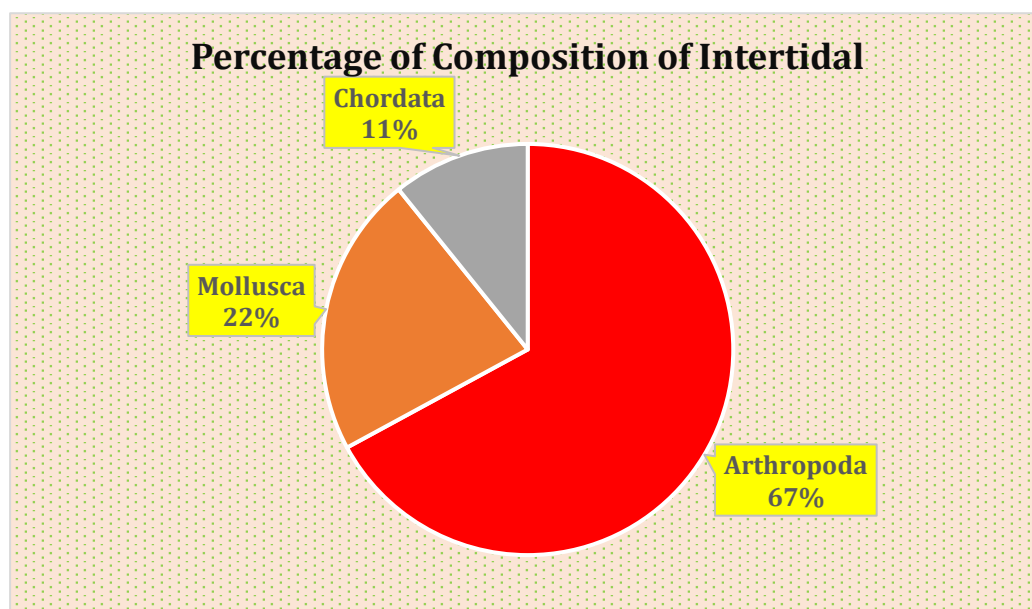


Figure 16: Percentage composition of intertidal fauna during Monsoon 2024

Regular Monitoring of Marine Ecology in and Around the Deendayal Port Authority and Continuous Monitoring Programme (Monsoon)

Highest percentage of organism contributed by *Austruca iranica* followed by *Austruca variegata* and least number of organism contributed by *Indothais lacera*, *Optediceros breviculum*.

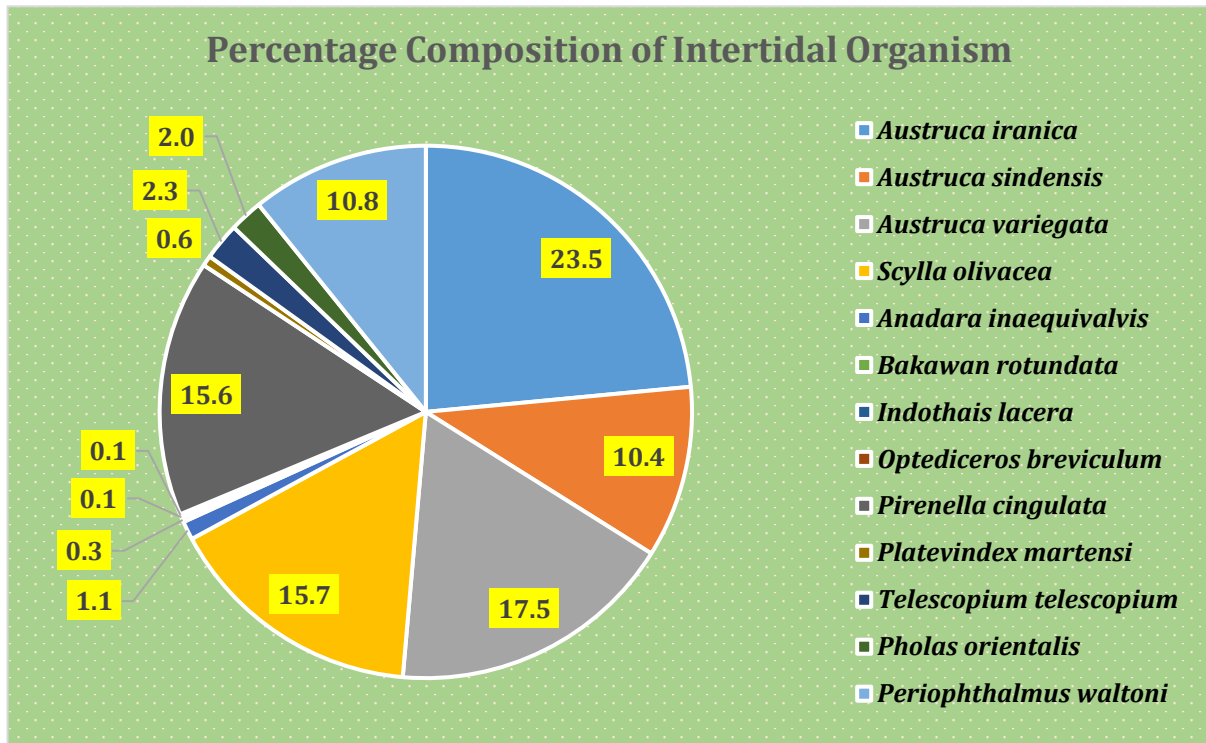


Figure 17: Cumulative % composition of intertidal fauna during Monsoon 2024

Intertidal Fauna density (No/m²)

The number of individuals of the fauna collected from the intertidal zone of the mangroves are presented in Fig 17. It was observed that the faunal density was the highest at S- 2 and the least from S-11.

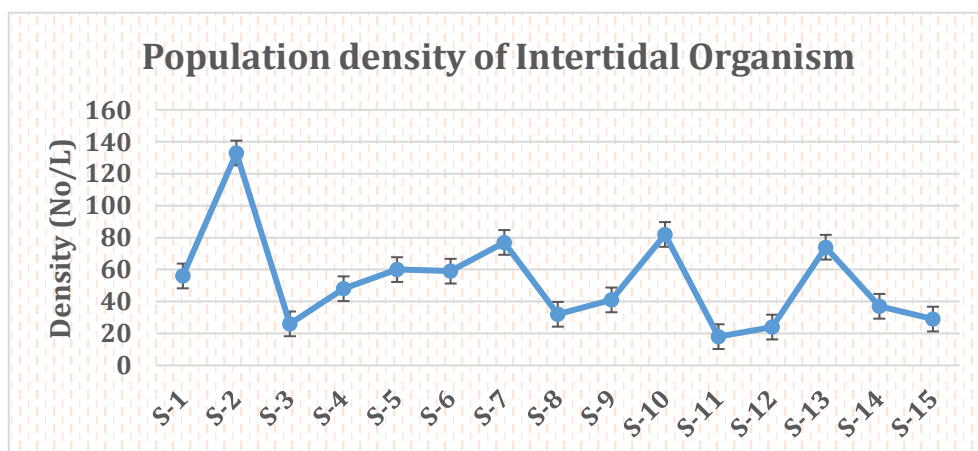


Figure 18: Density of intertidal fauna during Monsoon 2024

The Intertidal faunal diversity documented during the monsoon period of 2024 has shown that the highest number of animals were collected from S-2, and the lowest was from S-11. The most common species are the crustaceans such as *Austruca iranica* and *Austruca variegata* and among the Mollusca *Pirenella cingulata* (Table.5) and figure 17 represents the various diversity indices calculated for the different fauna recorded from the 15 sites adjoining the DPA port area as presented in figure 19.

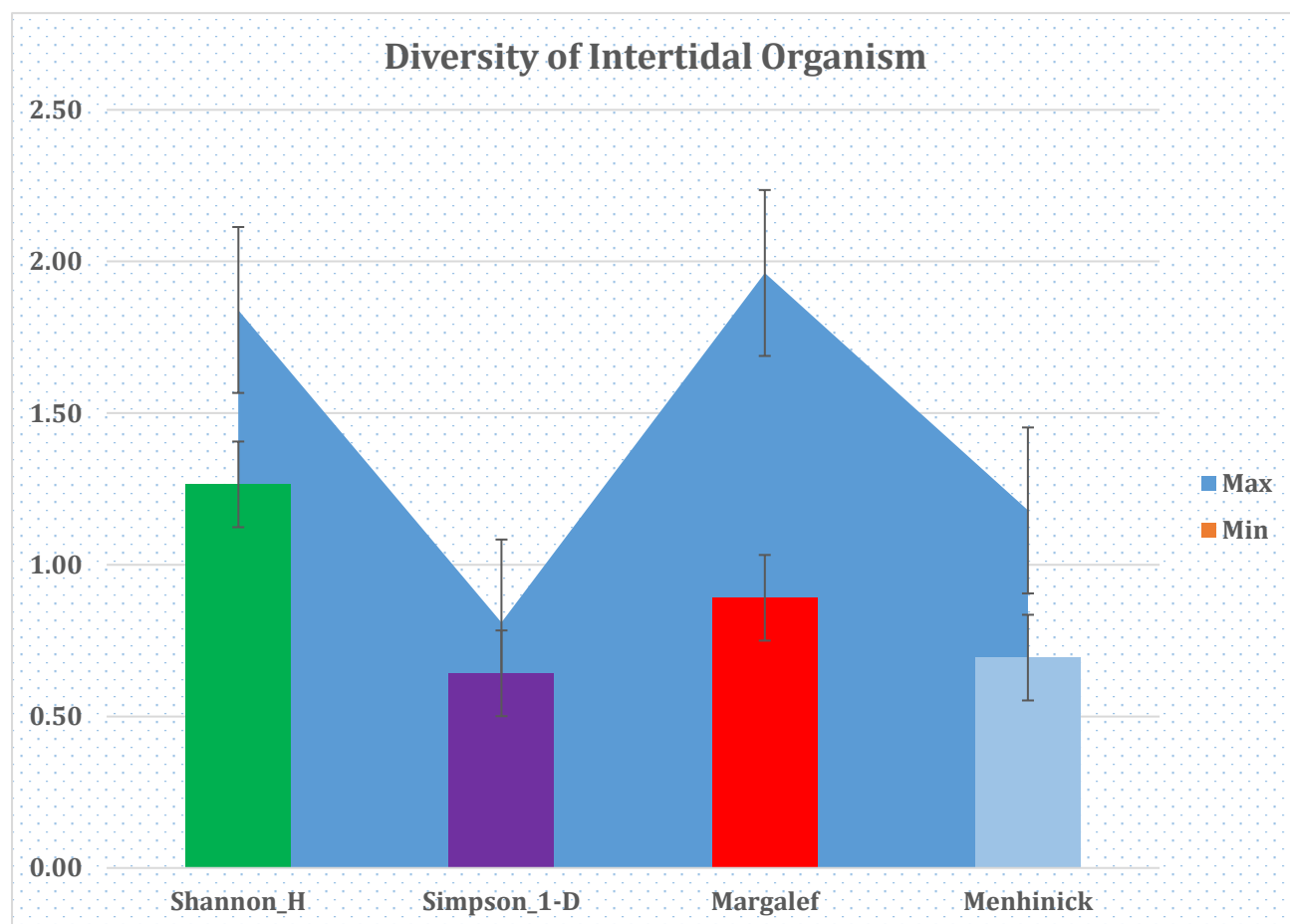


Figure 19. Diversity indices of Intertidal fauna

The maximum and minimum diversity is represent 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). The intertidal diversity of organism represent in poor conditions.

Table 6: Intertidal faunal distribution along Deendayal Port Authority area during Monsoon 2024

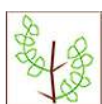
Phyla	Grpup	Station															PC
		S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15	
Arthropoda	<i>Austruca iranica</i>	21	25	14	20	27	18	10	10	12	10	2	6	2	5	5	23.49
	<i>Austruca sindensis</i>	0	3	0	0	3	6	6	5	12	4	10	6	7	17	4	10.43
	<i>Austruca variegata</i>	12	42	2	7	10	12	10	10	10	3	2	2	5	2	10	17.46
	<i>Scylla olivacea</i>	5	25	2	10	5	10	10	3	3	30	2	0	2	8	10	15.70
Mollusca	<i>Anadara inaequalis</i>	0	0	2	1	0	2	0	0	0	2	0	0	2	0	0	1.13
	<i>Bakawan rotundata</i>	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25
	<i>Indothais lacera</i>	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0.13
	<i>Optedicerus breviculum</i>	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.13
	<i>Pirenella cingulata</i>	15	35	5	0	0	0	29	0	0	0	0	0	40	0	0	15.58
	<i>Platevindex martensi</i>	0	1	0	0	0	0	0	0	0	4	0	0	0	0	0	0.63
	<i>Telescopium telescopium</i>	0	1	0	0	1	1	2	0	0	7	0	0	6	0	0	2.26
	<i>Pholas orientalis</i>	0	1	1	0	4	2	0	2	2	2	0	0	2	0	0	2.01
Chordata	<i>Periophthalmus waltoni</i>	0	0	0	10	10	7	10	2	2	20	2	10	8	5	0	10.80
Total Density of population (No/m2)		56	133	26	48	60	59	77	32	41	82	18	24	74	37	29	
Total genera		5	8	6	5	7	9	7	6	6	9	5	4	9	5	4	



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. Benthic fauna is an important component of marine ecosystems, providing key services including secondary production and remineralization. Being sedentary or having only limited mobility, benthic communities are particularly vulnerable to variations in environmental and ecological factors. As a result, they exhibit distinct spatial and temporal distribution patterns on small and large scales. Coastal areas are naturally highly dynamic, with several distinct habitat types coexisting nearby (e.g., estuaries and intertidal habitats) and supporting high biodiversity (Cowie and Woulds, 2011). The abiotic factors structuring benthic communities include salinity, temperature, sediment characteristics, and oxygen availability, however, their relative importance varies among the different habitats. On a fine scale, biotic factors such as competition for food and space, predation, reproductive strategies, and life-history traits influence the distribution and abundance of individual species, in turn determining community structure. Moreover, coastal habitats are also the most impacted by anthropogenic pressures, from climate change-related warming and acidification to habitat degradation and pollution. Benthic fauna, through their diverse feeding modes and lifestyles, not only are affected by conditions in the sediment environment, but also actively influence sediment textural and geochemical properties, the flow regime of bottom waters, and, through exchange of particles and solutes between water and sediments, also regulate properties in overlying waters (Meysman et al., 2006)

All marine sediments are anoxic below a certain depth from the sediment surface and, consequently, sulphidic sediments have a worldwide distribution. Organic sediment enrichment occurs through vertical and advective accumulation of organic carbon from the decomposition of the organic matter. On bottoms where accumulation of organic matter happens and leading to the reduction of oxygen at low concentration. The oxygen deficiency may very well be the most widespread anthropogenically induced deleterious effect in the marine environment that causes localized mortality of benthic macrofauna. Also there is a complicated interplay between oxygen concentration and sediment geochemistry that regulates the response of organisms to declining dissolved oxygen



concentrations. The physio-biochemical system of estuary is regulated by benthic faunal through burrowing and feeding activities. Benthic communities are the useful tools for biomonitoring and gathering large amount of data in relation to coastal marine health of marine ecosystem. It is important to identify which are the primary causal factors for degradation of coastal ecosystem for design the proper management system at the coastal region..

Distribution and composition of subtidal macrobenthos

The number of macro benthic species of the various groups recorded (Fig.20) & Table 6 from the DPA port environment includes Mollusca (10) and Annelida (4) Arthropoda (2). The percentage composition of the three phyla that occurred during the monsoon is shown in (Fig 20 & table 6) The phylum Mollusca is represented by maximum (65%) share of the subtidal Fauna, followed by Annelida (25.5%), Arthropoda (9.8%) in the total benthic samples collected (Fig.21).

Subtidal Faunal density (No/m²) variation between the stations

The number of individuals of the animals collected from the different sites are shown in Fig 22. The density of the Fauna was high at S-14 (700/m²), and the lowest number (175/m²) was noticed at S-9 during the monsoon 2024.

Diversity index

The figure 22 represent the subtidal microbenthic faunal diversity documented in the monsoon 2024. The highest number of species diversity was documented from stations S-14, S-9, S-3 and S-13. The most common species are *Optediceros breviculum*, *Glaucanome angulata* and *Pirenella cingulata*. The least diversity was documented for *Solen* sp were found significantly less diversity. The figure 24 represents the various diversity indices calculated for the different fauna recorded from the 15 sites adjoining the DPA port area. Invariably the minimum and maximum index values of the three indices were observed at S-8&9 and S 14 respectively. Shannon diversity index varied , from 1.00 to 2.00 Simpson index ranged between 0.56 and 0.85 and the Margalef index ranged from 1.03 and 3.30.



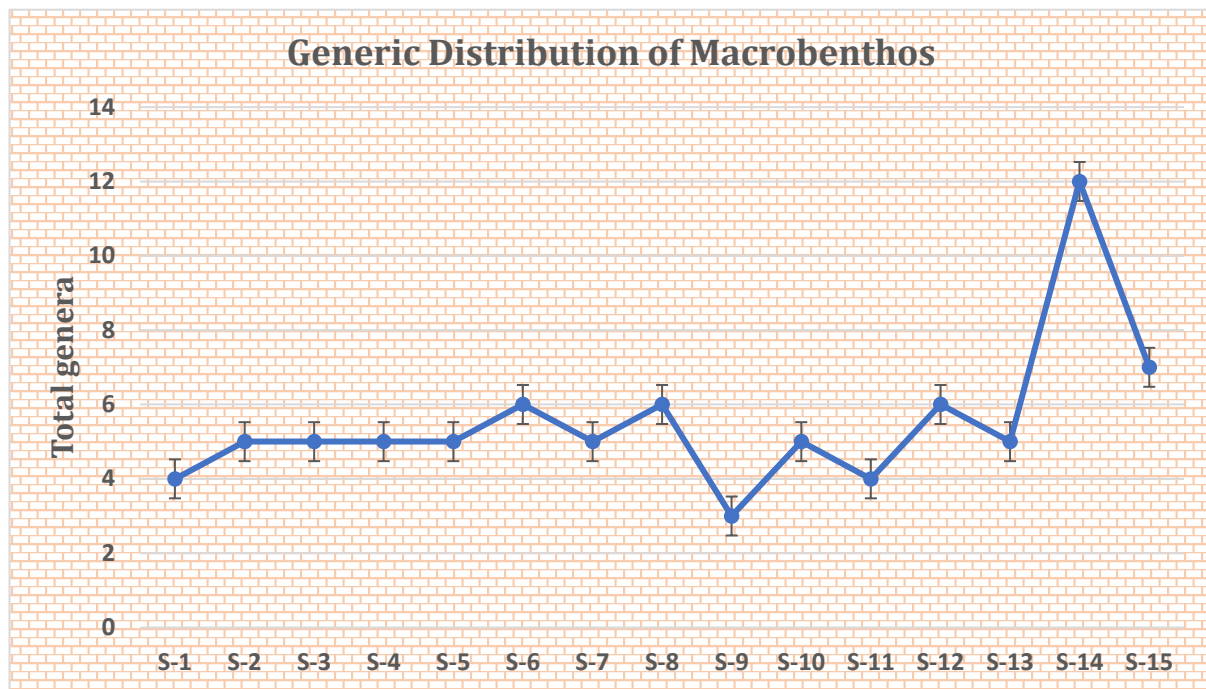


Figure 20. Number of genera of macrobenthos during Monsoon 2024

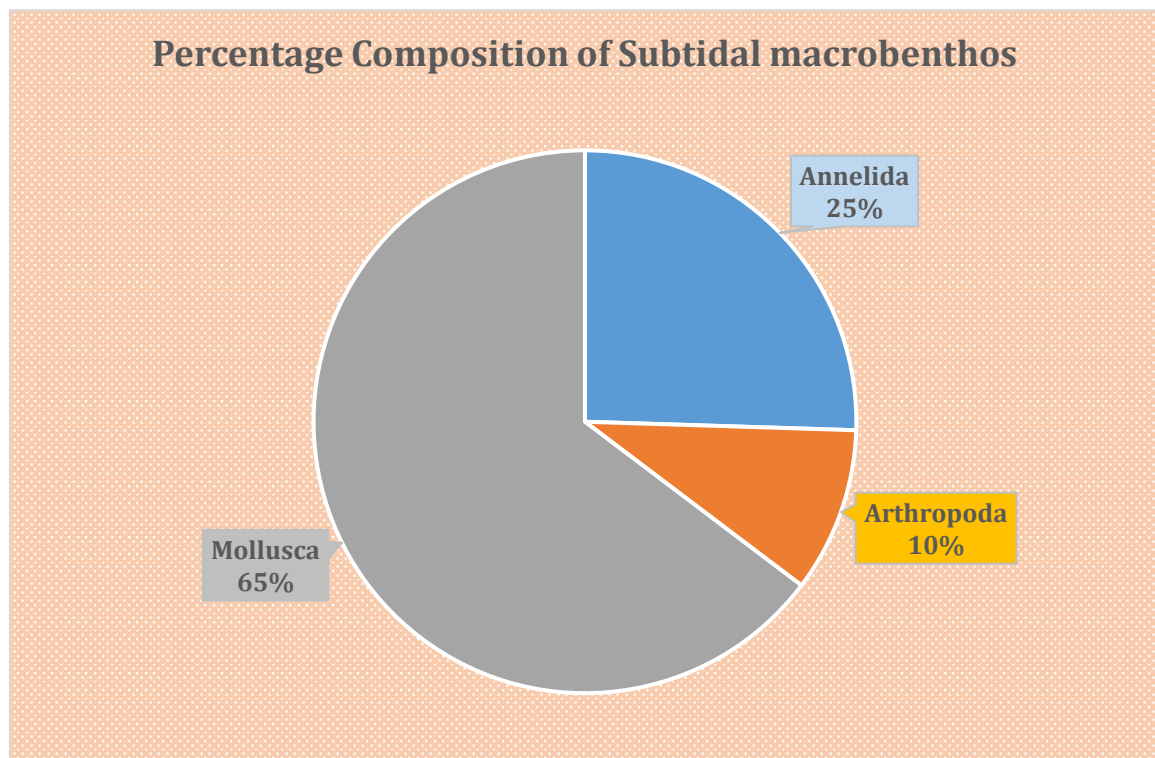


Figure 21. Percentage composition of macrobenthos during Monsoon 2024

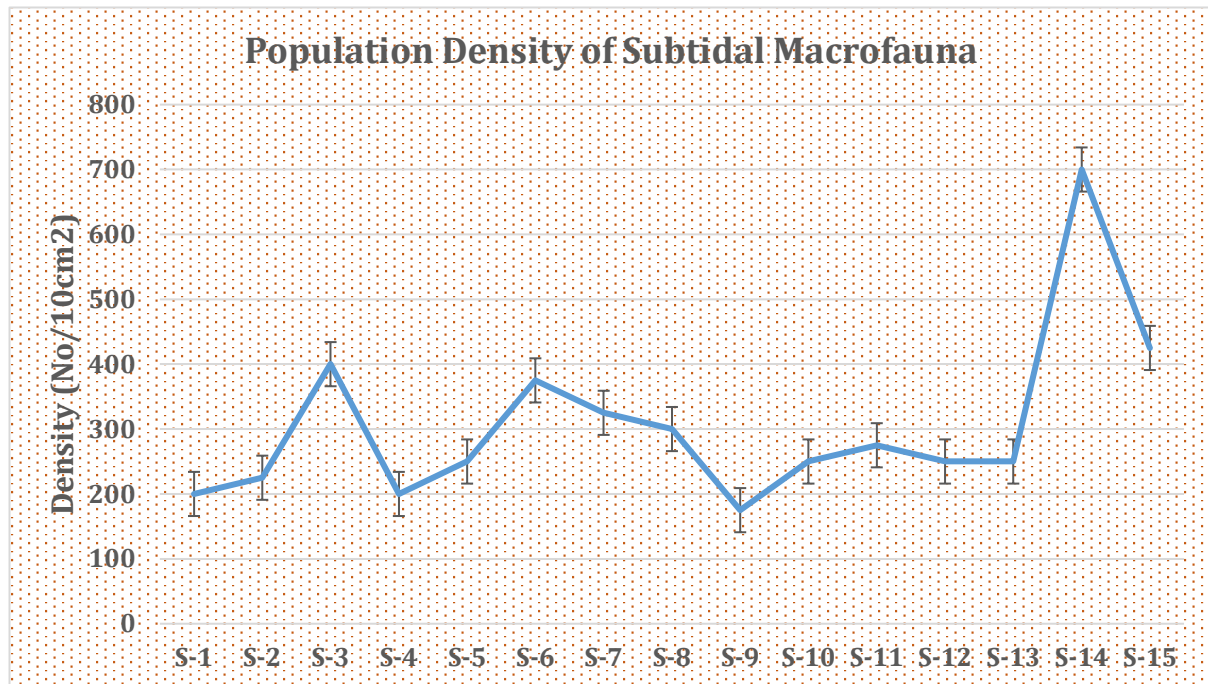


Figure 22. Subtidal fauna density during Monsoon 2024

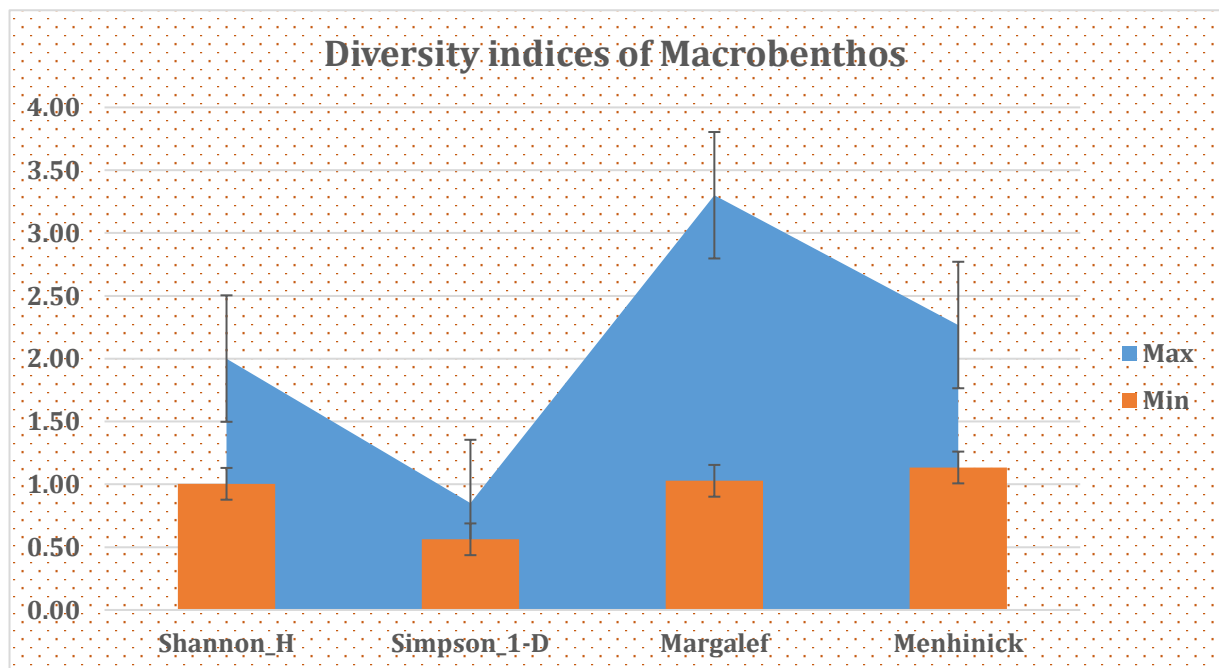


Figure 23. Subtidal macrofaunal diversity indices

Table 7: Macro-benthic faunal distribution during Monsoon 2024 in Deendayal Port Authority

Phyla	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
Annelida	<i>Capitella sp.</i>	0	1	0	0	3	0	0	0	1	0	3	1	0	1	0	5.4
	<i>Lumbrineria sp.</i>	1	0	4	0	0	0	1	0	0	2	0	2	2	0	2	7.6
	<i>Nephtys sp.</i>	1	0	2	0	0	0	0	2	3	0	0	0	0	1	0	4.9
	<i>Nereis sp.</i>	0	3	1	0	0	1	0	0	0	1	4	0	1	0	3	7.6
Arthropoda	<i>Ampithoe sp.</i>	0	0	0	0	2	0	0	1	0	0	0	2	0	2	0	3.8
	<i>Penaeus sp.</i>	0	2	0	0	1	1	0	0	0	0	2	0	2	0	3	6.0
Mollusca	<i>Mitrella blanda</i>	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	1.6
	<i>Natica sp</i>	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1.1
	<i>Optedicerus breviculum</i>	1	0	0	2	2	2	3	2	0	0	0	0	0	1	3	8.7
	<i>Pirenella cingulata</i>	5	0	0	0	0	2	1	2	3	1	0	2	3	12	2	17.9
	<i>Turritella sp</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1.1
	<i>Marcia sp.</i>	0	0	0	2	0	1	2	3	0	0	0	1	2	1	2	7.6
	<i>Glaucanome angulata</i>	0	2	7	1	2	8	6	2	0	6	0	2	0	0	0	19.6
	<i>Dosinia sp</i>	0	0	2	2	0	0	0	0	0	0	0	0	0	3	0	3.8
	<i>Gafrarium divaricatum</i>	0	1	0	0	0	0	0	0	0	0	0	0	0	2	2	2.7
	<i>Solen sp.</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0.5
Total Population		8	9	16	8	10	15	13	12	7	10	11	10	10	28	17	
Density No/m2		200	225	400	200	250	375	325	300	175	250	275	250	250	700	425	
Total genera		4	5	5	5	5	6	5	6	3	5	4	6	5	12	7	



8. Seaweeds

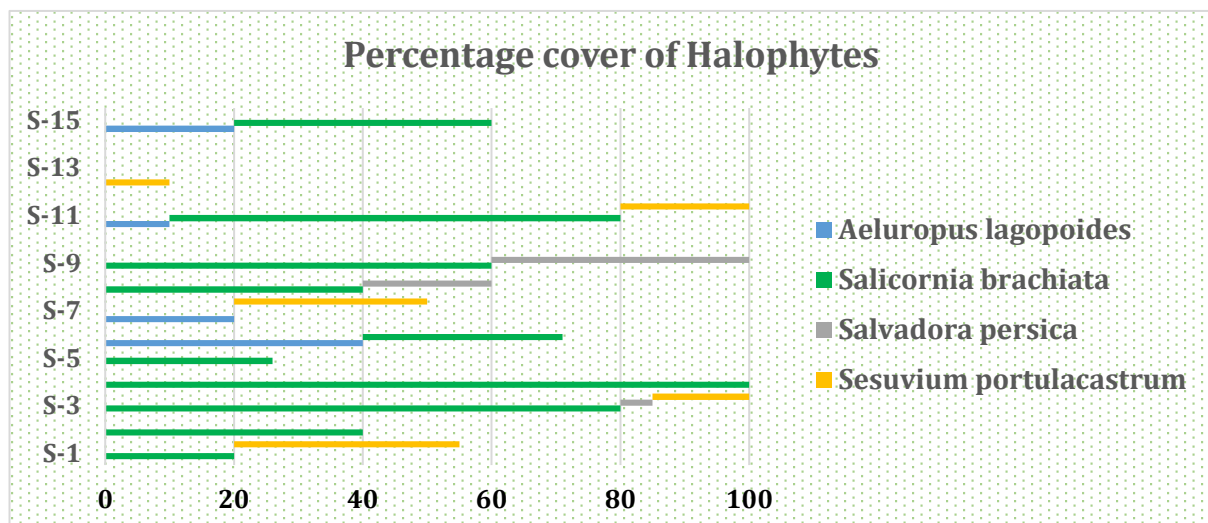
There is no observation of seaweed during the study period

3.9. Seagrass

Similar to seaweed seagrass also not encounter during present observation

3.10. Halophytes

The halophytes are the plants that are adapted to live in coastal estuaries and salt marshes. It is common in arid and desert milieu which often have substantial salt accumulation. Technically these are the plants which have tolerance to moderate to high salt concentration in its growth substrate. Halophytes, that survive and reproduce in environments where the salt concentration is 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, *Salicornia brachiata* (a), *Aeluropus lagopoides* (c), *Salvadora persica* (d) and *Sesuvium portulacastrum*(b) (Plate-7) were recorded along the selected Deendayal Port Authority sites during the monsoon sampling. Among the halophyte species recorded, *Salicornia brachiata* alone was found at ten sampling locations. (Fig.24) and the percentage of cover was found to be the highest at S-4 (100%) and the lowest at S-2 &S-8(40%).



Fifure24.Halophytes diversity of Deendayal Port Authority



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

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



3.11. Mangroves

Mangroves in Gujarat are distributed across four main regions: Kachchh, Gulf of Kachchh, Saurashtra, Gulf of Khambhat including South Gujarat. Kachchh and Gulf of Kachchh have the largest mangrove forests, which are meticulously studied and documented by the Gujarat Institute of Desert Ecology (GUIDE). The GUIDE research reveals the unique vegetation characteristics, species composition, ecological importance, and conservation status of these crucial coastal ecosystems. Mangroves serve as critical habitats for a wide variety of marine and terrestrial species, playing a significant role in coastal protection, biodiversity conservation, and local livelihoods. The efforts to study and conserve these ecosystems highlight their importance and the need for sustainable management

Tree Density

During the 2024 monsoon, 15 mangrove sites were selected in and around the Deendayal port Authority to undertake assessment on plant density and growth parameters such as height, girth, and canopy cover. The overall average tree density from the study sites along the DPA, was recorded as 2,189 trees/ha during the monsoon of 2024. However, the area under mangrove cover is shrinking due to increase in the anthropogenic activities such as salt pan formation and other developmental interferences. Among the 15 sampling locations, Tuna Creek had the highest mean plant density with 2535 trees/ha, followed by Kharo Creek with 2486 trees/ha. However, in Kharo creek only one station is located. Regarding individual sample locations, the S-6 had the highest tree density (3,673 trees/ha), followed by S-1 (3,522 trees/ha). The S-15 (1,027 trees/Ha) and S-11 (1,221 trees/Ha) had the lowest average tree density. The varying status of the mangroves across different locations (as illustrated in Fig. 25) reflect the seasonal changes in the local geomorphology as well as the distinct biological and environmental characteristics of each site.

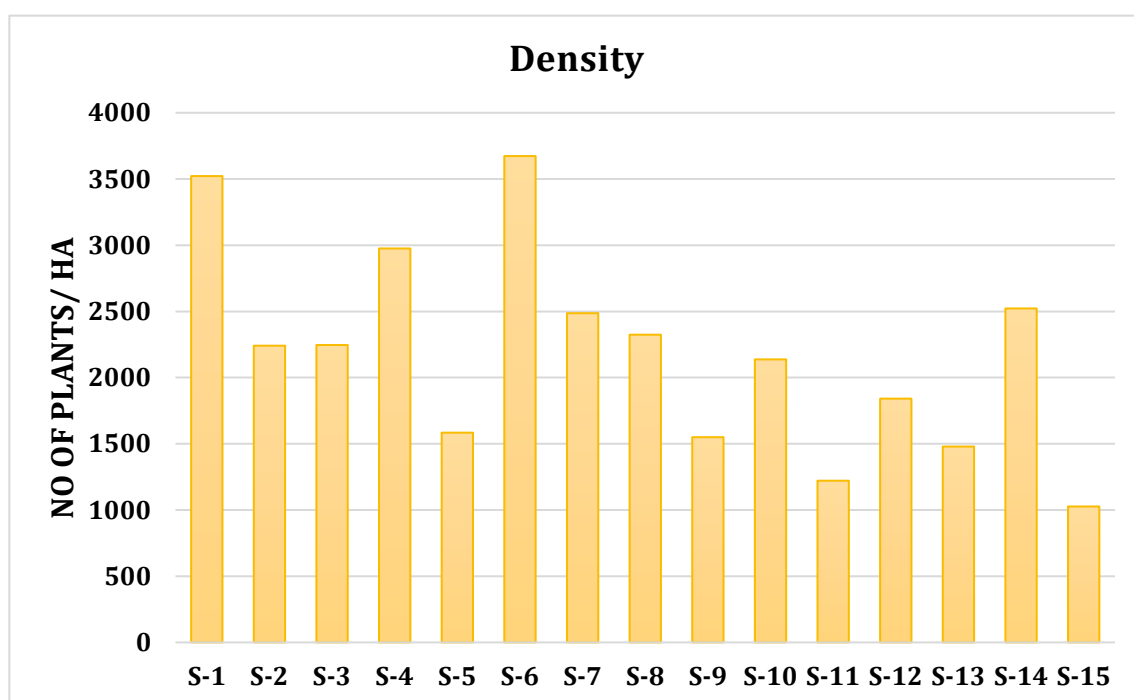


Figure 25. Plant density during monsoon 2024

Height

The overall mean height of the mangroves from the DPA, Kandla environment was 1.8 m during the monsoon of 2024. The highest average tree height was 2 m, recorded at Veera coast area followed by Tuna and Phang creek (1.8 m). In Veera area, only one station (S-14) is located. While considering the sites individually, the average tree height was 2.4 m at S-10 located at Phang creek, followed by site S-12 (2.3 m) located at Tuna creek (Fig.26). During the study, it was observed that the average tree height at several sites varied between 1.3 m and 2.4 m. Height is a crucial factor since it indicates whether trees are developing normally or exhibiting stunted growth. Height also contributes to the complexity of the habitat. Taller mangroves provide better protection against storm surges and high waves. They act as a buffer, reducing the energy of waves before they reach inland areas, thus protecting coastal communities from flooding and erosion. S



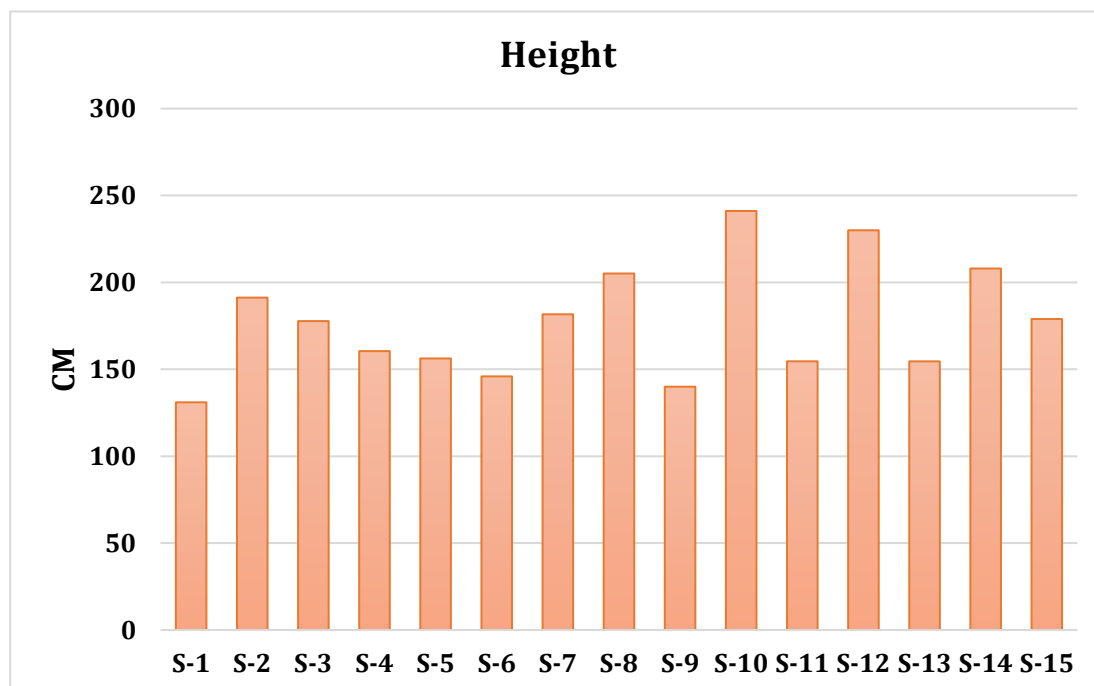


Figure 26. Plant height during monsoon 2024

Canopy Crown Cover

The survey conducted during the 2024 monsoon revealed that the average canopy cover across the mangrove study sites was 3.8 m². The figure 27 reflects the overall extent of the mangrove canopy, which plays a vital role in providing habitat for diverse species, stabilizing shorelines, and maintaining ecological balance. The station S-10 at Phang Creek and S-15 at Kandla Creek are noted for having higher average canopy covers compared to other locations. Navlakhi Creek had the highest average canopy cover at 5.2 m², followed by Phang Creek at 4.5 m², while, S-1 at Tuna Creek, and S-4 at Kandla Creek had comparatively lower average canopy cover. These variations in canopy cover across different sites in the Kandla sample region underscore significant differences influenced by local environmental and biological factors.

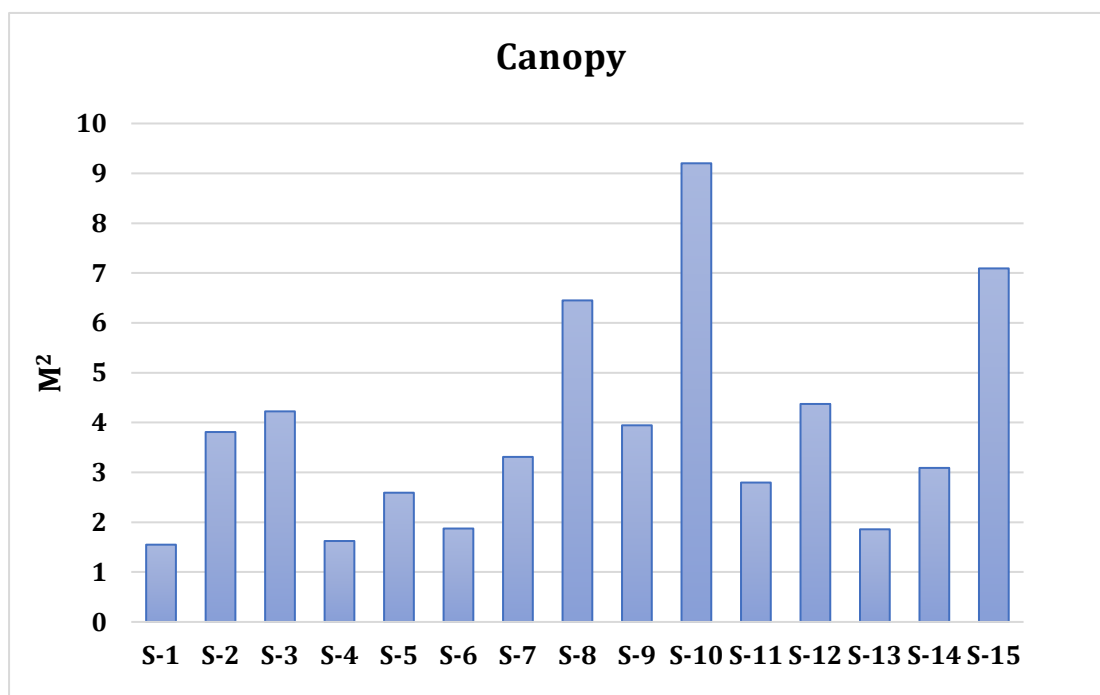


Figure 27. Mangrove canopy cover during monsoon 2024

Basal Girth

The average basal girth of the mangroves at the DPA sampling sites was reported to be 13 cm during the monsoon of 2024. Among the individual sampling sites, the highest average basal girth was recorded at site S-10 (22 cm) and site S-8 (18 cm), located in Phang Creek and Navlakhi Creek respectively (Fig.28). The lowest average basal girth was reported at site S-6 and S-9 (8 cm) in Janghi Creek and Navlakhi Creek, respectively. In the DPA Kandla area, as in other parts of Gujarat and the entire Gulf of Kutch, *Avicennia marina* is predominant, characterized by its multiple stem pattern. However, some larger trees in a few sites exhibit the higher basal girth measurements

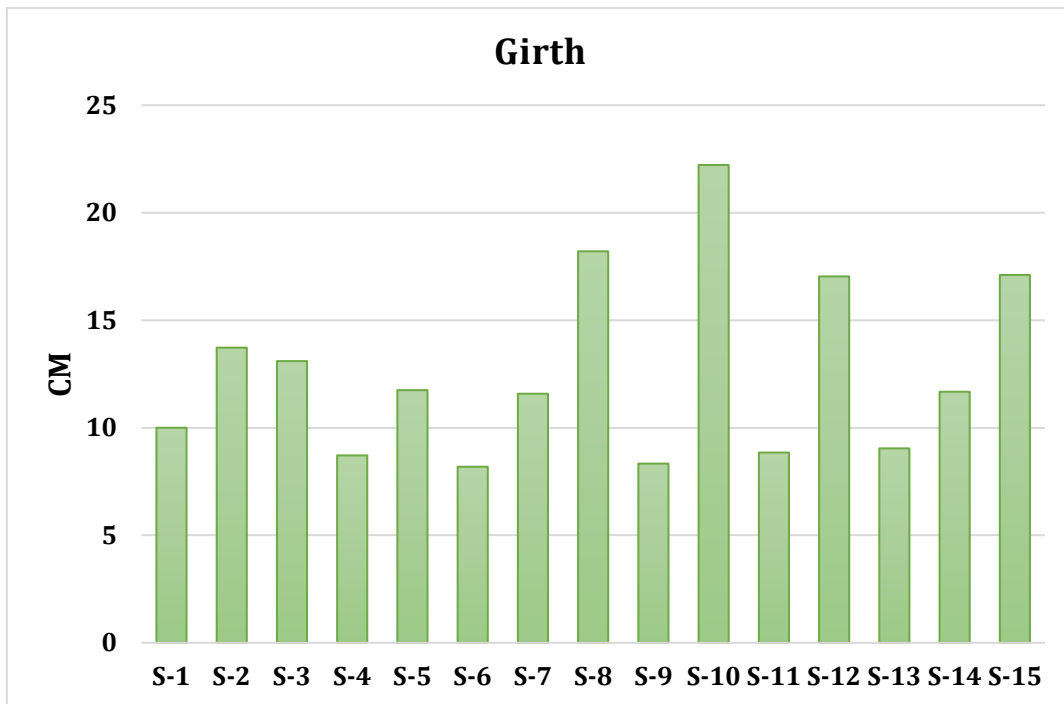


Figure 28. Basal girth of mangrove

Regeneration and recruitment class

The mangrove density and growth parameters were recorded during the survey conducted in the monsoon season of 2024 in the DPA Kandla area. The overall average regeneration class density was recorded as 29,692 plants/ha and the overall average recruitment class density was recorded as 5,308 plants/ha. In site-wise observations, the highest average regeneration class plants were recorded at site S-8 (73,000 plants/ha) which is followed by S-9 (52,000 plants/ha) both located along the Navlakhi creek area, For the recruitment class, the maximum plant density (average) was (11,750 plants/ha) at site S-7 located in the Kharo creek during this survey. Younger class mangroves can assure future availability of matured plants of full-grown trees in the area. Young mangroves help to stabilize soil and trap sediments, preventing coastal degradation and maintaining water quality. As they grow, these young plants will eventually contribute to the various ecosystem services and enhance the coastal protection offered by mature mangroves, shielding shorelines from erosion and storm surges.



Plate 8: Mangrove species recorded along the Deendayal Port area

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

3.12. Marine Reptiles

The saw-scaled viper *Echis carinatus sochureki* normally encounter in while visit in mangrove survey but during the present observation in all the 15 study location there is no single encounter in study area. The literature describes the species as aggressive and strikes at a lightning speed, the observed specimen was active. In monsoon, the maximum number of this snake was recorded in S-10 located on the northern part of Sat Saida bet in previous record .

3.13. Marine Mammals

Sousa plumbea (Cuvier, 1829) is commonly referred to as the Indian Ocean humpback dolphin. 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). During the field surveys, the Indian Ocean humpback dolphin (*Sousa plumbea*) was not cited in monsoon season.

3.14. Marine Fishery

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 near the Marine National Park, in Jamnagar, 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*, (Plate 9) the maximum during monsoon. Around 2kg of Mugil was catch in 10 minutes of in 1 km stretch.





Plate 9 Fish catch along the Deendayal Port Authority in monsoon 2024

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 bulk density (or apparent density) is defined as the density of a large volume of porous material powder including the pore spaces within the material particles in the measurement volume. The data on the bulk density of the sediment samples are presented in (Fig.29). The bulk density of mangrove soil at Deendayal Port Authority coastal region ranged from 1.30 g/cm³ to 1.61 g/cm³. The highest bulk density was recorded at S-13 sites followed by S-14. The lowest bulk density was recorded at S-5 located at Janghi creek.

Total Organic Carbon (TOC)

The highest TOC value (3.1%) was recorded at S-13 followed by S-1 and lowest TOC value was reported at site S-10 (Fig.30). It is observed that TOC values varied significantly among the sampling stations which means that organic carbon is dependent on the living life forms and variations in the life forms in the mudflats. The TOC concentration is a direct indicator of mudflat productivity and blue carbon sequestration. The data on monsoon samplings revealed that the different sampling sites of Deendayal Port Authority jurisdiction have considerable variations with respect to organic carbon.



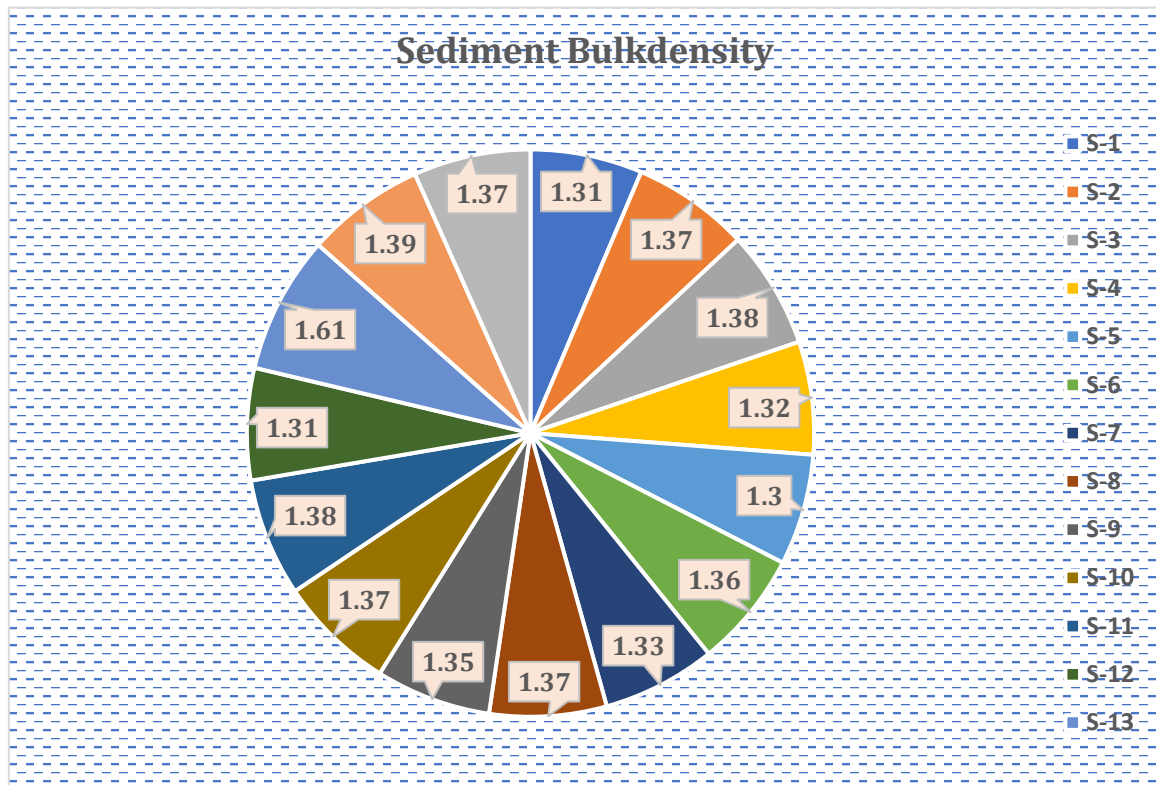


Figure 29: Bulk density of mudflat sediment during Monsoon 2024

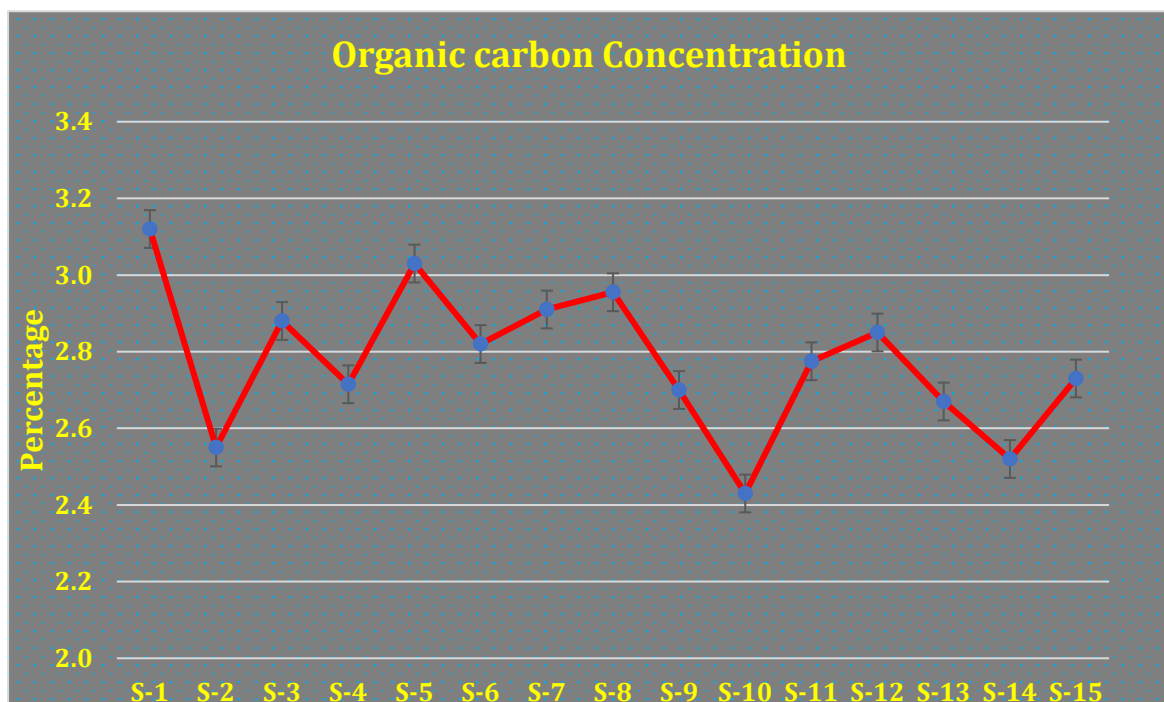


Figure 30: Mudflat sediment Organic Carbon during Monsoon 2024

5. Avifauna

Globally, avifauna has the highest level of diversity. Indian subcontinent comprehends around 1340 species of birds which contribute more than 15% of the world's bird species (Ali and Ripley 1987, Manakadan and Pittie 2001, Grimmett *et al.* 2011, Cox 2010). Thus, understanding the diversity and structure of bird communities to describe the importance of regional or local landscapes for avian conservation and assessment of avian diversity has become an important tool in biodiversity conservation (Safiq *et al.* 1997). The baseline data on diversity, distribution and species composition plays a significant role for identifying priority areas and formulating the species-specific conservation plan (Peterson *et al.* 2000, Colin 2000) and evaluate the habitat quality (Chettri *et al.* 2005, Manjunath and Joshi 2012). While, numerous bird species use their foraging ecology to sustain a trophic level, making birds another key animal group in an ecosystem. Scavenging carcasses, eliminating vermin and insect pests, cycling nutrients, dispersing seeds, pollination, and pest control are some of these services. As scavengers and possible pollinators, they have a functional role in the ecosystem and are appropriately referred to as bio-indicators (Bruford 2002, Gregory *et al.* 2003, Parmar *et al.* 2016, Maznikova *et al.* 2024). The aim of the present study was to understand the occurrence and distribution of avifauna in the coastal areas of the Deendayal Port Authority, Kandla, India (Fig. 31).

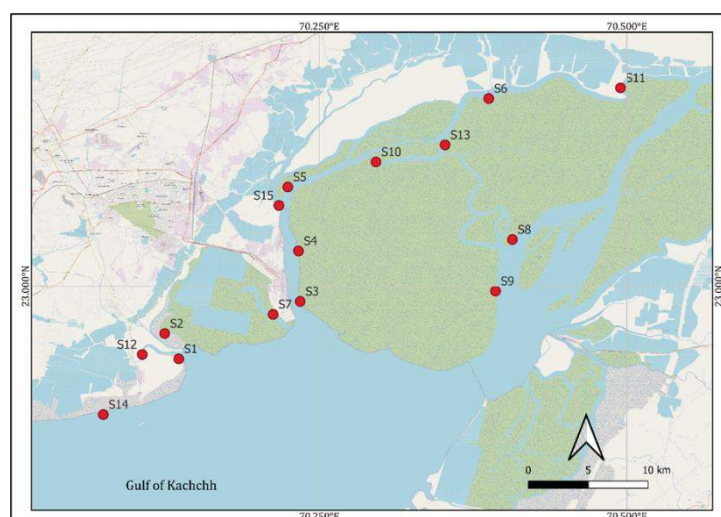


Figure 31. Permanent study sites at Deendayal Port Authority, Kandla, India

Status, Diversity and Distribution of avifauna in different station

The status and diversity of avifauna was studied in coastal areas of Deendayal Port Authority, Kandla, India for the monsoon season. The entire survey was comprehensively carried out by boat survey and walking along the fixed sampling station, for documentation of avifauna. A total of 53 species (32 species terrestrial and 21 aquatic bird) representing 9 order, 22 families and 37 genera were recorded during the study period (**See Annexure 1& Plate 10,11**). Scolopacidae (nine species) were the most dominant family in terms of species richness followed by Ardeidae (seven species), whereas Columbidae and Laridae (five species), whereas others represent less species (Fig.32)

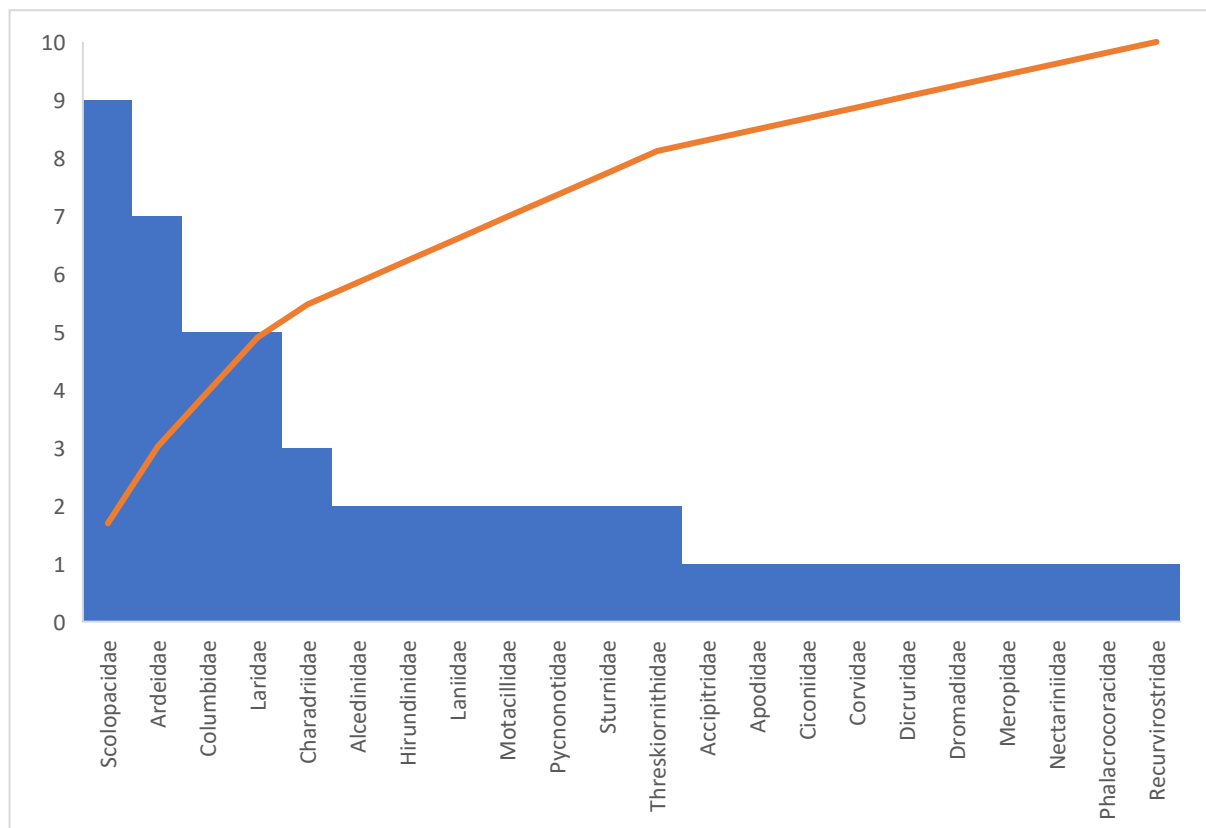


Figure 32 Distribution of families and species at the Deendayal Port Authority

Among the survey station, site 13 (53 species) were the most dominant with 37 genera and 22 families species richness followed by site 5 and 12 (45 species), and site 1 have 44 species and other sites have less species composition (Fig. 33).

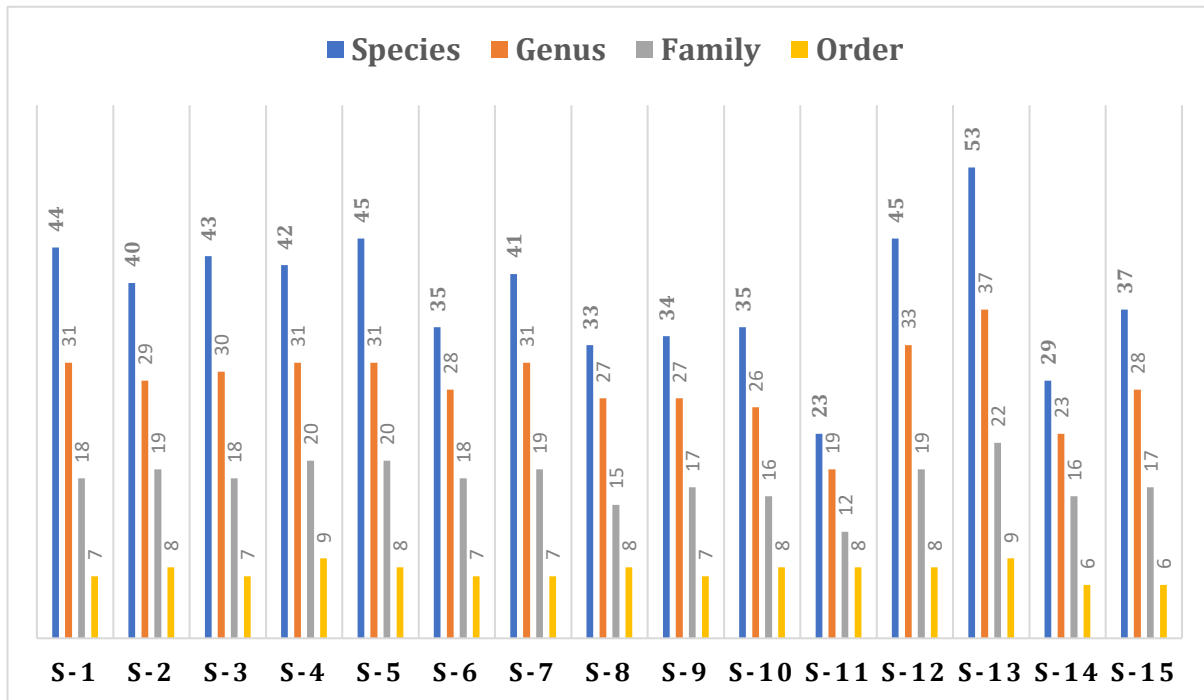


Figure 33 Site wise distribution of Avifauna recorded during monsoon season from the Deendayal Port Authority

The Shannon-Wiener diversity indices shows that site 13 ($H=3.738$), followed by site 12 ($H=3.61$), site 5 and 1 ($H=3.57$), whereas others represent less diversity (Table 7). Based on the movement pattern 36 species (68%) of birds were residence, 14 (26%) are migratory and three (6%) species are regional migratory (Annexure 1, Fig. 34). Considering the abundance of the species during the study period, 32 taxa were recorded from terrestrial, 21 from aquatic habitat. Among 53 species, only five species viz. Painted Stork *Mycteria leucocephala* (Pennant, 1769), Black-headed Ibis *Threskiornis melanocephalus* (Latham, 1790), Glossy Ibis *Plegadis falcinellus* (Linnaeus, 1766), Black-tailed Godwit *Limosa limosa* (Linnaeus, 1758) and Eurasian curlew *Numenius arquata* (Linnaeus, 1758) are under the Near Threatened (NT), whereas, River Tern *Sterna aurantia* (Gray, JE, 1831) is under vulnerable (VU) categories of IUCN Red List of Threatened Species. Moreover, two species (4%) River Tern *Sterna aurantia* (Gray, JE, 1831) and Common Greenshank *Tringa nebularia* (Gunnerus, 1767) were under the

Schedule I, and species (96%) were under Schedule II categories of Wild Life (Protection) Act, 1972 (Fig 35)

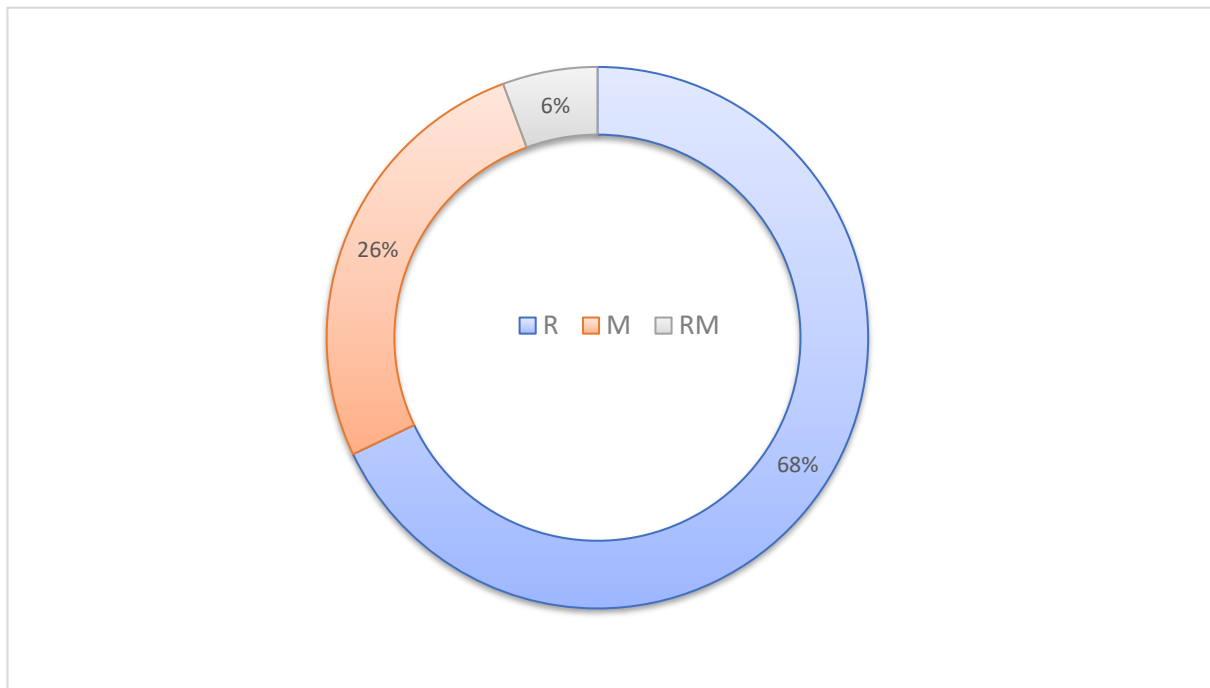


Figure 34 Behavioral status of avifauna from the Deendayal Port Authority,

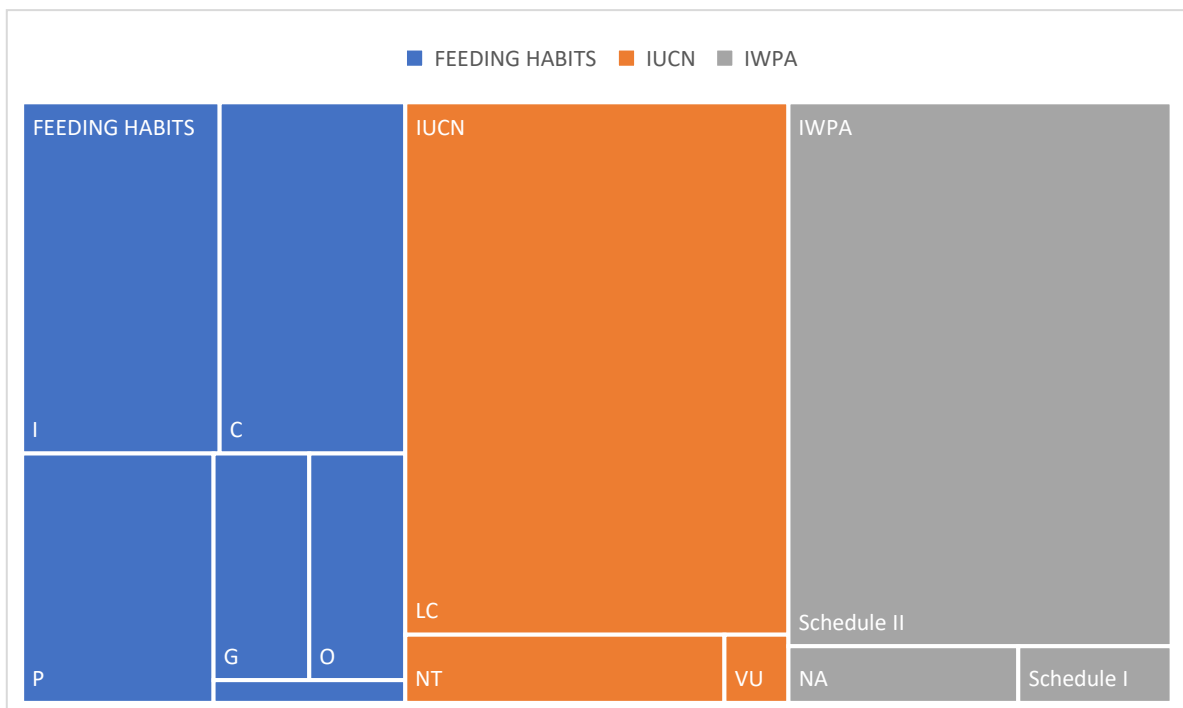


Figure 35 Status of foraging guild and threatened species recorded from Deendayal Port Authority,

Table 8. Site wise diversity indices recorded from DPA in Monsoon 2024

Site	Species	Individuals	Shannon_H	Evenness_e^H/S	Margalef	Equitability_J
S-1	44	115	3.60	0.84	9.06	0.95
S-2	40	126	3.55	0.87	8.06	0.96
S-3	43	170	3.49	0.76	8.18	0.93
S-4	42	185	3.61	0.88	7.85	0.96
S-5	45	172	3.62	0.83	8.55	0.95
S-6	35	105	3.39	0.85	7.31	0.95
S-7	41	159	3.58	0.87	7.89	0.96
S-8	33	95	3.41	0.92	7.03	0.98
S-9	34	91	3.41	0.89	7.32	0.97
S-10	35	136	3.39	0.84	6.92	0.95
S-11	23	62	2.96	0.84	5.33	0.94
S-12	45	171	3.66	0.86	8.56	0.96
S-13	53	218	3.75	0.80	9.66	0.94
S-14	29	74	3.22	0.86	6.51	0.96
S-15	37	96	3.47	0.87	7.89	0.96



**Plate 10 Critical Mangroves and Mudflat habitats of birds at Deendayal Port
Authority, Kandla (A-F)**



Plate 11 . Common and migratory birds from the Deendayal Port Authority, Kandla. (A) Lesser black-backed gull *Larus fuscus* Linnaeus, 1758 (B) Caspian gull *Larus cachinnans* Pallas, 1811 (C) Western Reef Heron *Egretta gularis* (Bosc, 1792) (D) Crab-plover *Dromas ardeola* Paykull, 1805 (E) Black Headed Ibis *Threskiornis melanocephalus* (Latham, 1790) (F) Eurasian curlew *Numenius arquata* (Linnaeus, 1758).

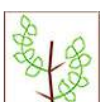
References

- Abott, R.T. (1954). American Sea shells. Dvan Nostrand Company Inc, Newyork, pp 541
- Ali, S. and Ripley, S. D. 1987. *Compact Handbook of the Birds of India and Pakistan together with those of Bangladesh, Nepal, Bhutan, and Sri Lanka*. Oxford University Press, Delhi, India, 737 pp.
- Ali, S. and Ripley, S. D. 1987. *Compact Handbook of the Birds of India and Pakistan together with those of Bangladesh, Nepal, Bhutan, and Sri Lanka*. Oxford University Press, Delhi, India, 737 pp.
- Amr, Z.S. 2021. The state of biodiversity in Kuwait. Gland, Switzerland: IUCN; The State of Kuwait, Kuwait: Environmental Public Authority Crane (1975), Holthuis, L.B. (1993). The Recent genera of the caridean and stenopodidean shrimps (Crustacea, Decapoda): With an appendix on the order Amphionidacea. Nationaal Natuurhistorisch Museum Leiden. 328.
- APHA, 2017. Standard Methods for the Examination of Water and Wastewater (23rd ed.). Washington DC: American Public Health Association.
- Bruford, M. W. 2002. Biodiversity-Evolution, Species, Genes. *In: Norris, K. and Pain, D.J. (Eds.), Conserving Birds Biodiversity-General Principals and their Application*. Cambridge University Press, U.K, 1-19.
- Bruford, M. W. 2002. Biodiversity-Evolution, Species, Genes. *In: Norris, K. and Pain, D.J. (Eds.), Conserving Birds Biodiversity-General Principals and their Application*. Cambridge University Press, U.K, 1-19.
- Chettri, N., Deb, D. C., Sharma, E. and Jackson, R., 2005. The relationship between bird communities and habitat: A study along a trekking corridor of the Sikkim Himalaya. *Mountain Research and Development* 25(3): 235-244
- Chettri, N., Deb, D. C., Sharma, E. and Jackson, R., 2005. The relationship between bird communities and habitat: A study along a trekking corridor of the Sikkim Himalaya. *Mountain Research and Development* 25(3): 235-244
- Colin, B., Jones, M. and Marsden, S. 2000. *Expedition Field Techniques Bird Survey*, BirdLife International press, Cambridge, p. 75.



Regular Monitoring of Marine Ecology in and Around the Deendayal Port Authority and Continuous Monitoring Programme (Monsoon)

- Colin, B., Jones, M. and Marsden, S. 2000. *Expedition Field Techniques Bird Survey*, BirdLife International press, Cambridge, p. 75.
- Cox, G. W. 2010. *Bird Migration and Global Change*. Island Press, Wahington. Covelo, London, 1-291.
- Cox, G. W. 2010. *Bird Migration and Global Change*. Island Press, Wahington. Covelo, London, 1-291.
- Day, J.H. 1967. A Monograph on the Polychaeta of Southern Africa part I Errantia. Trustees of the British Museum (Natural History) London, 458pp.
- Desikachary, T.V. (1987). Atlas of diatoms, 3 and 25. Madras Science Foundation Madras: plates, 22-4000
- Dyer, K.R., Christie, M.C. & Wright, E.W. 2000. The classification of intertidal mudflats. *Continental Shelf Research*, 20(10-11): 1039-1060.
- Edward, J.K.P., Ravinesh, R. & Biju Kumar, A. 2022. Molluscs of the Gulf of Mannar, India and Adjacent Waters: A Fully Illustrated Guide, (Dekker, H. & Oliver, P.G. Eds.). Suganthi Devadason Marine Research Institute, Tuticorin & Department of Aquatic Biology & Fisheries, University of Kerala, India, 524pp.
- Fischer, W. & Bianchi, G. 1984. FAO species identification sheets for fishery purposes Western Indian Ocean, Fishing area 51 Prepared and prints with the support of the Danish International Development Agency DANIDA Rome, Food and Agricultural Organization of the United Nations, I-IV 20-55
- Gregory, R. D., Noble, D., Field, R., Marchant, J., Raven, M. and Gibbons, D. W. 2003. Using birds as indicators of biodiversity. *Ornis Hungarica* 12&13: 11-24.
- Gregory, R. D., Noble, D., Field, R., Marchant, J., Raven, M. and Gibbons, D. W. 2003. Using birds as indicators of biodiversity. *Ornis Hungarica* 12&13: 11-24.
- Grimmett, R., Inskipp, C. and Inskipp, T. 2011. *Birds of the India, Pakistan, Nepal, Bangladesh, Bhutan, Sri Lanka and the Maldives*. Princeton University Press, New Jersey, 528 pp.



Regular Monitoring of Marine Ecology in and Around the Deendayal Port Authority and Continuous Monitoring Programme (Monsoon)

Grimmett, R., Inskipp, C. and Inskipp, T. 2011. *Birds of the India, Pakistan, Nepal, Bangladesh, Bhutan, Sri Lanka and the Maldives*. Princeton University Press, New Jersey, 528 pp.

Hammer, J., Harper, D. A. T., & Ryan, P. D. 2001. PAST: Paleontological Statistics Software Package for Education and Data Analysis. *Palaeontologia Electronica*, 4, 9 p. http://palaeo-electronica.org/2001_1/past/issue1_01.htm

Hartman, O. (1968). Atlas of the errantiate polychaetous annelids from California. Allan Hancock Foundation, University of Southern California. Los Angeles, 828. Rouse and

Kamboj, R.D., Salvi, H., Patel, R. & Bhagat, R. 2018' Monograph on Phytolankton of Gulf of Kachchh. Gujarat Ecological Education and Research (GEER) Foundation . 182

Klein, G.D. (1985). Intertidal Flats and Intertidal Sand Bodies, pp187-224. In: Davis, R.A. (eds) *Coastal Sedimentary Environments*. Springer, New York, NY McCann, 1980

Liang, J., Ma, C. -W., Kim, S. -K., & Park, S. -H. (2024). Assessing the Benthic Ecological Quality in the Intertidal Zone of Cheonsu Bay, Korea, Using Multiple Biotic Indices. *Water*, 16(2), 272. <https://doi.org/10.3390/w16020272>

Maiti, S. K., 2012. *Ecorestoration of the coalmine degraded lands*. Springer Science & Business Media, pp. 333 Cintron and Novelli (1984).

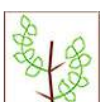
Manakadan, R. and Pittie, A. 2001. Standardised common and scientific names of the birds of the Indian subcontinent. *Buceros* 6(1): 1-37

Manakadan, R. and Pittie, A. 2001. Standardised common and scientific names of the birds of the Indian subcontinent. *Buceros* 6(1): 1-37

Manjunath, K. and Joshi, B. 2012. Avifaunal diversity in Gulbarga region, north Karnataka. *Recent Research in Science and Technology* 4(7), 27-34.

Manjunath, K. and Joshi, B. 2012. Avifaunal diversity in Gulbarga region, north Karnataka. *Recent Research in Science and Technology* 4(7), 27-34.

Masuda, H., Amaoka, K., Araka, C., Vayeno, T. & Yoshino T 1984. *The Fishes of Japanese Archipelago*. Tokai University Press, Japan 437. de Bruin et al. (1995) and



- Maznikova, V. N., Ormerod, S. J. and Gomez-Serrano, M. A. 2024. Birds as bioindicators of river pollution and beyond: specific and general lessons from an apex predator. *Ecological Indicators* 158: 11136.
- Maznikova, V. N., Ormerod, S. J. and Gomez-Serrano, M. A. 2024. Birds as bioindicators of river pollution and beyond: specific and general lessons from an apex predator. *Ecological Indicators* 158: 11136.
- Mohsin, A.K.M. & Ambiak, M.A. (1996). Marine Fishes and Fisheries of Malaysia and Neighboring Countries. University Pertanian Malaysia Press, Serdang 743
- Naderloo, R. (2017). Atlas of Crabs of the Persian Gulf. Springer International Publishing AG, Switzerland, 445pp.
- Parmar, T.K., Rawtani, D. and Agrawal, Y. K. 2016. Bioindicators: the natural indicator of environmental pollution. *Frontiers in Life Science* 9(2): 110–118.
- Peterson, A. T., Ball, L. G. and Brady, K. W. 2000. Distribution of the birds of the Philippines: biogeography and conservation priorities. *Bird Conservation International* 10(2): 149-167
- Ravinesh, R., Biju Kumar, A. and Anjana, V.L (2021) Diversity and distribution of molluscan fauna of Asthamudi estuary, Kerala, India, *Wetlands Ecology and Management*. 29 (5), 745-765
- Robin S.W., Pat, H.A. & Glasby, C.J. (2003). Polychaetes: An Interactive Identification Guide. CSIRO Publishing, Melbourne.
- Santhanam, P., Pachiappan, P., and Begum, A. (2019). Methods of Collection, Preservation and Taxonomic Identification of Marine Phytoplankton. pp25-61. In: Santhanam, P., Begum, A., Pachiappan, P. (eds) Basic and Applied Phytoplankton Biology. Springer, Singapore.
- Shafiq, T., Javed, S. and Khan, J. A. 1997. Bird community structure of middle altitude oak forest in Kumaon Himalayas, India: a preliminary investigation. *International Journal of Ecology and Environmental Science* 23: 389-400.
- Strickland, J.D.H. and Parsons, T.R. 1972 A Practical Hand Book of Seawater Analysis. Fisheries Research Board of Canada Bulletin 157, 2nd Edition, 310 p.

Subba Rao (2017),

Truskewycz A, Gundry TD, Khudur LS, Kolobaric A, Taha M, Aburto-Medina A, Ball AS, Shahsavari E (2019). Petroleum Hydrocarbon Contamination in Terrestrial Ecosystems- Fate and Microbial Responses. *Molecules*. Sep 19;24(18):3400. doi: 10.3390/molecules24183400. PMID: 31546774; PMCID: PMC6767264. Periathamby and Dadrasnia, 2013

USDA (United States Department of Agriculture) 1951. Soil Survey Manual. Handbook No. 18, Soil Survey Staff, Bureau of Plant Industry, Soils and Agricultural Engineering, United States Department of Agriculture, Washington DC, 205.

Vine, P. (1986). Red Sea Invertebrates. Immel Publishing, London. 224 pp Oliver, 1992;

Walkley, A.J. and Black, I.A. 1934 Estimation of soil organic carbon by the chromic acid titration method. *Soil Sci.* 37, 29-38.

Walkley, A.J. and Black, I.A. 1934. Estimation of soil organic carbon by the chromic acid titration method. *Soil Sci.* 37, 29-38.

Xavier, J.C., Cherel, Y., Boxshall, G., Brandt, A., Coffey, T., Forman, J., Havermans, C., Jazdzewska, A.M., Kouwenberg, K., Schiaparelli, S., Schnabel, K., Siegel, V., Tarling, G.A., Thatje, S., Ward, P. & Gutt, J. (2020) Crustacean guide for predator studies in the Southern Ocean. Scientific Committee on Antarctic Research, Cambridge, UK. 253 .



Annexture 1. Checklist of Avifauna recorded during the monsoon season from the Deendayal Port Authority, Kandla, India.

Sl. No.	Order, Family, Common & Scientific Name	MS	FS	IUCN	IWPA	Habitat
A	CHARADRIIFORMES					
1	Charadriidae					
1	Little ringed plover <i>Charadrius dubius</i> Scopoli, 1786	R	C	LC	Schedule II	A
2	Red-wattled Lapwing <i>Vanellus indicus</i> (Boddaert, 1783)	R	I	LC	Schedule II	T
3	Yellow-wattled Lapwing <i>Vanellus malabaricus</i> (Boddaert, 1783)	R	I	LC	Schedule II	T
2	Dromadidae					
4	Crab-plover <i>Dromas ardeola</i> Paykull, 1805	M	C	LC	Schedule II	A
3	Laridae					
5	Common tern <i>Sterna hirundo</i> Linnaeus, 1758	RM	P	LC	Schedule II	A
6	Little tern <i>Sternula albifrons</i> (Pallas, 1764)	R	P	LC	Schedule II	A
7	River Tern <i>Sterna aurantia</i> (Gray, JE, 1831)	R	P	V	Schedule I	A
8	Caspian gull <i>Larus cachinnans</i> Pallas, 1811	M	P	LC	Schedule II	A
9	Lesser black-backed gull <i>Larus fuscus</i> Linnaeus, 1758	M	C	LC	Schedule II	A
4	Recurvirostridae					
10	Black Winged Stilt <i>Himantopus himantopus</i> (Linnaeus, 1758)	R	C	LC	Schedule II	A
5	Scolopacidae					
11	Black-tailed Godwit <i>Limosa limosa</i> (Linnaeus, 1758)	M	O	NT	Schedule II	T
12	Common Greenshank <i>Tringa nebularia</i> (Gunnerus, 1767)	M	I	LC	Schedule I	T
13	Common Redshank <i>Tringa tetanus</i> (Linnaeus, 1758)	M	I	LC	Schedule II	A
14	Common Sandpiper <i>Actitis hypoleucos</i> (Linnaeus, 1758)	M	I	LC	Schedule II	A
15	Eurasian curlew <i>Numenius arquata</i> (Linnaeus, 1758)	M	C	NT	Schedule II	A
16	Green Sandpiper <i>Tringa ochropus</i> Linnaeus, 1758	M	I	LC	Schedule II	T
17	Marsh Sandpiper <i>Tringa stagnatilis</i> (Bechstein, 1803)	M	C	LC	Schedule II	T
18	Temminck's stint <i>Calidris temminckii</i> (Leisler, 1812)	M	C	LC	Schedule II	T
19	Whimbrel <i>Numenius phaeopus</i> (Linnaeus, 1758)	M	P	LC	Schedule II	A
B	COLUMBIFORMES					
6	Columbidae					

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20	Blue Rock Pigeon <i>Columba livia</i> (Gmelin, JF, 1789)	R	G	LC	NA	T
21	Spotted Dove <i>Spilopelia chinensis</i> (Scopoli, 1786)	R	G	LC	Schedule II	T
22	Eurasian Collared Dove <i>Streptopelia decaocto</i> (Fridvaldszky, 1838)	R	G	LC	Schedule II	T
23	Laughing Dove <i>Spilopelia senegalensis</i> (Linnaeus, 1766)	R	G	LC	Schedule II	T
24	Red Collared Dove <i>Streptopelia tranquebarica</i> (Hermann, 1804)	R	G	LC	Schedule II	T
C	CORACIIFORMES					
7	Alcedinidae					
25	Common Kingfisher <i>Alcedo atthis</i> (Linnaeus, 1758)	R	P	LC	Schedule II	A
26	White-throated Kingfisher <i>Halcyon smyrnensis</i> (Linnaeus, 1758)	R	C	LC	Schedule II	T
8	Meropidae					
27	Green Bee-eater <i>Merops orientalis</i> Latham, 1801	R	I	LC	Schedule II	T
D	PELECANIFORMES					
9	Ardeidae					
28	Cattle Egret <i>Bubulcus ibis</i> (Linnaeus, 1758)	R	C	LC	Schedule II	T
29	Great Egret <i>Ardea alba</i> (Linnaeus, 1758)	R	P	LC	Schedule II	A
30	Indian Pond Heron <i>Ardeola grayii</i> (Sykes, 1832)	R	C	LC	Schedule II	A
31	Intermediate Egret <i>Ardea intermedia</i> (Wagler, 1829)	R	P	LC	Schedule II	A
32	Little Egret <i>Egretta garzetta</i> (Linnaeus, 1766)	R	C	LC	Schedule II	A
33	Grey Heron <i>Ardea cinerea</i> Linnaeus, 1758	R	P	LC	Schedule II	T
34	Western Reef Heron <i>Egretta gularis</i> (Bosc, 1792)	RM	P	LC	Schedule II	A
10	Threskiornithidae					
35	Black Headed Ibis <i>Threskiornis melanocephalus</i> (Latham, 1790)	R	C	NT	Schedule II	A
36	Glossy Ibis <i>Plegadis falcinellus</i> (Linnaeus, 1766)	R	C	NT	Schedule II	T
E	CICONIIFORMES					
11	Ciconiidae					
37	Painted Stork <i>Mycteria leucocephala</i> (Pennant, 1769)	R	C	NT	Schedule II	A
F	PASSERIFORMES					
12	Corvidae					
38	House Crow <i>Corvus splendens</i> (Vieillot, 1817)	R	O	LC	NA	T



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13	Dicruridae					
39	Black Drongo <i>Dicrurus macrocercus</i> Vieillot, 1817	R	I	LC	Schedule II	T
14	Hirundinidae					
40	Barn Swallow <i>Hirundo rustica</i> (Linnaeus, 1758)	RM	I	LC	Schedule II	T
41	Wire-tailed Swallow <i>Hirundo smithii</i> Leach, 1818	R	I	LC	Schedule II	T
15	Laniidae					
42	Bay-backed Shrike <i>Lanius vittatus</i> Valenciennes, 1826	R	I	LC	Schedule II	T
43	Brown shrike <i>Lanius cristatus</i> Linnaeus, 1758	R	I	LC	Schedule II	T
16	Motacillidae					
44	White Wagtail <i>Motacilla alba</i> Linnaeus, 1758	M	I	LC	Schedule II	T
45	Yellow Wagtail <i>Motacilla flava</i> Linnaeus, 1758	M	I	LC	Schedule II	T
17	Nectariniidae					
46	Purple Sunbird <i>Cinnyris asiaticus</i> (Latham, 1790)	R	N	LC	Schedule II	T
18	Pycnonotidae					
47	White Eared Bulbul <i>Pycnonotus leucotis</i> (Gould, 1836)	R	O	LC	Schedule II	T
48	Red-vented Bulbul <i>Pycnonotus cafer</i> (Linnaeus, 1766)	R	O	LC	Schedule II	T
19	Sturnidae					
49	Common Myna <i>Acridotheres tristis</i> (Linnaeus, 1766)	R	O	LC	Schedule II	T
50	Brahminy Starling <i>Sturnia pagodarum</i> (Gmelin, JF, 1789)	R	I	LC	Schedule II	T
G	SULIFORMES					
20	Phalacrocoracidae					
51	Little Cormorant <i>Microcarbo niger</i> (Vieillot, 1817)	R	P	LC	Schedule II	A
H	Apodiformes					
21	Apodidae					
52	House Swift <i>Apus nipalensis</i> (Hodgson, 1837)	R	I	LC	Schedule II	
I	ACCIPITRIFORMES					
22	Accipitridae					
53	Black Kite <i>Milvus migrans</i> (Boddaert, 1783)	R	C	LC	Schedule II	T





Gujarat Institute of Desert Ecology
Mundra Road, Bhuj 370 001, Kachchh, Gujarat
E-mail: desert_ecology@yahoo.com
www.gujaratdesertecology.com

Annexure -E

Environmental Monitoring Report (EMR)

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: December 2024 -January 2025)



Document Ref No.: GEMI/DPA/782(2)(4)/2024-25/165

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Gujarat Environment Management Institute (GEMI)

(An Autonomous Institute of Government of Gujarat)

GEMI Bhavan, 246-247, GIDC Electronic Estate, Sector-25, Gandhinagar-382025

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

Certificate

This is to certify that the Monthly Environment Monitoring Plan (EMP) report for the period 15th December 2024 to 14th January 2025 for the work entitled, "**Preparing and Monitoring of Environmental Monitoring and Management Plan for Deendayal Port Authority at Kandla and Vadinar for a period of 3 years**" has been prepared in line with the work order no. EG/WK/EMC/1023/2011/III/239 dated 15/02/2023 allotted by Deendayal Port Authority.

The report has been delivered as per the terms and conditions of the work order Sr. No. 4(2).



S. S. O. & Lab Head

Authorized Signatory

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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 (DPA) at Kandla and Vadinar for a period of 3 years” by DPA, Kandla. Under the said project the report titled “*Environment Monitoring Report (Dec-2024-Jan-2025)*” is prepared.

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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
MMPA	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 near the city of Gandhidham in Gujarat state in western India. Located on the Gulf of Kachchh, it is one of major ports on the western coast, and is located at 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. 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. Deendayal Port Authority (DPA), India's busiest major port in recent years, is gearing up to add substantial cargo handling capacity with private sector participation. DPA has created new record by handling 137 MMTPA (at Kandla and Vadinar) during the financial year 2022-23. The 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, with a capacity of 54 MMTPA. Further, significant Quantum of infrastructural upgradation has been carried out & excellent maritime infrastructure has been created at Vadinar for the 32 MMTPA Essar Oil Refinery in Jamnagar District.

1.2 Green Ports Initiative

DPA 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.

DPA had also appointed GEMI as an Advisor for "Making Deendayal Port a Green Port-Intended Sustainable Development under the Green Port Initiatives. DPA 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 DPA. 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 encompassing 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 should indicate the details of various measures are taken 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 not only during the construction and operational phases of the new port but also for operation of existing ports to ensure the effectiveness of the mitigation measures implemented and to further provide guidance as to the most appropriate way of dealing with any unforeseen impacts.

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 essential 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 environmental monitoring done during the period from 17th December-16th January 2024-2025.

1.4 Objectives and scope of the Study

In line with the work order, the key objective of the study is to carry out the Environmental Monitoring and preparation the Management Plan for Kandla and Vadinar for a period of 3 years". Under the project, Environmental monitoring refers to systematic assessment of ambient air, water (drinking and surface), soil, sediment, noise and ecology in order to monitor the performance and implementation of a project in compliance with Environmental quality standards and/or applicable Statutory norms.

The scope of work includes not limited to following:

1. To review the locations/stations of Ambient Air, Ambient Noise, drinking water, and Marine Water, Soil and Sediments monitoring 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 locations (18 at Kandla and 2 at Vadinar) 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. Weekly sample collection and analysis of inlet & Outlet points of the Sewage Treatment Plant (STP) to check the water quality being discharged by DPA as per the CC&A.
9. Carrying out monthly Noise monitoring; 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, hence precise and continuous data collection is of utmost importance. Meteorological data on wind speed, wind direction, temperature, relative humidity, solar radiation and

rainfall shall be collected from one permanent station at DPA, Kandla and one permanent station at Vadinar.

11. To suggest 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 based on Monitoring programme and findings of the study.

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 Gujarat. The Major Port Authorities Act 2021 is the governing statute for Administration of Major Ports, under which, Deendayal Port Trust (DPT) has become Deendayal Port Authority (DPA). At Kandla, DPA has sixteen (16) cargo berths for handling various types of Dry Bulk Cargo viz, fertilizer, food grains, Coal, sulphur, etc.

- **Climatic conditions of Kandla**

Kandla has a semi-desert climate. Temperature varies from 25°C to 44°C during summer and 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

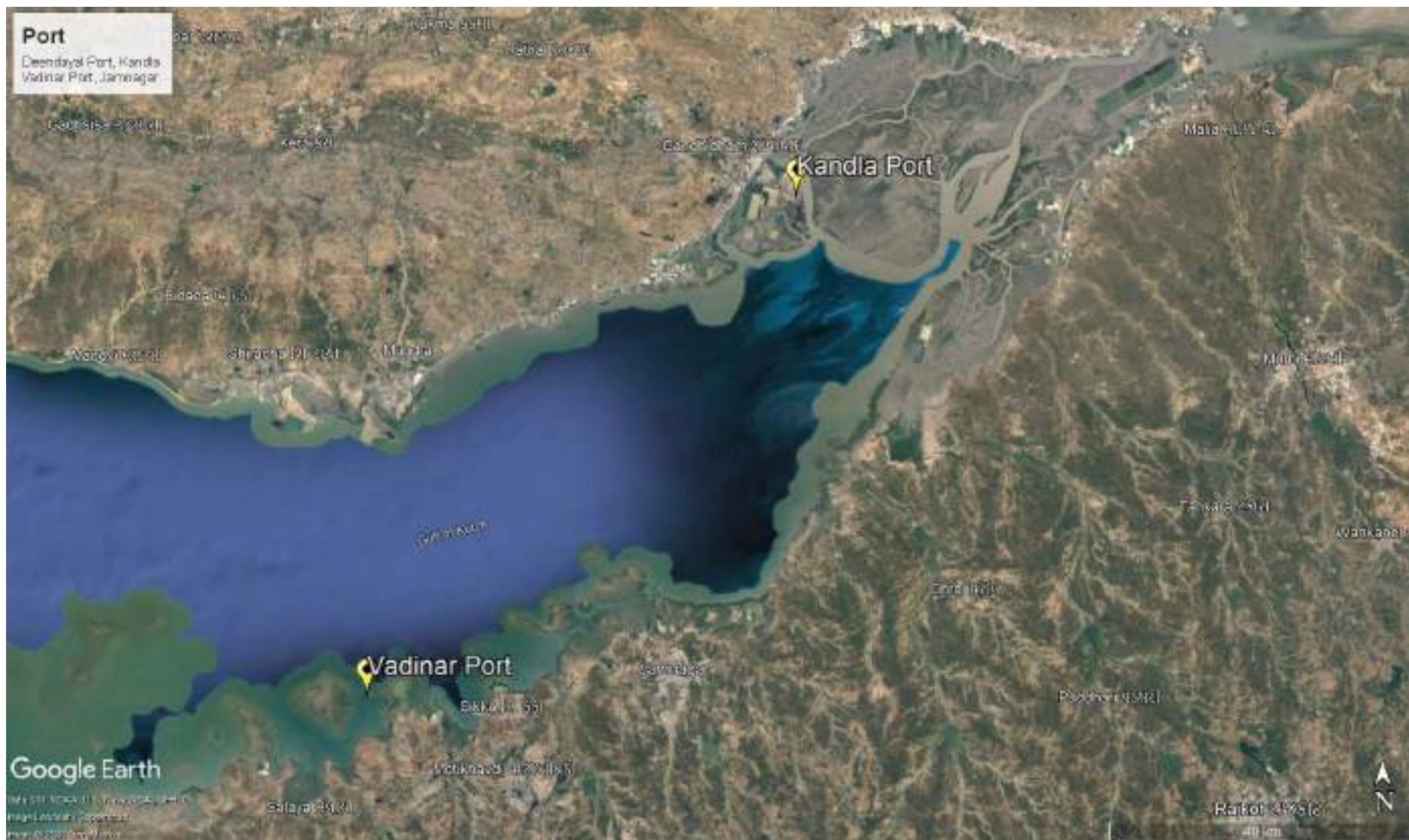
Vadinar is a small coastal town located in Devbhumi Dwarka district of the Gujarat state in India located at coordinates 22° 27' 16.20" N - 069° 40' 30.01". DPA had commissioned the Off Shore Oil Terminal (OOT) facilities at Vadinar in the year 1978, for which M/s. Indian Oil Corporation Limited (IOCL)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

DPA also handled 43.30 MMT at Vadinar (which includes transshipment), the containerized cargo crossed 4.50 lakh TEU, grossing a total of 100 MMT overall. Major commodities handled by the Deendayal Port are Crude Oil, Petroleum product, Coal, Salt, Edible Oil, Fertilizer, etc.

- **Climatic conditions of Vadinar**

Vadinar has a hot semi-arid climate. 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 i.e., Jamnagar. The annual mean temperature is 26.7 °C. Rainy season with extremely erratic monsoonal rainfall that averages around 630 millimetres. The winter season is from October-to-February remains hot during the day but has negligible rainfall, low humidity and cool nights.

The Kandla and Vadinar port have been depicted in the **Map 1** as follows:



Map 1: Locations of Kandla and Vadinar Port



Map 2: Locations of Kandla Port



Map 3: Locations of Vadinar Port

2.2 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 identifying any deterioration in environmental conditions, thereby assist in recommending 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 a well-defined monitoring program. Environmental Monitoring is vital 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 have been mentioned below:

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

GEMI has been entrusted by DPA to carry out the monitoring of the various aforementioned environmental aspects at the port, so as to verify effectiveness of prevailing Environment Management plan, if it confirms to the statutory and/or 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, interpretation and communication of results. The analysis was carried out in GEMI's NABL/MoEF accredited/recognized laboratory.

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 whole process of management through effective decision-making and problem solving. The methodology adopted for the present study is shown in **Figure 1** as given below:

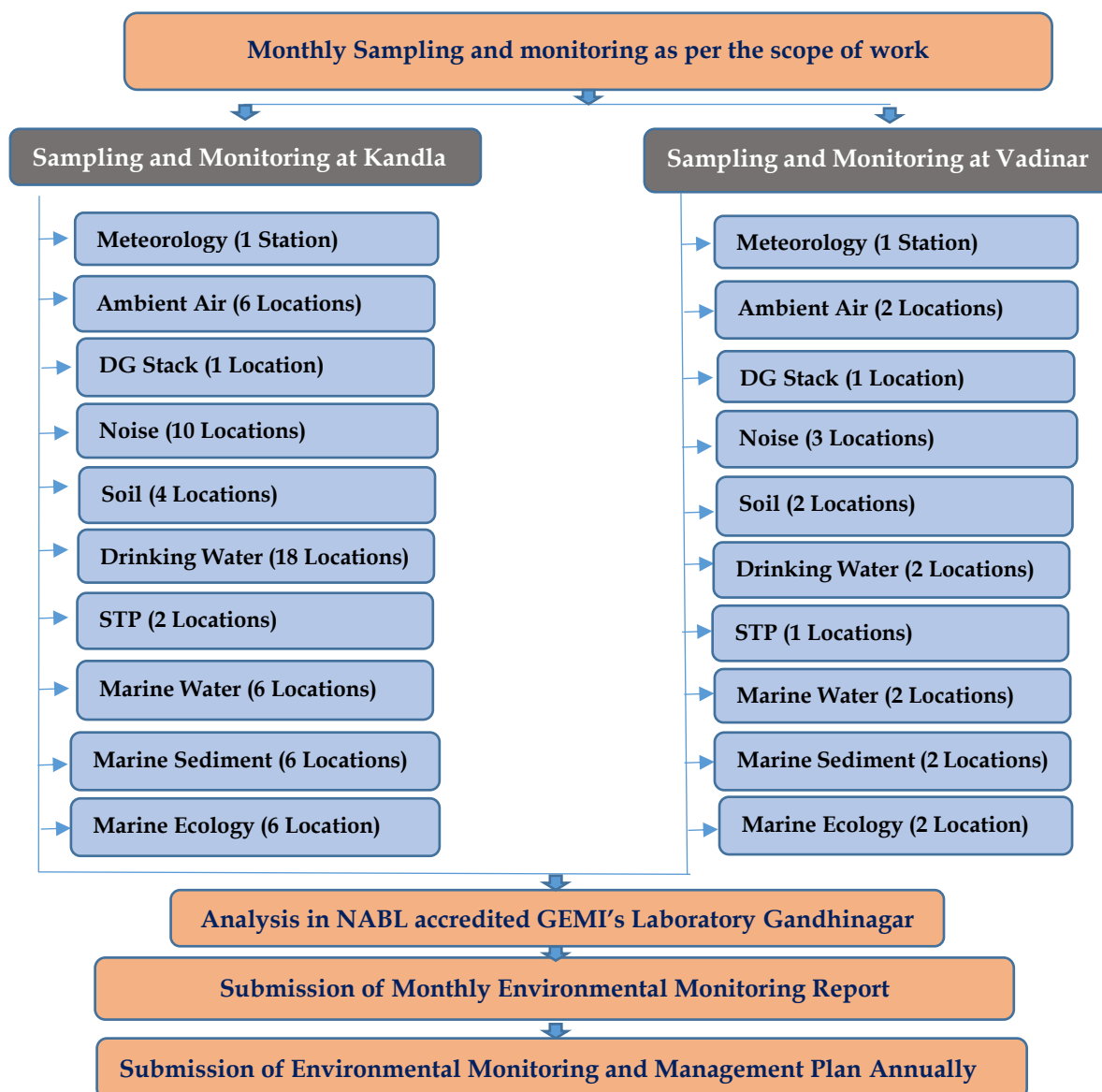


Figure 1: Methodology flow chart

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 as well as 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 make (Model: WM280) were installed at both the sites of Kandla and Vadinar at 10 m above the ground. The details of the AWS installed 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

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 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	°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 sampling period of at both the observatory site.

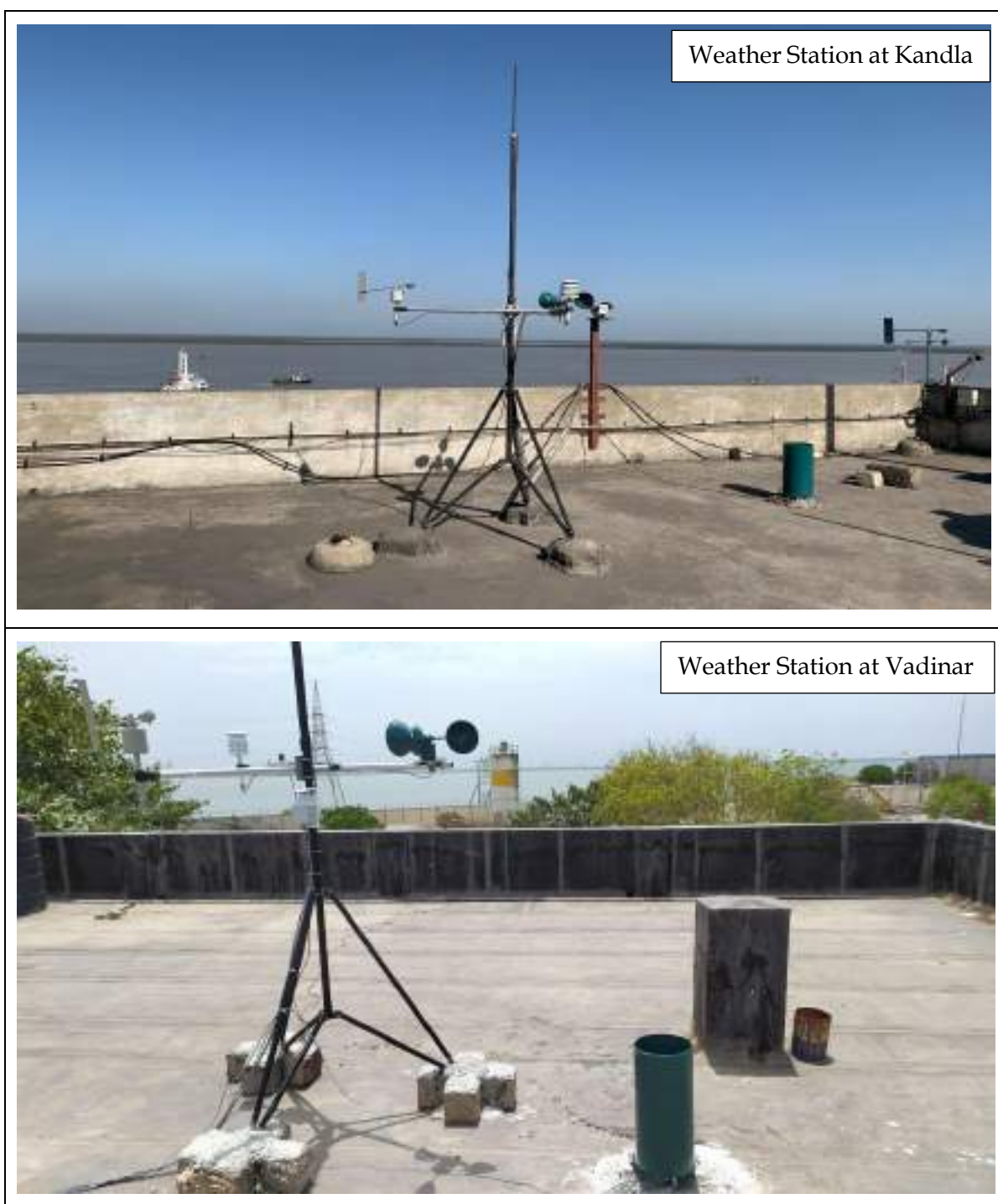


Figure 2: Photographs of Automatic Weather Monitoring Station at Kandla and Vadinar

3.2 Results and discussion

The summary of hourly climatological observations recorded at Kandla and Vadinar during the monitoring period, with respect to significant parameters has been mentioned in **Table 3** as follows:

Table 3: Meteorological data for Kandla and Vadinar

Details of Micro-meteorological data at Kandla Observatory												
Monitoring Period	Wind Speed (Km/h)			Temperature (°C)			Relative humidity (%)			Solar Radiation (W/m ²)	Wind Direction (°)	Rainfall (mm)
Stat.	Mean	Max.	Min	Mean	Max	Min	Mean	Max	Min			
December-January, 2024-2025	7.25	48	3.12	20.27	34.1	13.5	52.38	78	27.8	57.19	South	0
Details of Micro-meteorological data at Vadinar Observatory												
Monitoring Period	Wind Speed (Km/h)			Temperature (°C)			Relative humidity (%)			Solar Radiation (W/m ²)	Wind Direction (°)	Rainfall (mm)
Stat.	Mean	Max.	Min	Mean	Max	Min	Mean	Max.	Min			
December-January, 2024-2025	7.91	74.7	2.96	20.90	27.3	14.1	60.62	104.1	29.4	69.28	South-West	0

3.3 Data Interpretation and Conclusion

- **Temperature**

- a. **Kandla:** The ambient temperature for the monitoring period varies between the range of 13.5–34.1 °C for Kandla, with average temperature of 20.27°C.
- b. **Vadinar:** The ambient temperature for the monitoring period varies between the range of 14.1–27.3°C for Vadinar, with average temperature of 20.90°C.

- **Relative Humidity**

- a. **Kandla:** The Relative Humidity recorded between the range of 27.8–78, with average Humidity of 52.38%.
- b. **Vadinar:** During the study period, the Relative Humidity varies between 29.4–101.1%, with average Humidity of 60.62%.

- **Rainfall**

- a. **Kandla:** 0 rainfall was observed at Kandla.
- b. **Vadinar:** 0 rainfall was observed at Vadinar.

- **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 3.12–48 Km/hr.
- b. **Vadinar:** During the monitoring period, the Wind speed recorded ranges between 2.96–74.7 Km/hr.

- **Solar Radiation:**

- a. **Kandla:** The average Solar Radiation for the monitoring period was recorded as 57.19 W/m².
- b. **Vadinar:** The average Solar Radiation was recorded as 69.28 W/m².

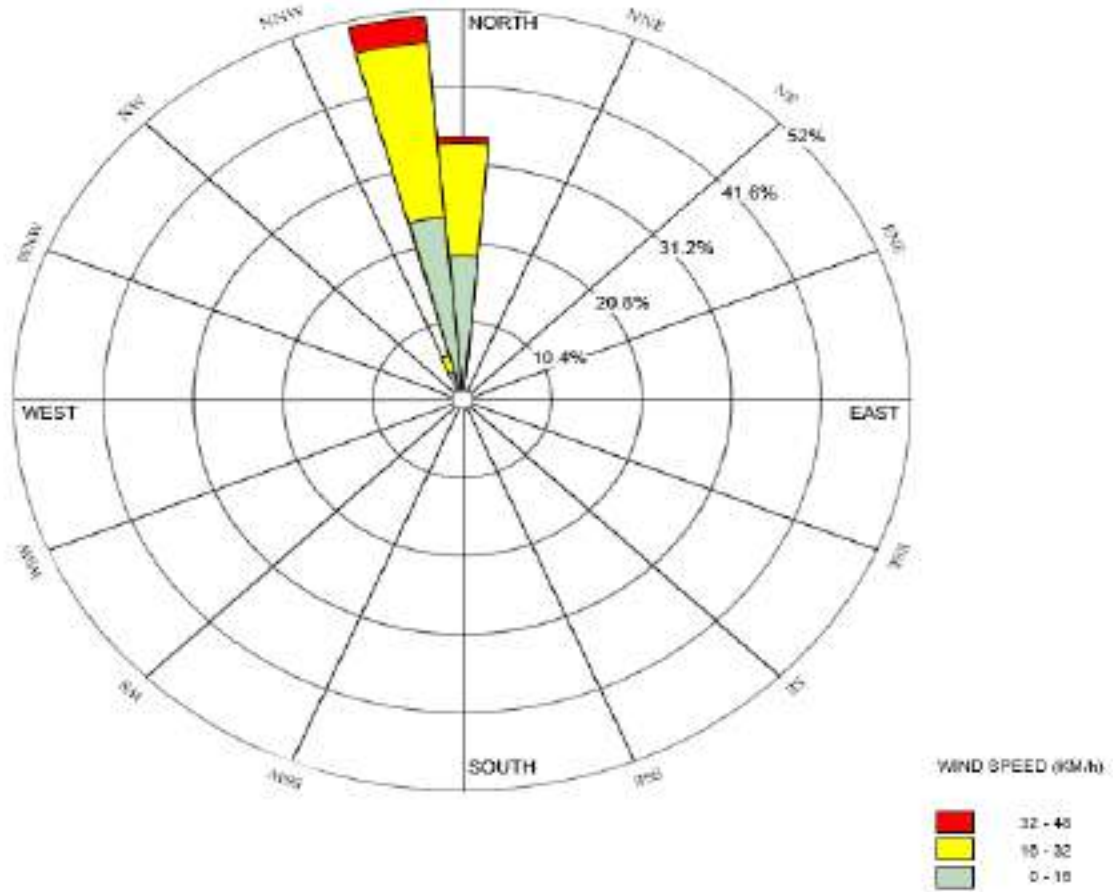
- **Wind rose diagram -**

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

This Wind Rose Diagram reveals that at Kandla and Vadinar, during the monitoring period, the prevailing winds predominantly blow from the West South West direction at Kandla, whereas, high speed winds were also observed to blow from South direction. At Vadinar, the winds were observed to blow from South-West direction.

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

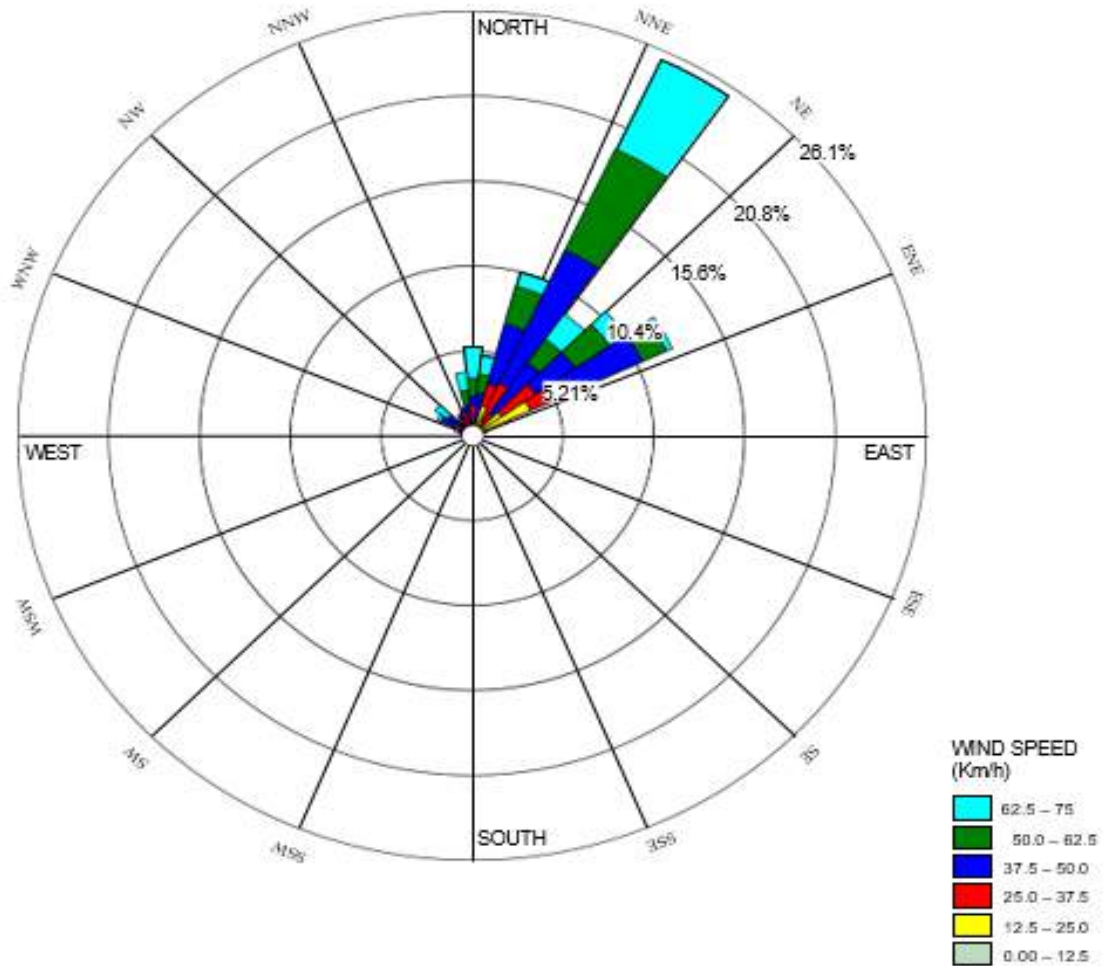
Display: Wind Direction
Wind Speed (Km/hr)



Modeler: Envirotech Instruments Pvt. Ltd. Delhi.

Wind Rose Plot
M/s Deendayal Port Authority
Site: Vadinar Port (Canteen Area)

Display: Wind Direction
Wind Speed (Km/hr)



Modeler: Envirotech Instruments Pvt. Ltd. Delhi.

CHAPTER 4: AMBIENT AIR QUALITY MONITORING

4.1 Ambient Air Quality

It is necessary to monitor the ambient air quality of the study area, in order to determine the impact of the shipping activities and port operations on the ambient air quality. The prime objective of ambient air quality monitoring is to assess the present air quality and its conformity to National Ambient Air Quality Standards i.e. NAAQS, 2009. Ambient air quality has been monitored from 17th December 2024 to 16th January 2025.

Methodology

The study area represents the area occupied by DPA and its associated Port area. 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. Considering the below factors, under the study, as per the scope specified by DPA eight locations wherein, 6 stations at Kandla and 2 at Vadinar have been finalized within the study area

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

The description of various air quality stations monitored at Kandla and Vadinar have been specified 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	Liquid containers and 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 and dust emission
4.		A-4	Marine Bhavan	23.007653N 70.222197E	Construction and vehicular 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 map in **Map 4 and 5** respectively.

Ambient Air monitoring photos

Kandla

A-1: Oil Jetty No. 1



A-2: Oil Jetty No. 7



A-3: Kandla Port Colony



A-4: Marine Bhavan



A-5: Coal Storage Area



A-6: Gopalpuri Hospital

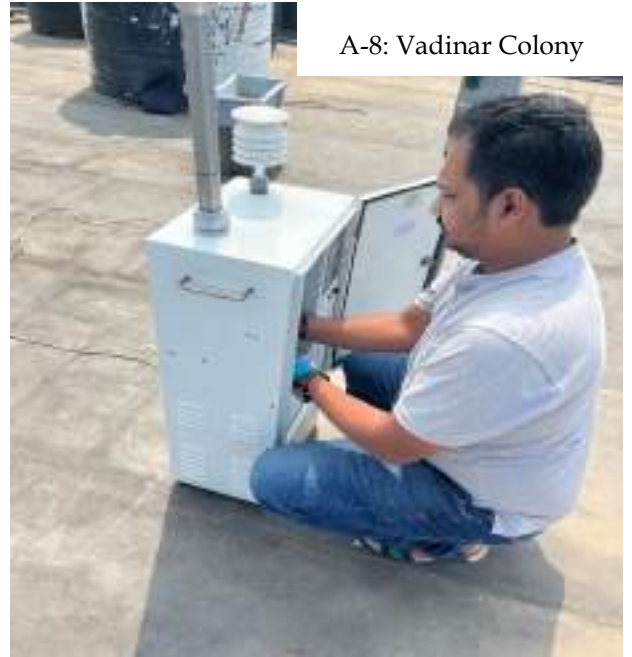


Vadinar

A-7: Admin Building

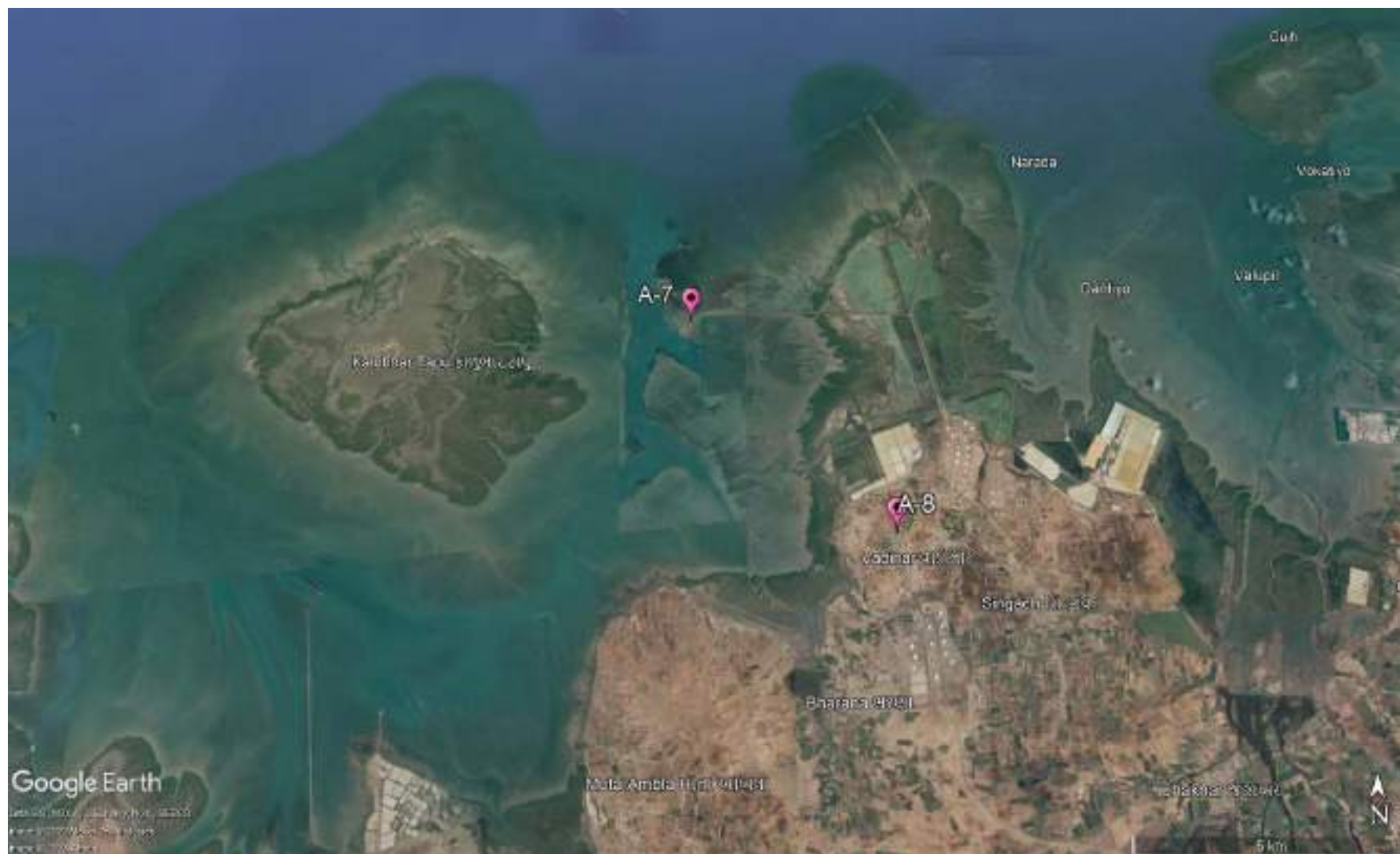


A-8: Vadinar Colony





Map 4: Locations for Ambient Air Monitoring at Kandla



Map 5: Locations for Ambient Air Monitoring at Vadinar

Frequency

The sampling for Particulate matter i.e. PM₁₀ and PM_{2.5} and the gaseous components like SO_x, NO_x, CO as well as the Total VOCs were monitored twice in a week for a period of 24 hours a day. Whereas, the sampling for the components of PAH, Benzene and non-Methane VOCs was conducted on monthly basis.

Sampling and Analysis

The Sampling of the Ambient Air Quality parameters and analysis is conducted as per the 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 PM₁₀, calibrated 'Respirable Dust Samplers' were used, where Whatman GF/A microfiber filter paper of size 8" x 10" were utilized, where the Gaseous attachment of the make Envirotech instrument was attached with Respirable Dust Sampler for the measurement of SO_x and NO_x. The Fine Particulate Sampler for collection of PM_{2.5} was utilized for the 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 SO₂ 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 measured flow rate of 1 liter/minute (L/min). Similarly, NO_x 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 PM₁₀, PM_{2.5}, SO_x and NO_x samples of 24-hour carried out twice a week. 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 (LVS) 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 LVS during two hours monitoring is approx. 24 L.

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, Benzene, 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/m ³	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/m ³	IS:5182 (Part:24):2019	Fine Particulate Sampler (FPS) conforming to IS:5182 (Part-24): 2019	
3.	Sulphur Dioxide (SO _x)	µg/m ³	IS 5182 (Part:2): 2001	Gaseous Attachment conforming to IS:5182 Part-2	
4.	Oxides of Nitrogen (NO _x)	µg/m ³	IS:5182 (Part-6): 2006	Gaseous Attachment conforming to IS:5182 Part-6	
5.	Carbon Monoxide (CO)	mg/m ³	GEMI/SOP/AAQM/11 ; Issue no 01, Date 17.01.2019: 2019	Sensor based Instrument	
6.	VOC	µg/m ³	IS 5182 (Part 17): 2004	Low Flow Air Sampler	
8.	PAH	µg/m ³	IS: 5182 (Part 12): 2004	Respirable Dust Sampler (RDS) conforming to IS:5182 (Part-12): 2004	Monthly
7.	Benzene	µg/m ³	IS 5182 (Part 11): 2006 RA: 2017	Low Flow Air Sampler	
9.	Non-methane VOC	µg/m ³	IS 5182 (Part 11): 2006	Low Volume Sampler	

4.2 Result and Discussion

The summarized results of ambient air quality monitoring for the study period are presented in Table-6 to 9 along with the graphical representation from 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 PM₁₀, PM_{2.5}, SO₂, NO_x, VOC and CO for Ambient Air quality monitoring

Station Code & Name	Unit of Average Concentration	Average Pollutant Concentration					
	Pollutants	PM ₁₀ (µg/m ³)	PM _{2.5} (µg/m ³)	SO ₂ (µg/m ³)	NO _x (µg/m ³)	VOC (µg/m ³)	CO (mg/m ³)
	Duration	(24 hr)				(2 hr)	(1 hr)
	NAAQS by CPCB Monitoring days	100	60	80	80	-	2
A-1: Oil Jetty No.1, Kandla	16-12-2024	288.45	59.98	53.31	33.23	0.05	0.88
	18-12-2024	284.13	76.86	50.42	24.14	0.06	0.63
	23-12-2024	285.33	68.85	13.09	21.12	0.12	0.83
	26-12-2024	132.58	23.08	9.45	10.48	0.17	0.79
	30-12-2024	154.79	62.87	16.62	21.43	0.1	0.82



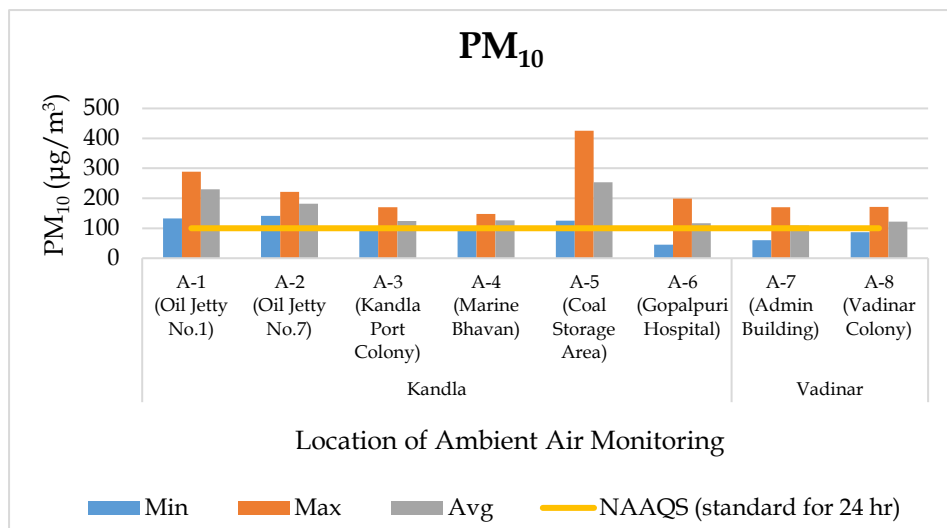
Station Code & Name	Unit of Average Concentration	Average Pollutant Concentration					
	Pollutants	PM ₁₀ (µg/m ³)	PM _{2.5} (µg/m ³)	SO ₂ (µg/m ³)	NO _x (µg/m ³)	VOC (µg/m ³)	CO (mg/m ³)
	Duration	(24 hr)				(2 hr)	(1 hr)
	NAAQS by CPCB Monitoring days	100	60	80	80	-	2
	02-01-2025	260.09	80.83	20.07	27.43	0.12	0.81
	06-01-2025	210.54	60.52	13.86	18.97	0.2	0.82
	07-01-2025	221.02	56.07	14.78	23.16	0.21	0.81
	Minimum	132.58	23.08	9.45	10.48	0.05	0.63
	Maximum	288.45	80.83	53.31	33.23	0.21	0.88
	Average	229.62	61.13	23.95	22.50	0.13	0.80
	Std. Deviation	60.85	17.62	17.51	6.57	0.06	0.07
A-2: Oil Jetty No.7, Kandla	16-12-2024	157.04	47.49	14.12	18.32	0.16	0.84
	18-12-2024	190.54	74.27	12.34	12.52	0.20	0.88
	23-12-2024	208.91	80.64	28.18	20.47	0.19	0.89
	26-12-2024	158.75	23.69	8.56	14.75	0.14	0.81
	30-12-2024	221.71	60.32	14.96	11.16	0.07	0.84
	02-01-2025	141.48	67.90	17.16	13.84	0.13	0.84
	06-01-2025	187.49	51.67	16.66	32.53	0.11	0.85
	07-01-2025	186.94	44.70	13.05	7.47	0.09	0.88
	Minimum	141.48	23.69	8.56	7.47	0.07	0.81
	Maximum	221.71	80.64	28.18	32.53	0.20	0.89
	Average	181.61	56.34	15.63	16.38	0.14	0.85
	Std. Deviation	27.34	18.37	5.75	7.67	0.05	0.03
A-3: Kandla Port Colony, Kandla	16-12-2024	103.64	26.50	10.26	27.56	0.25	0.76
	18-12-2024	115.94	30.87	14.83	20.56	0.10	0.79
	23-12-2024	142.12	24.10	28.78	10.32	0.06	0.82
	26-12-2024	136.52	24.26	12.69	15.27	0.14	0.86
	30-12-2024	127.02	15.86	11.58	17.60	0.18	0.87
	02-01-2025	169.82	21.33	20.57	12.37	0.20	0.81
	06-01-2025	100.35	33.68	13.54	8.53	0.24	0.85
	07-01-2025	101.56	21.41	24.56	11.30	0.16	0.77
	Minimum	100.35	15.86	10.26	8.53	0.06	0.76
	Maximum	169.82	33.68	28.78	27.56	0.25	0.87
	Average	124.62	24.75	17.10	15.44	0.17	0.82
	Std. Deviation	24.30	5.64	6.75	6.31	0.07	0.04
A-4: Marine Bhavan, Kandla	16-12-2024	112.54	27.08	9.54	8.76	0.14	0.79
	18-12-2024	106.87	13.67	15.68	11.74	0.21	0.83
	23-12-2024	126.95	25.34	12.45	10.37	0.18	0.89
	26-12-2024	145.50	15.98	21.89	11.52	0.11	0.76
	30-12-2024	135.26	19.57	22.42	13.90	0.08	0.81
	02-01-2025	125.63	24.68	16.74	12.39	0.07	0.88
	06-01-2025	110.25	18.76	19.85	5.75	0.10	0.81
	07-01-2025	147.32	15.48	11.02	18.20	0.12	0.86
	Minimum	106.87	13.67	9.54	5.75	0.07	0.76
	Maximum	147.32	27.08	22.42	18.20	0.21	0.89
	Average	126.29	20.07	16.20	11.58	0.13	0.83
	Std. Deviation	15.66	5.06	4.93	3.65	0.05	0.05



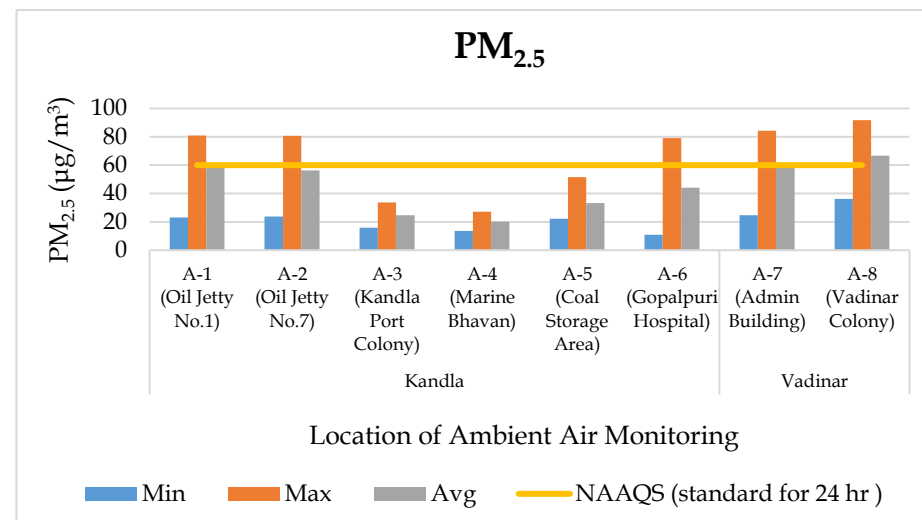
Station Code & Name	Unit of Average Concentration	Average Pollutant Concentration					
	Pollutants	PM ₁₀ (µg/m ³)	PM _{2.5} (µg/m ³)	SO ₂ (µg/m ³)	NO _x (µg/m ³)	VOC (µg/m ³)	CO (mg/m ³)
	Duration	(24 hr)				(2 hr)	(1 hr)
	NAAQS by CPCB Monitoring days	100	60	80	80	-	2
A-5: Coal Storage Area, Kandla	16-12-2024	159.63	36.38	26.58	8.84	0.29	0.93
	18-12-2024	125.48	29.31	14.67	9.78	0.07	0.98
	23-12-2024	169.84	40.28	13.52	30.62	0.23	1.02
	26-12-2024	415.26	22.13	19.64	11.40	0.16	0.97
	30-12-2024	425.68	51.64	20.15	28.51	0.17	0.88
	02-01-2025	348.61	27.88	12.06	19.77	0.19	0.92
	06-01-2025	228.78	24.65	8.4	24.39	0.13	0.96
	07-01-2025	157.62	34.58	26.87	13.28	0.10	0.99
	Minimum	125.48	22.13	8.40	8.84	0.07	0.88
	Maximum	425.68	51.64	26.87	30.62	0.29	1.02
	Average	253.86	33.36	17.74	18.32	0.17	0.96
	Std. Deviation	123.55	9.57	6.74	8.70	0.07	0.04
A-6: Gopalpuri Hospital, Kandla	16-12-2024	56.81	16.60	4.94	15.15	0.05	0.75
	18-12-2024	45.26	21.16	36.41	14.27	0.09	0.70
	23-12-2024	112.63	10.92	4.87	10.10	0.10	0.69
	26-12-2024	154.21	18.61	4.37	7.73	0.19	0.68
	30-12-2024	199.56	79.04	13.01	<6	0.13	0.64
	02-01-2025	183.59	73.01	21.16	27.47	0.17	0.61
	06-01-2025	104.11	66.03	13.01	6.42	0.07	0.62
	07-01-2025	76.55	67.61	13.51	27.9	0.17	0.6
	Minimum	45.26	10.92	4.37	6.42	0.05	0.60
	Maximum	199.56	79.04	36.41	27.90	0.19	0.75
	Average	116.59	44.12	13.91	15.58	0.12	0.66
	Std. Deviation	57.60	29.58	10.78	8.86	0.05	0.05
A-7: Admin Building, Vadinar	16-12-2024	60.52	24.61	12.03	6.12	0.08	0.70
	18-12-2024	92.96	54.94	11.45	<6	0.19	0.60
	23-12-2024	160.57	79.35	11.37	17.11	0.15	0.62
	26-12-2024	169.87	82.15	12.66	6.65	0.16	0.62
	30-12-2024	86.86	46.73	12.67	<6	0.14	0.63
	02-01-2025	82.64	69.48	45.56	12.19	0.17	0.62
	06-01-2025	91.27	29.82	14.91	<6	0.16	0.56
	07-01-2025	125.49	84.19	26.28	7.01	0.13	0.72
	Minimum	60.52	24.61	11.37	6.12	0.08	0.56
	Maximum	169.87	84.19	45.56	17.11	0.19	0.72
	Average	108.77	58.91	18.37	9.82	0.15	0.63
	Std. Deviation	39.18	23.59	12.05	4.75	0.03	0.05
A-8: Vadinar Colony, Vadinar	16-12-2024	87.32	36.57	11.71	<6	0.20	0.65
	18-12-2024	120.29	65.04	10.78	<6	0.14	0.55
	23-12-2024	149.90	81.26	10.73	<6	0.20	0.55
	26-12-2024	171.58	76.15	12.81	6.02	0.15	0.58
	30-12-2024	116.51	60.18	12.99	<6	0.18	0.55
	02-01-2025	109.79	91.70	40.11	12.07	0.13	0.56

Station Code & Name	Unit of Average Concentration	Average Pollutant Concentration					
	Pollutants	PM ₁₀ (µg/m ³)	PM _{2.5} (µg/m ³)	SO ₂ (µg/m ³)	NO _x (µg/m ³)	VOC (µg/m ³)	CO (mg/m ³)
	Duration	(24 hr)				(2 hr)	(1 hr)
	NAAQS by CPCB Monitoring days	100	60	80	80	-	2
	06-01-2025	111.08	36.25	11.96	7.14	0.17	0.63
	07-01-2025	112.69	85.93	18.23	9.60	0.08	0.65
	Minimum	87.32	36.25	10.73	6.02	0.08	0.55
	Maximum	171.58	91.70	40.11	12.07	0.20	0.65
	Average	122.40	66.64	16.17	8.71	0.16	0.59
	Std. Deviation	26.26	21.30	9.96	2.69	0.04	0.05

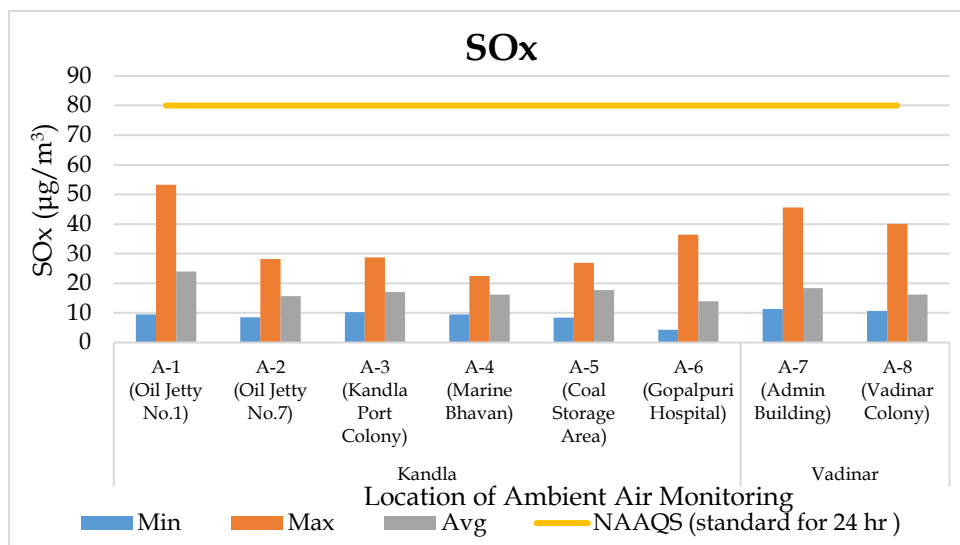
Graphs 1-6 shows spatial trend of ambient air parameter at all the eight-monitoring location (six at Kandla and 2 at Vadinar)



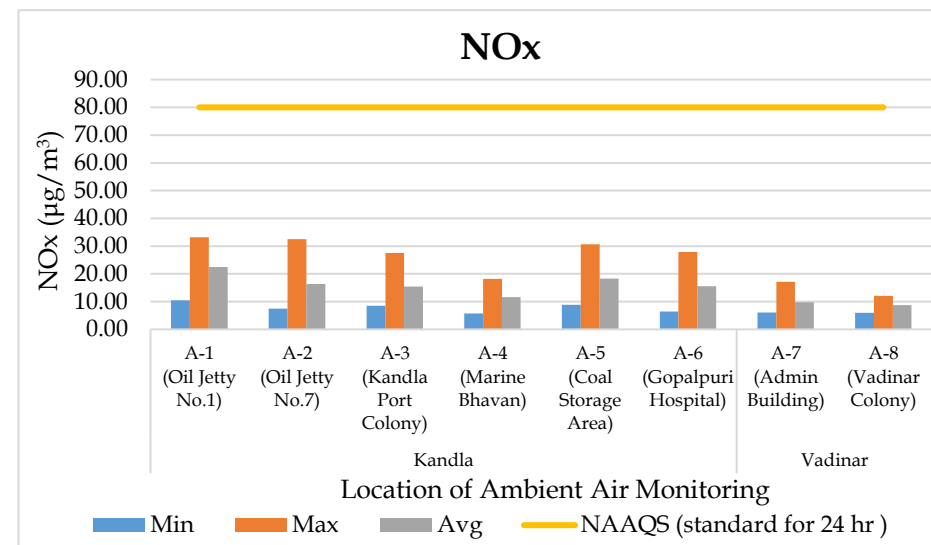
Graph 1: Spatial trend in Ambient PM₁₀ Concentration



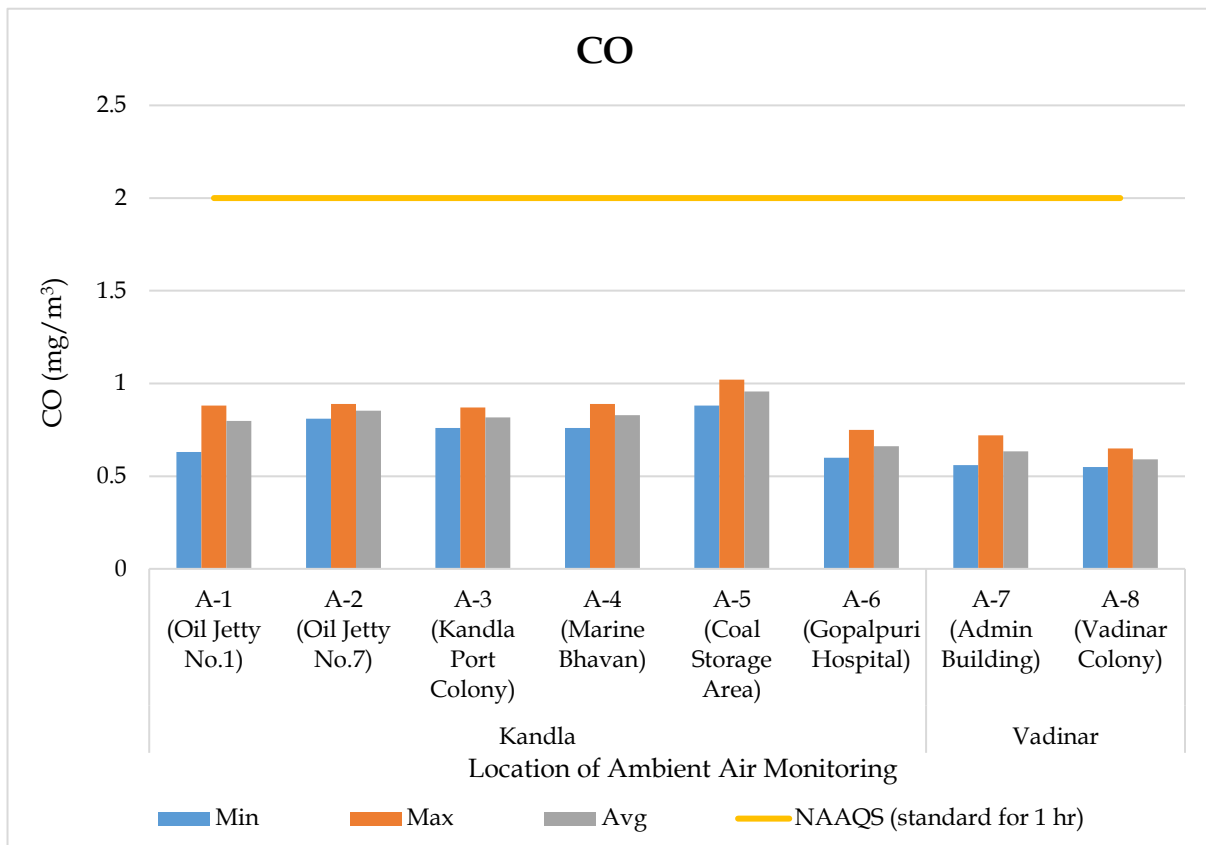
Graph 2: Spatial trend in Ambient PM_{2.5} Concentration



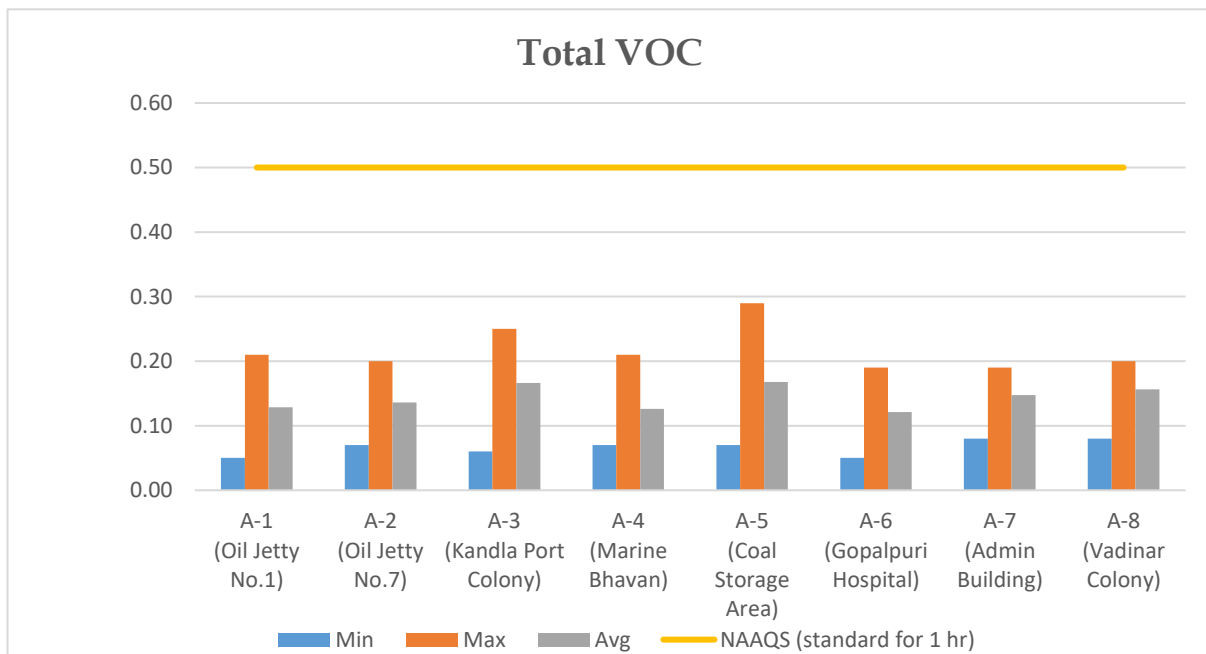
Graph 3: Spatial Trend in Ambient SO_x Concentration



Graph 4: Spatial trend in Ambient Nox Concentration



Graph 5: Spatial trend in Ambient CO Concentration



Graph 6: Spatial trend in Ambient Total VOCs

Table 7: Summarized results of Benzene for Ambient Air quality monitoring

Benzene ($\mu\text{g}/\text{m}^3$)									
Sr. No	Kandla						Vadinar		NAAQS standards (24 hr)
	A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8	
1	0.05	0.02	0.04	0.01	0.08	0	0	0	5 $\mu\text{g}/\text{m}^3$

Table 8: Summarized results of Polycyclic Aromatic Hydrocarbons

Sr. No.	Components	Kandla						Vadinar	
		A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8
1	Napthalene	1.10	1.52	0.02	1.53	1.2	0.01	0.46	0.41
2	Acenaphthylene	0.59	0.72	0.07	0.87	0.31	0.01	0.00	0.00
3	Acenaphthene	0.58	0.61	0.18	0.19	0.26	0.14	0.00	0.00
4	Fluorene	0.05	0.45	0.01	0.54	0.62	0.58	0.00	0.01
5	Anthracene	0.11	0.05	0.01	0.21	0.23	0.01	0.02	0.02
6	Phenanthrene	0.05	0.02	0.03	0.01	0.00	0.10	0.00	0.00
7	Fluoranthene	0.02	0.41	0.05	0.25	0.02	0.36	0.00	0.01
8	Pyrene	0.16	0.59	0.42	0.29	0.48	0.06	0.00	0.00
9	Chrycene	1.22	0.98	0.25	0.40	0.02	1.20	0.00	0.00
10	Banz(a)anthracene	0.22	0.26	0.36	0.27	0.02	0.15	0.00	0.00
11	Benzo[k]fluoranthene	3.7	0.20	2.6	0.2	1.02	1.68	0.00	0.04
12	Benzo[b]fluoranthene	0.02	0.06	0.02	0.02	0.05	0.03	0.00	0.02
13	Benzopyrene	1.74	0.93	3.56	0.01	0.63	0.05	0.00	0.00
14	Indeno [1,2,3-cd] fluoranthene	0.52	0.75	0.71	0.55	0.98	1.49	0.00	0.11
15	Dibenz(ah)anthracene	0.00	0.01	0.25	0.00	0.18	0.05	0.00	0.00
16	Benzo[ghi]perylene	1.3	8.9	28.1	13.2	9.3	12.8	0.00	0.00

Table 9: Summarized results of Non-methane VOC

Sr No	Kandla						Vadinar	
	A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8
1	0.92	0.96	1.13	1.26	1.56	1.10	1.45	1.12

4.3 Data Interpretation and Conclusion

The results were compared with the National Ambient Air Quality Standards (NAAQS), 2009 of Central Pollution Control Board (CPCB).

- The concentration of PM_{10} at Kandla varies in the range of **45.26 to 425.68 $\mu\text{g}/\text{m}^3$** with an average value of **172.10 $\mu\text{g}/\text{m}^3$** . PM_{10} exceeded NAAQS of all the monitoring locations in Kandla. Whereas, at Vadinar, the concentration varies from **60.52 to 171.58 $\mu\text{g}/\text{m}^3$** , with an average value of **115.68 $\mu\text{g}/\text{m}^3$** , and complies with the stipulated norm (100 $\mu\text{g}/\text{m}^3$).

- The elevated PM_{10} concentration at location A-5, the Coal Storage Area, can be attributed to several factors. Heavy vehicular traffic in upwind areas significantly contributes to the dispersion of particulate matter into the ambient air. The process of unloading coal directly onto trucks using grabs leads to the emission of coal dust into the air and its subsequent settling on the ground. This settled dust is re-entrained into the atmosphere as trucks travel through the area. Additionally, coal-loaded trucks are often not adequately covered with tarpaulin sheets, which exacerbates the suspension of coal particles during transit from vessels to the storage yard or site. These factors collectively contribute to increased PM_{10} levels in and around the Coal Storage Area and Marine.
- The $PM_{2.5}$ concentrations at Kandla varies from **10.92 to 80.83 $\mu\text{g}/\text{m}^3$** with average **39.96 $\mu\text{g}/\text{m}^3$** . The $PM_{2.5}$ concentration falls within the NAAQS limit for all locations of Kandla. Whereas, at Vadinar its concentration varies from **24.61 to 91.70 $\mu\text{g}/\text{m}^3$** with average **62.77 $\mu\text{g}/\text{m}^3$** . During winter, the concentrations of particulate matter (PM_{10} & $PM_{2.5}$) are seen to increase. Also due to construction and demolition all around the port contributing in increased particulate matter levels.
- The concentration of SO_x varies from **4.37 to 53.31 $\mu\text{g}/\text{m}^3$** with average concentration as **17.42 $\mu\text{g}/\text{m}^3$** at Kandla and **10.73 to 45.56 $\mu\text{g}/\text{m}^3$** with average as **17.27 $\mu\text{g}/\text{m}^3$** at Vadinar. The average concentration of SO_x complies with the prescribed limit of NAAQS (80 $\mu\text{g}/\text{m}^3$) for both the monitoring site.
- The concentration of NO_x varies from **5.75 to 33.23 $\mu\text{g}/\text{m}^3$** with average **16.63 $\mu\text{g}/\text{m}^3$** at Kandla and **6.02 to 17.11 $\mu\text{g}/\text{m}^3$** with average **9.26 $\mu\text{g}/\text{m}^3$** at Vadinar. The concentration of NO_x falls within the prescribed limit of NAAQS i.e. 80 $\mu\text{g}/\text{m}^3$ at both the monitoring site of Kandla and Vadinar.
- The concentration of CO varies from **0.60 to 1.02 $\mu\text{g}/\text{m}^3$** with average **0.82 $\mu\text{g}/\text{m}^3$** at Kandla and **0.55 to 0.72 $\mu\text{g}/\text{m}^3$** with average **0.61 $\mu\text{g}/\text{m}^3$** at Vadinar. The concentration falls within the norm of 2 mg/ m^3 specified by NAAQS at both the monitoring sites
- The concentration of **Total VOCs** levels was recorded in range of **0.05 to 0.29 $\mu\text{g}/\text{m}^3$** at Kandla and **in range of 0.08 to 0.20 $\mu\text{g}/\text{m}^3$** at the location of Vadinar respectively. The main source of VOCs in the ambient air may be attributed to the burning of Gasoline and Natural gas in Vehicle exhaust and burning fossil fuels, and garbage that release VOCs into the atmosphere. During the monitoring period, the wind flows towards South direction at Kandla, and hence the wind direction and speed also contribute to increased dispersion of pollutants from the upward areas towards the downward areas.
- **Benzene** was detected on the location of Kandla in the range of **0 to 0.08 ($\mu\text{g}/\text{m}^3$)** whereas not detected on the location of Vadinar.
- **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. These locations are commercial areas where Vehicular activity and dust emission is common. PAHs are a class of chemicals that occur naturally in coal, crude oil, and gasoline. The higher

concentration which results from burning coal, oil, gas, road dust, etc. Other outdoor sources of PAHs may be the industrial plants in-and-around the DPA premises.

- The Ambient air Monitoring location of Kandla recorded the **Non-methane VOC** (NM-VOC) concentration in the range of **0.92 to 1.56 $\mu\text{g}/\text{m}^3$** . While at Vadinar, the concentration of NM-VOC falls is found to be **1.12 to 1.45 mg/m^3** at both the location.

With reference to the Ambient Air Quality monitoring conducted under the study, it may be concluded that the particulate matter PM_{10} , were reported in higher concentration and apparently exceeds the NAAQS particularly at locations of Kandla., whereas $\text{PM}_{2.5}$ complies with the NAAQS at majority of the locations. For both the ambient air monitoring parameters (PM_{10} and $\text{PM}_{2.5}$), the major exceedance was observed at location A-5 i.e. Coal Storage Area. The gaseous pollutants (NO_x , SO_x , CO, VOCs etc.) falls within the permissible limit. The probable reasons contributing to these emissions of pollutants into the atmosphere in-and-around the port area are summarized as follows: -

1. **Port Machinery:** Port activities involve the use of various machinery and equipment, including cranes, for lifts, tugboats, and cargo handling equipment. These machines often rely on diesel engines, which can emit pollutants such as NO_x , Particulate matter, and CO. Older or poorly maintained equipment tends to generate higher emissions.
2. **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.
3. Apart from that, construction and demolition activities majorly contribute to particulate matter pollution.

4.4 Remedial Measures:

To improve air quality, DPA has implemented a number of precautionary measures, such as maintaining Green zone, initiated Inter-Terminal Transfer 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 unpaved 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 that can be implemented are as follows:

- 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 will help to reduce the suspension of pollutants in air.
- Frequent water sprinkling on roads to reduce dust suspension due to vehicular movement, this can be use during transporting coal to avoid suspension 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 construction site could considerably reduce dust emission. Prohibition of use of heavy diesel oil as fuel could be possibly reduce

pollutants. Encouraging use of low-sulfur fuels (viz. Marine Gas Oil (MGO)/Liquefied Natural Gas (LNG), can significantly reduce sulfur and PM emissions from ships.

- 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.
- 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.



CHAPTER 5: DG STACK MONITORING

5.1 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, SO₂, 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 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 10** as follows:

Table 10: Details of DG Stack 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 6 and 7** as follows:





Methodology:

Under the study, the list of parameters to be monitored under the projects for DG Stack Monitoring has been mentioned in **Table 11** as follows:

Table 11: DG stack parameters

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

The methodology for monitoring of DG Stack 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 (NO_x), Carbon Monoxide and Carbon Dioxide, the monitoring is carried out by using the sensor-based Flue Gas Analyzer.

Frequency

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

5.2 Result and Discussion

The sampling and monitoring of DG stack emission was carried out at Kandla and Vadinar and its comparison with CPCB or Indian standards for Industrial Stack Monitoring the flue gas emission from DG set has given in **Table 12**.

Table 12: DG monitoring data

Sr. No.	Stack Monitoring Parameters for DG Sets	Stack Monitoring Limits / Standards As per CPCB	DG- 1 (Kandla)	DG-2 (Vadinar)
1.	Suspended Particulate Matter (SPM) (mg/Nm ³)	150	71.45	37.48
2.	Sulphur Dioxide (SO ₂) (PPM)	100	1.17	N.D.
3.	Oxides of Nitrogen (NO _x) (PPM)	50	25.49	9.04
4.	Carbon Monoxide (CO) (%)	1	0.15	0.011
5.	Carbon Dioxide (CO ₂) (%)	-	1.19	1.41

5.3 Data Interpretation and Conclusion

The results of DG stack emission are compared with the permissible limits mentioned in the consent issued by GPCB, and have been found within the prescribed limit for all the monitored parameters.

CHAPTER 6: NOISE MONITORING

6.1 Noise Monitoring

Noise can be defined as an unwanted sound, and 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 the subsequent activities may affect surrounding environment impacting the fauna and as well as the human population. 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 not only confined to commercial areas of DPA but also the residential areas of DPA.

The details of the noise monitoring stations are mentioned in **Table 13** and locations have been depicted in the **Map 8 and 9** as follow:

Table 13: 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



Map 8: Locations for Noise Monitoring at Kandla



Map 9: Locations for Noise Monitoring at Vadinar

Methodology:

The intensity of sound energy in the environment is measured in a logarithmic scale and is expressed in a decibel (dB(A)) scale. The 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). Whereas, 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. Noise levels were measured using an integrated sound level meter of the make Envirotech Sound Level Meter (Class-I) (model No. SLM-109). 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.

Frequency

Monitoring was carried out at each noise monitoring station for Leq. noise level (Day and Night), which was recorded for 24 hours continuously at a monthly frequency with the help of Sound/Noise Level Meter (Class-1). The details of the noise monitoring have been mentioned in **Table 14**.

Table 14: Details of the Noise Monitoring

Sr. No.	Parameters	Units	Reference Method	Instrument
1.	Leq (Day)	dB(A)	IS 9989: 2014	Noise Level Meter (Class-I) model No. SLM-109
2.	Leq (Night)	dB(A)		

Standard for Noise

Ministry of Environment & Forests (MoEF) has notified the noise standards vide the Gazette notification dated February 14, 2000 for different zones under the Environment Protection Act (1986). The day time noise levels have been monitored from 6.00 AM to 10.00 PM and night noise levels were measure from 10.00 PM to 6.00 AM at all the thirteen locations (10 at Kandla and 3 at Vadinar) monthly. The specified standards are as mentioned in **Table 15** as follows:

Table 15: 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

6.2 Result and Discussion

The details of the Noise monitoring conducted during the monitoring period have been summarized in the **Table 16** as below:

Table 16: 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	53.4	33.8	43.6	70	45.7	32.1	38.9
2	N-2	West Gate No.1	A	75	61.8	44.2	53	70	50.2	41.2	45.7
3	N-3	Canteen Area	B	65	54.2	43.5	48.8	55	47.2	32.4	39.8
4	N-4	Main Gate	A	75	71.9	44.6	58.2	70	50.2	33.7	41.9
5	N-5	Main Road	A	75	70.5	37.3	53.9	70	48.5	35.1	41.8
6	N-6	Marin Bhavan	B	65	61.7	42.8	52.2	55	49.8	32.9	41.3
7	N-7	Port & Custom Building	B	65	59.1	34.9	47	55	48.1	34.7	41.4
8	N-8	Nirman Building	B	65	62.5	35.6	49.0	55	47.2	32.9	40
9	N-9	ATM Building	B	65	56.9	36	46.4	55	50.2	33.4	41.8
10	N-10	Wharf Area/ Jetty	A	75	60.4	41.9	51.1	70	47.1	38.1	42.6
11	N-11	Near Main Gate	A	75	63.4	55.3	59.3	70	56.2	45.7	50.9
12	N-12	Near Vadinar Jetty	A	75	65.2	58.5	61.8	70	56.5	51.9	54.2
13	N-13	Port Colony Vadinar	C	55	43.3	38.4	40.8	45	39.7	34.2	36.9

6.3 Data Interpretation and Conclusion

The noise level at both the locations (Kandla and Vadinar) was compared with the standard limits specified in NAAQS by CPCB. During the Day Time, the average noise level at all 10 locations at Kandla ranged from **33.8 dB(A) to 71.9 dB(A)**, while at Vadinar, the noise levels for the three-locations ranged from **38.4 dB(A) to 65.2 dB(A)**. Whereas, during Night Time the average Noise Level ranged from **32.1 dB(A) to 50.2 dB(A)** at Kandla and **34.2 dB(A) to 56.5 dB(A)** at Vadinar.

6.4 Remedial Measures

Though, the noise levels detected at the locations of Kandla and Vadinar, are found within the prescribed norms, the noise can further be considerably reduced by adoption of low noise equipment or installation of sound insulation fences. Green belt of plants can be a good barrier. If noise exceeds the applicable norms, then the working hours may be altered as a possible means to mitigate the nuisances of construction activities.

CHAPTER 7: SOIL MONITORING

7.1 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 17**:

Table 17: Details of the Soil quality monitoring

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

Methodology

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 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 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, Gandhinagar 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 18** as follows:

Frequency

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

Table 18: Soil parameters

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	Kg/Hectare	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, 6 th Edition 2002 13-5.5.3 Sodium Absorption Ratio (SAR), Soluble cations	Flame Photometer
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		

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



Map 10: Locations for Soil Quality Monitoring at Kandla



Map 11: Locations for Soil Quality Monitoring at Vadinar

7.2 Result and Discussion

The analysis results of physical analysis of the soil samples collected during environmental monitoring mentioned in **Table 19** are shown below:

Table 19: Soil Quality for the sampling period

Sr. No	Location Parameters	Unit	Kandla				Vadinar	
			S-1 (Oil Jetty 7)	S-2 (IFFCO Plant)	S-3 (Khorī Creek)	S-4 (Nakti Creek)	S-5 (Near SPM)	S-6 (Near Vadinar Jetty)
1	pH	-	8.73	8.25	8.51	8.44	7.85	8.38
2	Conductivity	μS/cm	12210	13780	2630	15690	271	231
3	Inorganic Phosphate	Kg/ha	0.68	1.62	1.94	1.28	0.87	0.86
4	Organic Carbon	%	0.41	0.39	0.3	0.78	0.35	0.82
5	Organic Matter	%	0.71	0.67	0.52	1.35	0.6	1.42
6	SAR	meq/L	18.31	12.29	1.31	13.21	0.10	0.13
7	Aluminium	mg/Kg	12387	11554	8105	11739	34107	31358.80
8	Chromium	mg/Kg	52.24	52.52	49.18	58.81	69.59	71.12
9	Nickel	mg/Kg	22.89	15.87	21.32	28.84	28.84	32.53
10	Copper	mg/Kg	77.03	85.80	70.86	24.96	89.51	76.23
11	Zinc	mg/Kg	73.96	95.08	61.84	63.50	62.67	63.70
12	Cadmium	mg/Kg	BQL	BQL	BQL	BQL	BQL	BQL
13	Lead	mg/Kg	BQL	BQL	BQL	BQL	BQL	BQL
14	Arsenic	mg/Kg	0.95	0.93	2.31	3.86	0.35	0.72
15	Mercury	mg/Kg	BQL	BQL	BQL	BQL	BQL	BQL
16	Water Holding Capacity	%	52	47.2	48.8	60	47.2	65.59
17	Sand	%	61.69	67.68	70.4	57.69	78.24	78.96
18	Silt	%	26	32	21.28	39.99	20	14
19	Clay	%	12.32	0.32	8.32	2.32	1.76	7.04
20	Texture	-	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Loamy sand	Loamy sand

7.3 Data Interpretation and Conclusion

Soil samples were collected from 6 locations (4 at Kandla and 2 at Vadinar) and further analysed for its physical & chemical characteristics. Each of the parameters have been given an interpretation based on the observations as follows:

- The value of **pH** ranges from **8.25-8.73**, highest at location S-1 (Oil Jetty 7) and lowest at S-2 (IFFCO Plant); while the average pH for Kandla was observed to be 8.48. Whereas, at Vadinar the pH value observed at S-5 i.e., Near SPM (7.85) and at S-6 i.e.,

Near Jetty Area (8.38). As per the observation the pH was found to be **moderately to strongly alkaline** both the monitoring station of Kandla and Vadinar.

- At entire monitoring locations of Kandla the value of **Electrical Conductivity** ranges from **2630-15690 $\mu\text{S/cm}$** , highest at location S-4 (Nakti Creek) with the average as **11077.5 $\mu\text{S/cm}$** . Whereas, at Vadinar the range of conductivity was between the range of **231 to 271 $\mu\text{S/cm}$** with an average value of **251 $\mu\text{S/cm}$** .
- At Kandla, the concentration of **Inorganic Phosphate** varied from **0.68-1.94 Kg/ha**, with average **1.38 Kg/ha**. Whereas, at the locations of Vadinar, the Inorganic Phosphate was observed at S-5 i.e., Near SPM (**0.87 Kg/ha**) and detected at S-6 i.e., near Jetty Area (**0.86 Kg/ha**). The phosphorus availability in soil solution is influenced by a number of factors such as Organic matter, clay content, pH, temperature, etc.
- The concentration of **Total Organic Carbon** ranges from **0.30-0.78%** while the average TOC at Kandla was detected as **0.47%**. Whereas, at Vadinar the average TOC was found to be **0.58%** where the observed TOC value found at S-5 i.e. Near SPM (**0.35%**) and S-6 i.e. near Jetty Area to be **0.82 %** and below quantification limit respectively.
- The concentration of **Water Holding Capacity** in the soil samples of Kandla and Vadinar varies from **47.2-60%** and **47.2-65.59%** respectively.
- The concentration of **Sodium Adsorption Ratio** ranges from **1.31-18.31 meq/L** with an average value **11.28 meq/L** at Kandla. Whereas, at Vadinar, the average SAR was found to be **0.11 meq/L**. A component of conductivity is the SAR. A high SAR indicates a large concentration of sodium ions in the soil, which raises conductivity.

Sandy Loam to loamy sand **Soil Texture** was observed at all the monitoring locations of Kandla and Vadinar.

Heavy Metals

For the sampling period, the concentration of **Aluminium** varied from **8105 to 12387 mg/kg** at Kandla and **31358.8 to 34107.4 mg/kg** at Vadinar and the average value was observed to be **10946.25 and 32733.1 mg/kg** at Kandla and Vadinar monitoring station, respectively.

- The concentration of **Chromium** varied from **49.18 to 58.81 mg/kg** at Kandla and **69.59 to 71.12 mg/kg** at Vadinar and the average value was observed to be **53.18 and 70.35 mg/kg** at Kandla and Vadinar monitoring station, respectively.
- The concentration of **Nickel** varied from **15.87 to 28.84 mg/kg** at Kandla and **28.84 to 32.53 mg/kg** at Vadinar and the average value was observed to be **22.23 and 30.68 mg/kg** at Kandla and Vadinar monitoring station, respectively.

- The concentration of **Zinc** varied from **61.84 to 95.08 mg/kg** at Kandla and **62.67 to 63.70 mg/kg** at Vadinar and the average value was observed to be **73.59 and 63.18 mg/kg** at Kandla and Vadinar monitoring station, respectively
- The concentration of **copper** varied from **24.96 to 85.80 mg/kg** at Kandla and **76.23 to 89.51 mg/kg** at Vadinar and the average value was observed to be **64.66 and 82.87 mg/kg** at Kandla and Vadinar monitoring station, respectively.
- The concentration of **Arsenic** varied from **0.93 to 3.86 mg/kg** at Kandla and the average value was observed to be **2.01** at Kandla Vadinar and the average value was observed to be **0.35 and 0.72 mg/kg** at Kandla and Vadinar monitoring station.
- While other heavy metals in the Soil i.e., **Mercury, Lead and Cadmium** were observed “Below Quantification Limit” for majority of the soil samples collected at Kandla and Vadinar.

CHAPTER 8: DRINKING WATER MONITORING

8.1 Drinking Water Monitoring

It is necessary to check with the drinking water sources regularly so as to know whether water quality conforms to the prescribed standards for drinking. Monitoring the drinking water quality is essential to protect human health and the environment. With reference to the scope specified by DPA, a total of 20 locations (18 at Kandla and 2 at Vadinar) were monitored to assess the Drinking Water quality. The DW-2 location was replaced by Shramdeep due to demolition of past sampling location (port & custom building)

The details of the drinking water sampling stations have been mentioned in **Table 20** and the locations have been depicted through Google map in **Map 12 and 13**.

Table 20: Details of Drinking Water Sampling Locations

Sr. No.	Location Code	Location Name	Latitude/ Longitude
1.	DW-1	Oil Jetty 7	23.043527N 70.218456E
2.	DW-2	Shramdeep	23.009631N, 70.220877E
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.	DW-19	Near Vadinar Jetty	22.440759N 69.675210E
20.	DW-20	Near Port Colony	22.401619N 69.716822E



Map 12: Locations for Drinking Water Monitoring at Kandla



Map 13: Locations for Drinking Water Monitoring at Vadinar

Methodology

The water samples were collected from the finalized sampling locations and analyzed for physico-chemical and microbiological parameter, for which the analysis 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 parameters finalized to assess the drinking water quality have been mentioned in **Table 21** as follows:

Table 21: List of parameters for Drinking Water Quality monitoring

Sr. No.	Parameters	Units	Reference method	Instrument
1.	pH	-	APHA, 23 rd Edition (Section-4500-H+B):2017	pH Meter
2.	Colour	Hazen	APHA, 23 rd Edition, 2120 B:2017	Color Comparator
3.	EC	μS/cm	APHA, 23 rd Edition (Section-2510 B):2017	Conductivity Meter
4.	Turbidity	NTU	APHA, 23 rd Edition (Section -2130 B):2017	Nephlo Turbidity Meter
5.	TDS	mg/L	APHA, 23 rd Edition (Section-2540 C):2017	Vaccum Pump with filtration assembly and Oven
6.	TSS	mg/L	APHA, 23 rd Edition, 2540 D: 2017	
7.	Chloride	mg/L	APHA, 23 rd Edition (Section-4500-Cl-B):2017	Titration Apparatus
8.	Total Hardness	mg/L	APHA, 23 rd Edition (Section-2340 C):2017	
9.	Ca Hardness	mg/L	APHA, 23 rd Edition (Section-3500-Ca B):2017	
10.	Mg Hardness	mg/L	APHA, 23 rd Edition (Section-3500-Mg B):2017	
11.	Free Residual Chlorine	mg/L	APHA 23 rd Edition, 4500	
12.	Fluoride	mg/L	APHA, 23 rd Edition (Section-4500-F-D):2017	UV- Visible Spectrophotometer
13.	Sulphate	mg/L	APHA, 23 rd Edition (Section 4500-SO4-2-E):2017	
14.	Sodium	mg/L	APHA, 23 rd Edition (Section-3500-Na-B):2017	Flame Photometer
15.	Potassium	mg/L	APHA, 23 rd Edition, 3500 K-B: 2017	
16.	Salinity	mg/L	APHA, 23 rd Edition (section 2520 B, E.C. Method)	Salinity /TDS Meter
17.	Nitrate	mg/L	APHA, 23 rd Edition, 4500 NO3- B: 2017	UV- Visible Spectrophotometer

Sr. No.	Parameters	Units	Reference method	Instrument
18.	Nitrite	mg/L	APHA, 23 rd Edition, 4500 NO ₂ -B: 2017	
19.	Hexavalent Chromium	mg/L	APHA, 23 rd Edition, 3500 Cr B: 2017	
20.	Manganese	mg/L	APHA, 23 rd Edition, ICP Method 3120 B: 2017	ICP-OES
21.	Mercury	mg/L	EPA 200.7	
22.	Lead	mg/L	APHA ICP 23 rd Edition (Section-3120 B):2017	
23.	Cadmium	mg/L	APHA ICP 23 rd Edition (Section-3120 B):2017	
24.	Iron	mg/L	APHA ICP 23 rd Edition (Section-3120 B):2017	
25.	Total Chromium	mg/L	APHA ICP 23 rd Edition (Section-3120 B):2017	ICP-OES
26.	Copper	mg/L	APHA, 23 rd Edition, ICP Method 3120 B: 2017	
27.	Zinc	mg/L	APHA ICP 23 rd Edition (Section-3120 B):2017	
28.	Arsenic	mg/L	APHA ICP 23 rd Edition (Section-3120 B):2017	LAF/ Incubator
29.	Total Coliforms	MPN/ 100ml	IS 15185: 2016	

8.2 Result and Discussion

The drinking water quality of the locations at Kandla and Vadinar and its comparison with the to the stipulated standard (Drinking Water Specifications i.e., IS: 10500:2012) have been summarized in **Table 22** as follows:

Table 22: Summarized results 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	-	8.40	7.20	7.54	7.41	7.02	7.99	7.36	7.16	6.91	6.93	7.99	7.15	7.50	6.96	6.99	7.10	7.08	6.76	6.90	6.79
2.	Colour	Hazen	5	15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3.	EC	µS/ cm	-	-	125.5	279	23.1	43.9	50	149	23	25.4	61.4	217	138	212	65.4	203	174.4	49.2	29.7	126.8	165.3	105.6
4.	Salinity	PSU	-	-	0.06	0.13	0.02	0.03	0.03	0.06	0.02	0.02	0.03	0.11	0.09	0.10	0.04	0.10	0.09	0.03	0.02	0.06	0.08	0.05
5.	Turbidity	NTU	1	5	0.59	0.64	0.56	0.71	0.64	0.65	0.65	0.69	0.73	BQL	0.98	BQL	0.52	0.71	BQL	BQL	0.63	0.83	BQL	BQL
6.	Chloride	mg/L	250	1000	28.58	60.12	7.88	13.80	11.50	111.97	7.88	7.88	16.75	45.33	109.97	45.33	17.74	48.29	43.36	15.77	9.86	35.48	20.70	13.80
7.	Total Hardness	mg/L	200	600	16	40	2	2	5	180	2	2.5	7	42	160	34	8	26	10	4	2	6	54	22
8.	Ca Hardness	mg/L	-	-	8	18	1.5	1.5	3	100	1.5	2	4	24	90	18	2	12	8	2.5	1.5	4	26	12
9.	Mg Hardness	mg/L	-	-	8	22	BQL	BQL	2	80	BQL	BQL	3	18	70	16	6	14	2	1.5	BQL	2	28	10
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	66	92	12	22	26	342	12	14	32	112	346	108	34	106	90	26	16	66	84	54
12.	TSS	mg/L	-	-	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
13.	Fluoride	mg/L	1.0	1.5	BQL	BQL	BQL	0.62	BQL	0.435	BQL	BQL	BQL	BQL	0.349	BQL	BQL	BQL	0.35	BQL	BQL	BQL	BQL	BQL
14.	Sulphate	mg/L	200	400	BQL	15.25	BQL	BQL	BQL	36.66	BQL	BQL	BQL	11.59	35.50	10.59	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
15.	Nitrate	mg/L	45	-	BQL	1.635	BQL	BQL	1.040	5.851	BQL	BQL	BQL	1.236	5.470	1.246	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
16.	Nitrite	mg/L	-	-	BQL	BQL	BQL	BQL	BQL	0.033	BQL	BQL	BQL	BQL	0.263	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
17.	Sodium	mg/L	-	-	19.91	30.35	BQL	BQL	7.26	76.79	BQL	BQL	BQL	17.55	71.89	16.59	5.08	19.27	16.79	BQL	BQL	5.25	8.67	5.06
18.	Potassium	mg/L	-	-	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL



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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
19.	Hexavalent Chromium	mg/L	-	-	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
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	9.792	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	0.0072	BQL	BQL	BQL	0.0080	0.0062	BQL	0.0058	BQL	BQL	BQL	BQL	BQL	BQL	BQL	0.0086
24.	Iron	mg/L	0.3	-	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	0.139	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	0.00335	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	BQL	BQL
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
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*	MPN/100ml	Shall not be detected		150	BQL	BQL	BQL	BQL	BQL	BQL	10	BQL	BQL	85	BQL	65	40	110	20	BQL	170	235	BQL

A: Acceptable, P:Permissible, BQL: Below Quantification limit; Turbidity (QL=0.5 NTU), Free Residual Chlorine (QL=2 mg/L), Total Suspended Solids (QL=2 mg/L), Fluoride (QL=0.3 mg/L), Sulphate (QL=10 mg/L), Nitrate as NO₃ (QL=1 mg/L), Nitrite as NO₂ (QL=0.1mg/L), Sodium as Na (QL=5mg/L), Potassium as K (QL=5mg/L), Hexavalent Chromium (QL=0.01 mg/L), Arsenic (QL=0.005 mg/L), Cadmium (QL=0.002 mg/L), Copper (QL=0.005 mg/L), Iron (QL=0.1mg/L), Lead (QL=0.002 mg/L), Manganese (QL=0.04 mg/L), Mercury (QL=0.0005 mg/L), Total Chromium (QL=0.005 mg/L), Zinc (QL=0.5 mg/L), Total Coliforms (QL=1 MPN/ 100ml)

AQL: Above Quantification Limit; Total Coliforms (QL=1000000)

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

8.3 Data Interpretation and Conclusion

Drinking water samples were taken at 20 locations (18 at Kandla and 2 at Vadinar), and their physical and chemical properties were analyzed. The analysis's results were compared with standard values as prescribed in IS 10500:2012 Drinking Water Specification.

- **pH:** The pH values of drinking water samples in Kandla were reported to be in the range of **6.76 to 8.40** with an average pH of **7.30**. In Vadinar, its values ranged from **6.90 to 6.79**, with an average pH of **6.85**. remarkably, the pH values at project locations are within the permissible range of 6.5 to 8.5. specified under IS: 10500:2012, expect DW-19 and DW-20.
- **Colour:** The value of Color in Drinking water sample at Kandla is found to be **1 Hazen** in each sample. In Vadinar the color value is found to be **1 Hazen** in both the locations.
- **Turbidity:** At the drinking water locations of Kandla, the turbidity was found to be in the range of **0.52 to 0.98** with an average of **0.68**. Whereas, in Vadinar the value of turbidity was reported BQL for both the monitoring location.
- **Total Dissolved Solids (TDS):** Monitoring TDS is crucial because it provides an indication of overall quality of the water. During the monitoring period, the TDS concentrations in Kandla were observed to vary in a wide range i.e., between **12 to 346 mg/L**, with an average concentration of **84.55 mg/L**. while in Vadinar, it ranged from **84 to 54 mg/L**, with average at **69 mg/L**.

It is important to note that the TDS concentrations in both Kandla and Vadinar fall well within the acceptable limit of 500 mg/L.

- **Electrical Conductivity (EC):** It is a measure of the ability of a solution to conduct electric current, and it is often used as an indicator of the concentration of dissolved solids in water. During the monitoring period, the EC values for samples collected in Kandla were observed to range from **23 to 279 $\mu\text{S/cm}$** , with an average value of **110.87 $\mu\text{S/cm}$** . In Vadinar, the EC values showed variation from **105.6 to 165.3 $\mu\text{S/cm}$** , with an average value of **135.45 $\mu\text{S/cm}$** . It's important to regularly monitor EC levels in drinking water as it can provide valuable information about water quality and presence of dissolved substances.
- **Chlorides:** The concentrations in the drinking water samples collected from Kandla and Vadinar were within acceptable limits, as specified by the BIS. The chloride in Kandla varied from **7.88 to 111.97 mg/L**, with an average value of **35.41 mg/L**. In Vadinar, it ranged from **13.80 to 20.70 mg/L**, with an average value of **17.25 mg/L**. It's important to note that all the recorded chloride concentrations in both Kandla and Vadinar were well below the acceptable limit of 250 mg/L except for location DW-5, DW-11.
- **Total Hardness (TH):** Total Hardness varied from **2 to 180 mg/L**, with the average value as **30.47 mg/L**. While at Vadinar, the variation was observed from **22 to 54 mg/L**; with the average conc. At **38 mg/L**. It's important to note that all the recorded chloride concentrations in both Kandla and Vadinar were well below the acceptable limit of 200 mg/L.

- **Sulphate:** During monitoring period in Kandla and Vadinar, the sulphate concentrations were found to be within the acceptable limits i.e., 200 mg/L as per the specified norms. In Kandla, the sulphate concentrations varied from **10.59 to 36.66 mg/L**, with an average value of **21.92 mg/L**. In Vadinar, the sulphate concentration was observed below quantification limit.
- **Sodium:** During the monitoring period, at Kandla variation in the concentration of sulphate was observed to be in the range of **5.08 to 76.79 mg/L**, with the average concentration of **26.06 mg/L**. While at Vadinar, the concentration recorded **8.67 mg/L at DW-19** and **5.06 mg/L at DW-20** with the average concentration of **6.87 mg/L**.
- **Nitrate:** During the monitoring period, at Kandla & Vadinar variation in the concentration of Nitrate was observed to be in the range of **1.04 to 5.85 mg/L**, with the average concentration of **2.74 mg/L** also majority of the location recorded as “**BQL**”. While at Vadinar, the concentration recorded as below Quantification limit.
- **Fluoride:** The concentration was found to be BQL in majority of the monitoring location except for location DW-4 (Workshop) i.e. 0.62 mg/L, DW-6 (West Gate 1) i.e. 0.43 mg/L, DW-11 (Wharf area/Jetty) i.e. 0.34 mg/L at Kandla. While at Vadinar its value also reported to be BQL for both the monitoring location.
- **Nitrite:** The Concentration was found to be **BQL** in all of the monitoring location except for location DW-6 (West Gate 1) i.e. 0.033 mg/L, DW-11 (Wharf Area/Jetty) i.e. 0.263 mg/L at Kandla. While at Vadinar its value also reported to be BQL for both the Monitoring location.
- **Iron:** The Concentration was found to be **BQL** in all of the monitoring location except for location DW-18 (Hospital Gopalpuri) i.e. 0.139 mg/L at Kandla.
- **Copper:** The Concentration was found to be **BQL** in all of the monitoring location except for location DW-5 (Canteen Area) i.e. 0.00720 mg/L, DW-10 (Port Colony Kandla) i.e. 0.00623 mg/L, DW-12 (Hospital Kandla) i.e. 0.00587 mg/L, at Kandla. While at Vadinar, the concentration recorded BQL at DW-19 and 0.00868 mg/L at DW-20 with the average concentration of 0.00868 mg/L.
- The parameters such as **Free Residual Chlorine, Lead, Potassium, Total Suspended Solids, Manganese, Hexavalent Chromium**, and the metals **Arsenic, Cadmium, Total Chromium and Zinc** were all observed to have concentrations “Below the Quantification Limit (BQL)” at majority of the locations during the monitoring period.
- **Total Coliforms:** During the monitoring period, at Kandla variation in the concentration of sulphate was observed to be in the range of **10 to 170 MPN/100ml**, with the average concentration of **81.25 MPN/100ml**. While at Vadinar, the concentration recorded **235 MPN/100ml** at DW-19 and **BQL** at DW-20.

8.4 Remedial Measures

Appropriate water treatment processes should be administered to eradicate coliform bacteria. The methods of disinfection such as **chlorination, ultraviolet (UV), or ozone** etc, apart from that, filtration systems can also be implemented to remove bacteria, sediment, and other impurities.

The following steps can be implemented to ensure that the water being supplied is safe for consumption:

- Regular monitoring should be carried out to assess 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 contaminants in the drinking water.
- It is necessary to carry out a system assessment to determine whether the drinking-water supply chain (up to the point of consumption) as a whole can deliver water of a quality that meets identified targets. This also includes the assessment of design criteria of the treatment systems employed.
- Identifying control measures in a drinking-water system that will collectively control identified risks and ensure that the health-based targets are met. For each control measure identified, an appropriate means of operational monitoring should be defined that will ensure that any deviation from required performance (water quality) is rapidly detected in a timely manner.
- Management and communication plan should be formulated describing actions to be taken during normal operation as well as during incident conditions (such as drinking water contamination) and documenting the same.

CHAPTER 9: SEWAGE TREATMENT PLANT MONITORING

9.1 Sewage Treatment Plant (STP) Monitoring:

The principal objective of STP 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 STP Monitoring is to be carried out weekly at three locations, one at Kandla, one at Gopalpuri and one STP at Vadinar. The samples from the inlet and outlet of the STP have been collected weekly. The details of the locations of STP to be monitored for Kandla and Vadinar have been mentioned in **Table 23** as follows:

Table 23: Details of the monitoring locations of STP

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 GPCB were referred for the details of the STP for Kandla and Gopalpuri. The CC&A of Kandla and Gopalpuri entails that the treated domestic sewage should conform to the norms specified in **Table 24**. 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 24: Treated effluent Standards (as per CC&A of Kandla STP)

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 3 and 4** as follows:

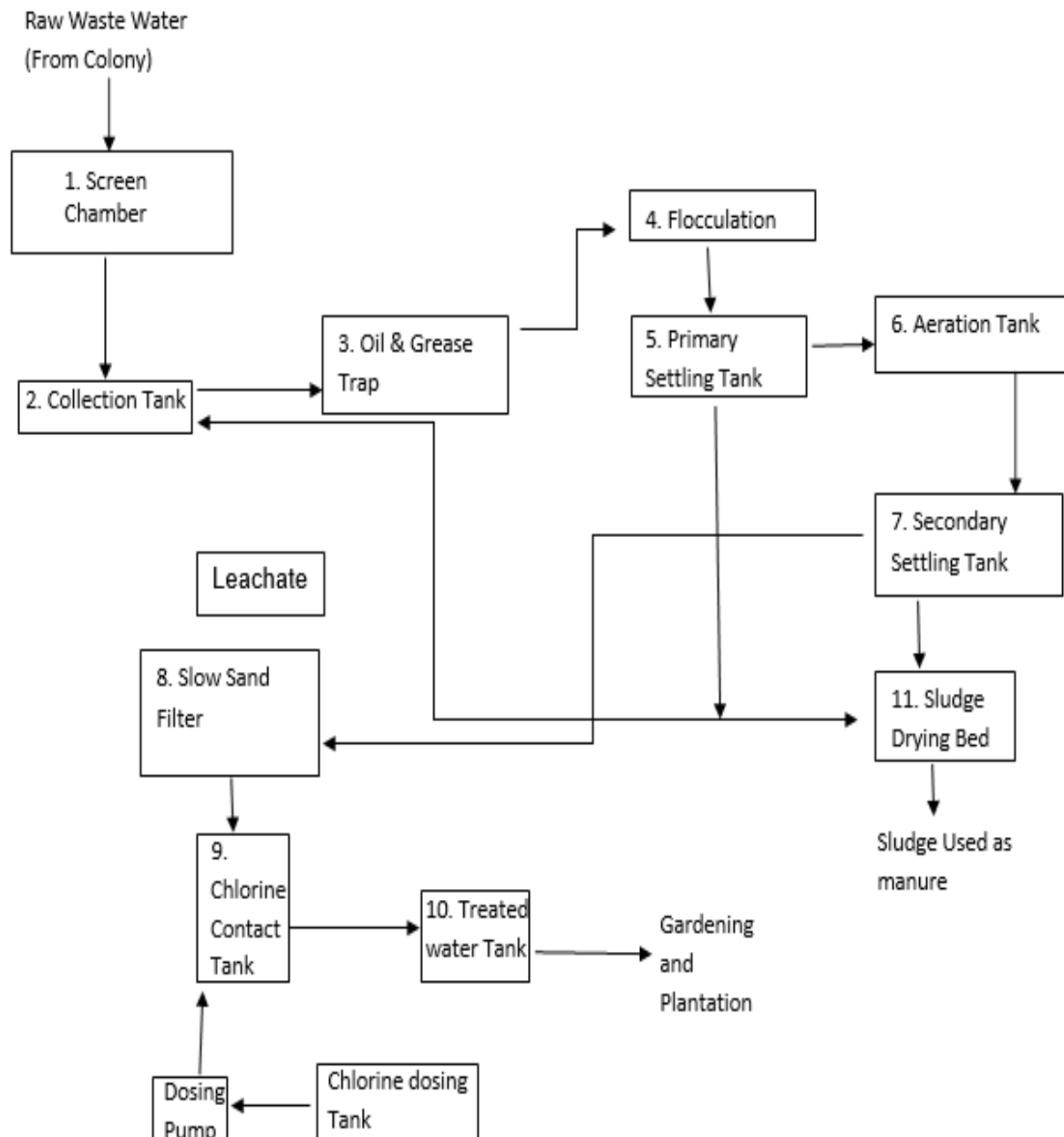


Figure 3: Process flow diagram of STP at Kandla

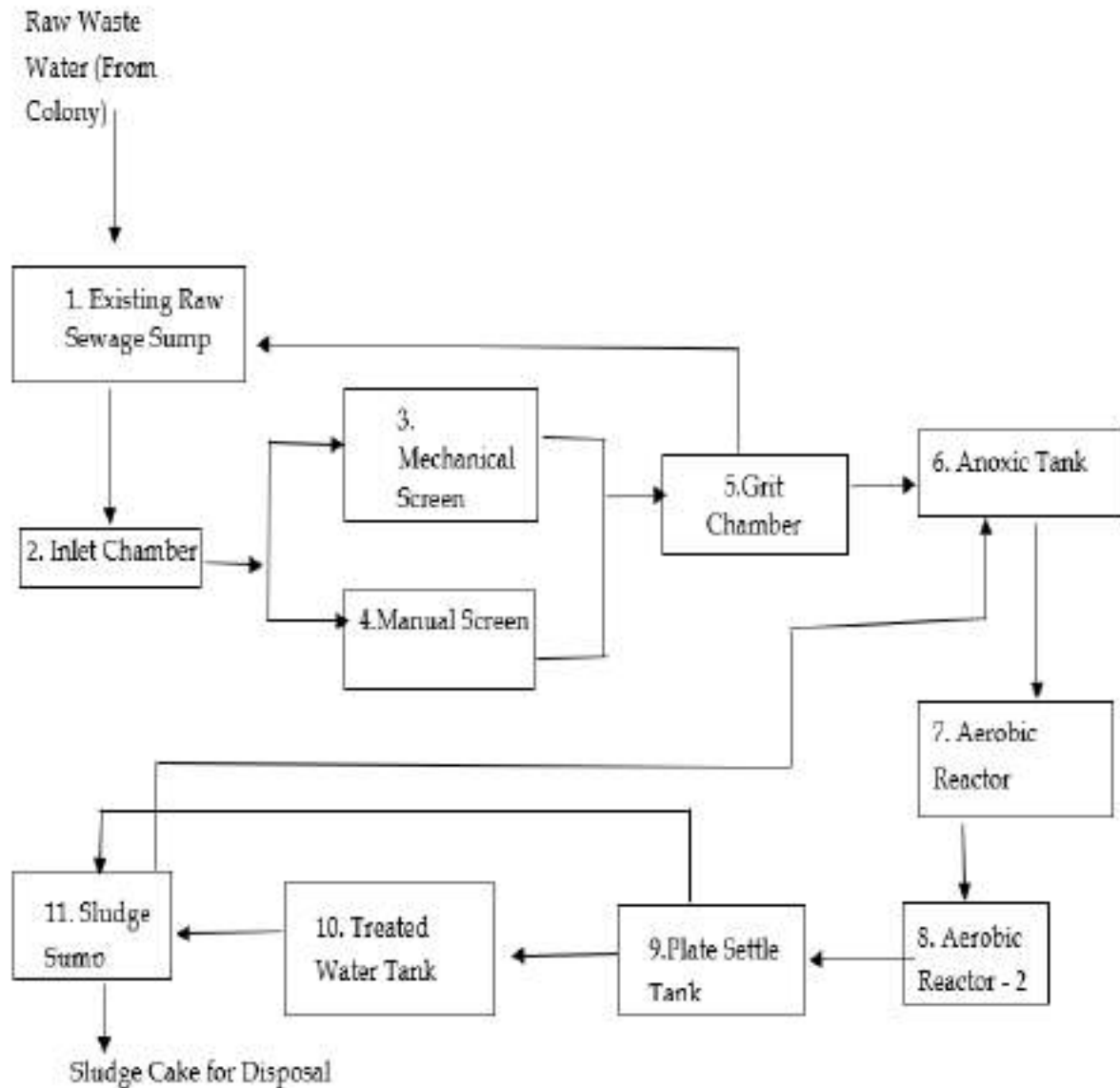


Figure 4: Process flow diagram of STP at Gopalpuri

STP at Vadinar

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 GPCB has been referred for the details of the said STP. The CC&A of the Vadinar STP suggests that the domestic effluent generated shall be treated as per the norms specified in **Table 25**. 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 25: Norms of treated effluent as per CC&A of Vadinar STP

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 5** as follows:

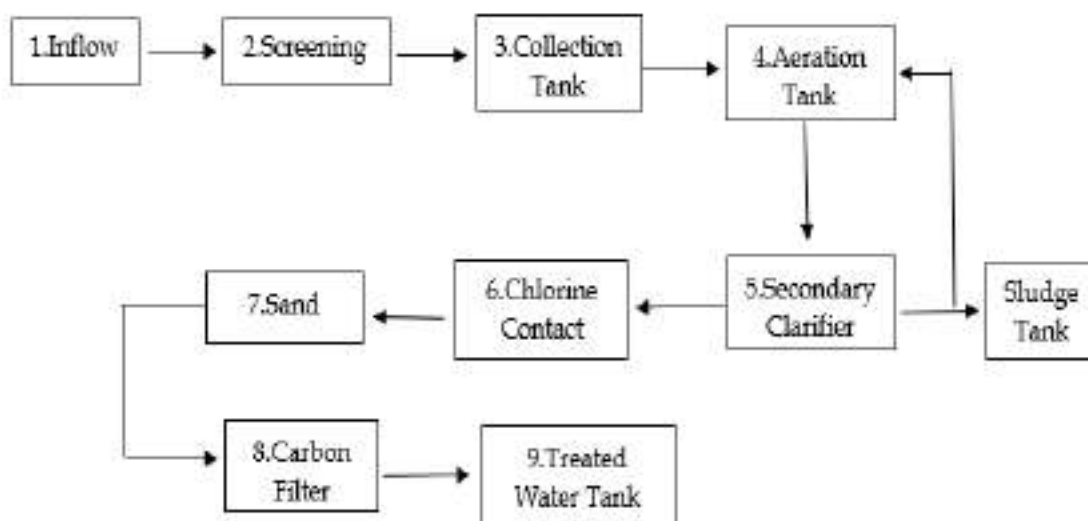
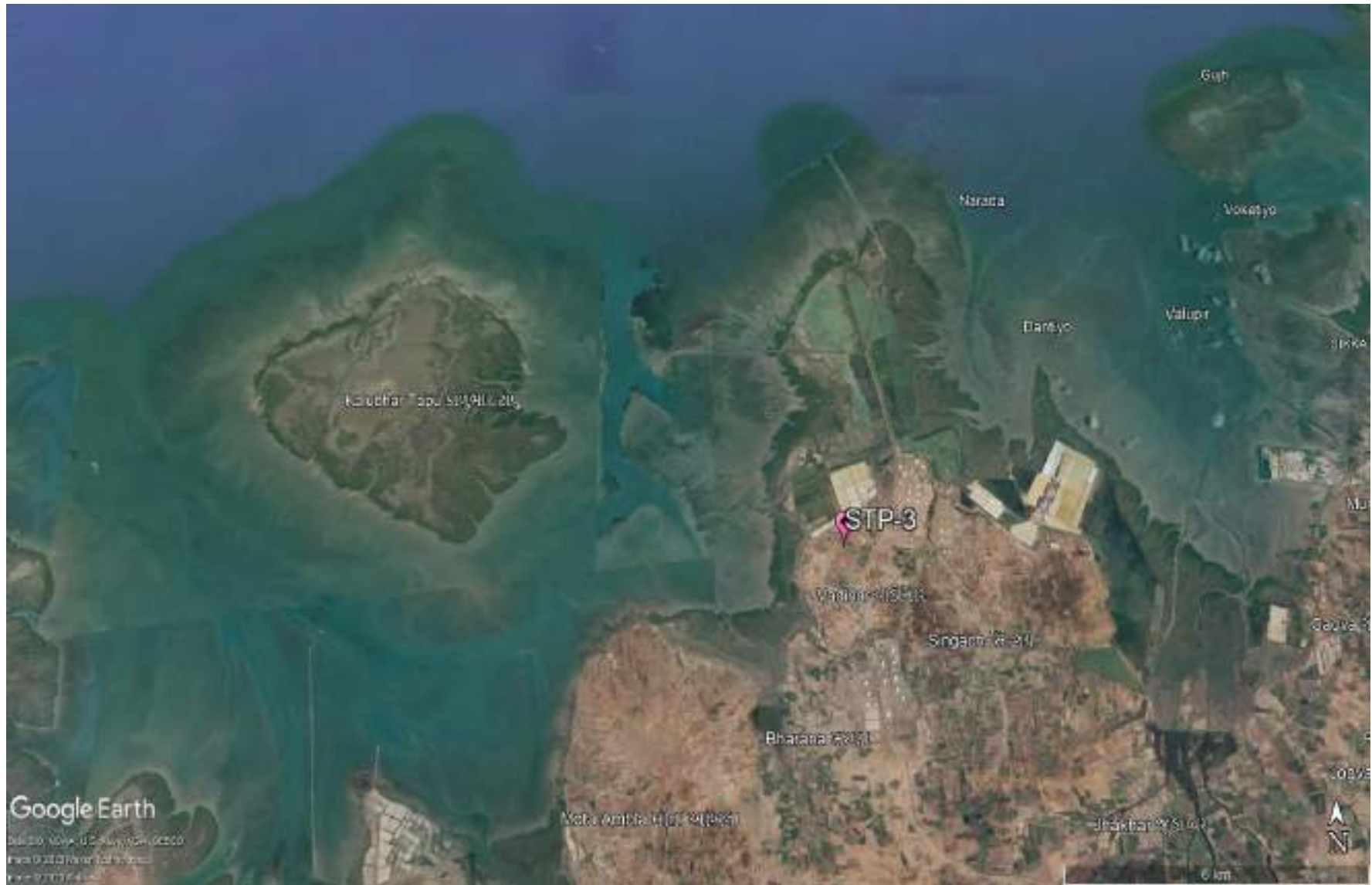


Figure 5: Process flowchart for the STP at Vadinar

The map depicting the locations of STP to be monitored in Kandla and Vadinar have been shown in **Map 14 and 15** as follows:



Map 14: Locations for STP Monitoring at Kandla



Map 15: Locations for STP Monitoring at Vadinar

Methodology

As per the defined scope by DPA, the sampling and analysis of water samples from the inlet and outlet of the STP's 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 26** as follows:

Frequency

Monitoring is required to be carried out once a week for monitoring location of Kandla and Vadinar i.e., two STP station at Kandla and one STP station at Vadinar.

Table 26: List of parameters monitored for STP's at Kandla and Vadinar

Sr. No.	Parameters	Units	Reference method	Instruments
1.	pH	-	APHA, 23 rd edition, 4500- H ⁺ B, 2017	pH Meter
2.	TDS	mg/L	APHA, 23 rd Edition, 2540 C: 2017	Vacuum Pump with filtration assembly and Oven
3.	TSS	mg/L		
4.	DO	mg/L	APHA, 23 rd Edition, 4500 C: 2017	Titration Apparatus
5.	COD	mg/L	APHA, 23 rd 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

9.2 Result and Discussion

Analytical results of the STP samples collected from the inlet and the outlet of the STP's of Kandla and Vadinar have been summarized in **Table 27 & 28**. Further it was compared with the standard norms specified in the CC&A of the respective STPs.

Table 27: Water Quality of inlet and outlet of STP of Kandla

Sr No.	Parameter	Units	GPCB Norms (Kandla)	Kandla															
				Week 3 of December				Week 4 of December				Week 1 of January				Week 2 of January			
				STP-1 (Inlet)	STP-1 (Outlet)	STP-2 (Inlet)	STP-2 (Outlet)	STP-1 (Inlet)	STP-1 (Outlet)	STP-2 (Inlet)	STP-2 (Outlet)	STP-1 (Inlet)	STP-1 (Outlet)	STP-2 (Inlet)	STP-2 (Outlet)	STP-1 (Inlet)	STP-1 (Outlet)	STP-2 (Inlet)	STP-2 (Outlet)
1.	pH	-	6.5-8.5	7.14	7.12	7.17	7.23	7.1	7.08	7.01	7.38	7.20	7.11	7.07	7.41	7.45	7.16	7.08	7.40
2.	TDS	mg/L	-	1352	1321	1398	1518	1458	1324	1464	1450	1358	1316	1430	1390	1467	1364	1340	1410
3.	TSS	mg/L	100	31	20	108	16	41	16	70	12	64	14	220	18	48	12	280	26
4.	COD	mg/L	-	180	73.2	316.0	48.0	248	164	247.0	51.8	176.7	72.3	441.3	72.9	196.0	56.0	842.0	76.6
5.	DO	mg/L	-	BQL	3.2	BQL	3.7	BQL	1.5	BQL	1.7	BQL	3.4	BQL	1.7	BQL	2.5	BQL	2.0
6.	BOD	mg/L	30	42.58	26.8	98.75	6.0	36.54	12.74	77.19	6.47	29.46	9.04	132.39	7.29	45.34	8.40	252.60	7.66
7.	SAR	meq/L	-	11.15	9.30	7.56	9.14	9.87	5.68	5.90	4.62	9.36	8.68	8.65	10.82	12.32	10.10	6.99	6.94
8.	Total Coliforms	MPN/100ml	<1000	1600	240	1600	1600	1600	280	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600

Table 28: Water Quality of inlet and outlet of STP of Vadinar

Sr No.	Parameter	Units	GPCB Norms (Vadinar)	Week 3 of December		Week 4 of December		Week 1 of January		Week 2 of January	
				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	-	6.5-8.5	7.28	7.44	7.15	7.20	6.52	7.12	7.03	7.16
2.	TDS	mg/L	-	408	382	488	374	418	362	424	358
3.	TSS	mg/L	20	8	4	72	10	90	6	38	4
4.	COD	mg/L	50	168.0	56.0	293.2	52.2	498.0	32.4	196.8	36.1
5.	DO	mg/L	-	1.2	8.4	0.7	7.0	BQL	6.0	1.5	6.9
6.	BOD	mg/L	10	50.40	5.60	91.63	6.53	149.40	3.24	59.04	3.61
7.	SAR	meq/L	-	2.21	2.60	1.37	2.31	2.13	2.21	2.45	1.96
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), Biochemical Oxygen Demand (QL=3 mg/L)

9.3 Data Interpretation and Conclusion

For physicochemical analysis, the treated sewage water was gathered from the Kandla STP, Gopalpuri STP, and Vadinar STP and the analytical results were compared with the standards mentioned in the Consolidated Consent and Authorization (CC&A) by GPCB.

- The **pH** of treated effluent from STPs at Kandla (STP-1 and STP-2) and Vadinar (STP-3) conform to their respective stipulated norms of **7.08 to 7.41** at Kandla and **7.12 to 7.44** at Vadinar respectively.
- The **TDS** of treated sewage at Kandla was ranges from **1316 to 1518 mg/L**, whereas for Vadinar it ranges from **358 to 382 mg/L**.
- The **TSS** of the Treated effluent for the STP-1 and STP-2 at Kandla and STP-3 at Vadinar falls within the stipulated norms of **4 and 26 mg/L** respectively as mentioned in their respective CCA.
- **COD** value for Kandla was observed in the range of **48 to 164 mg/L**. Whereas for Vadinar the value of COD falls within the range of **32.4 to 56 mg/L**.
- The value of **DO** was observed in the range of **1.50 to 3.70 mg/L** at Kandla, whereas for Vadinar it was observed in the range of **6.0 to 8.4 mg/L**.
- The **BOD** of the outlet for the STPs of Kandla and Vadinar falls within the stipulated norms.
- The value of **SAR** for Kandla was observed in the range of **4.62 to 10.82 meq/L**, whereas for Vadinar, it was observed in the range of **1.96 to 2.6 meq/L**.
- The value of **Total Coliforms** for Kandla was observed in the range of **240 to 1600 MPN/100 ml**, whereas for Vadinar, it was observed in the range of **1600 MPN/100 ml**.

During the monitoring period, only Total Coliforms were observed to be exceeding the limits at STPs of Kandla and Vadinar while rest of the treated sewage parameters for STP outlet were within norms as specified under the CCA at both the monitoring sites. Regular monitoring of the STP performance should be conducted on regular basis to ensure adequate treatment as per the norms.

9.4 Remedial Measures:

- The quantum of raw sewage (influent) entering the STP should be monitored by installation of the 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 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.

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 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 has been 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. Details of the locations to be monitored have been mentioned in **Table 29**:

Table 29: Details of the sampling locations for Marine water

Sr. No.	Location Code	Location Name	Latitude Longitude
1.	Kandla	MW-1	Near Passenger Jetty One
2.		MW-2	Kandla Creek (nr KPT Colony)
3.		MW-3	Near Coal Berth
4.		MW-4	Khori Creek
5.		MW-5	Nakti Creek (nr Tuna Port)
6.		MW-6	Nakti Creek (nr NH-8A)
7.	Vadinar	MW-7	Near SPM
8.		MW-8	Near Vadinar Jetty

The map depicting the locations of Marine Water to be sampled and analysed for Kandla and Vadinar have been mentioned in **Map 16 and 17** as follows:



Map 16: Locations for Marine Water Monitoring at Kandla



Map 17: Locations for Marine Water Monitoring at Vadinar

Methodology

The methodology adopted for the sampling and monitoring of Marine Water was carried out as per the '**Sampling Protocol for Water & Wastewater**' developed by GEMI. The water samples collected through the Niskin Sampler are collected in a clean bucket to reduce the heterogeneity. The list of parameters to be monitored under the project for the Marine Water quality have been mentioned in **Table 30** along with the analysis method and instrument.

Frequency:

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

Table 30: List of parameters monitored for Marine Water

Sr. No	Parameters	Units	Reference method	Instrument
1.	Electrical Conductivity	μS/cm	APHA, 23 rd Edition (Section-2510 B):2017	Conductivity Meter
2.	Dissolved Oxygen (DO)	mg/L	APHA, 23 rd Edition, 4500 O C, 2017	Titration Apparatus
3.	pH	-	APHA, 23 rd Edition (Section-4500-H+B):2017	pH meter
4.	Color	Hazen	APHA, 23 rd 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, 23 rd Edition (Section-2540 C):2017	Vaccum Pump with Filtration Assembly and Oven
8.	Total Suspended Solids (TSS)	mg/L	APHA, 23 rd Edition, 2540 D: 2017	
9.	Particulate Organic Carbon	mg/L	APHA, 23 rd 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, 23 rd Edition, 4500 C, 2017	UV- Visible Spectrophotometer
13.	Phosphate	mg/L	APHA, 23 rd Edition, 4500 P-D: 2017	
14.	Sulphate	mg/L	APHA, 23 rd Edition, 4500 SO4-2 E: 2017	
15.	Nitrate	mg/L	APHA, 23 rd Edition, 4500 NO3-B: 2017	

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

10.2 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 31**. The said water quality has been represented in comparison with the standard values as stipulated by CPCB for Class SW-IV Waters.

Table 31: Results of Analysis of Marine Water Sample for the sampling period

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/m ³	-	1.021	1.02	1.02	1.021	1.022	1.021	1.02	1.021
2.	pH	-	6.5-9.0	8.13	8.11	8.19	8.24	8.12	8.2	8.19	8.24
3.	Color	Hazen	No Noticeable	5	5	5	5	5	5	5	5
4.	EC	μS/cm	-	51,500	52,300	54,100	54,300	52,400	51,800	54,100	54,300
5.	Turbidity	NTU	-	97	125	4.12	3.42	131	112	4.12	3.42
6.	TDS	mg/L	-	33,326	37,182	32,478	33,142	34,109	33,806	32,478	33,142
7.	TSS	mg/L	-	347	421	115	195	332	411	115	195
8.	COD	mg/L	-	32.7	30.9	47.89	51.26	31.56	33.11	47.89	51.26
9.	DO	mg/L	3.0 mg/L	5.9	6.3	6.1	5.7	6.1	5.8	6.1	5.7
10.	BOD	mg/L	5.0 mg/L	8.15	8.3	7.42	7.13	10.2	9.92	7.42	7.13
11.	Oil & Grease	mg/L	-	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
12.	Sulphate	mg/L	-	2364.6	2684.7	2897.4	3157.3	2739.8	2457.3	2897.4	3157.3
13.	Nitrate	mg/L	-	4.63	3.48	3.41	2.980	3.86	4.12	3.41	2.980
14.	Nitrite	mg/L	-	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
15.	Phosphate	mg/L	-	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
16.	Silica	mg/L	-	3.01	2.71	0.93	0.79	3.83	2.76	0.93	0.79
17.	Sodium	mg/L	-	9485	9206	9,827	9,541	9642	9468	9,827	9,541
18.	Potassium	mg/L	-	360.21	320	421.7	391.40	347.60	247.67	421.7	391.40
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	-	BQL	6.22	BQL	BQL	6.68	BQL	BQL	BQL
24.	Iron	mg/L	-	1.831	2.281	0.586	0.378	1.819	2.192	0.586	0.378
25.	Lead	mg/L	-	3.16	3.22	2.412	2.984	2.41	3.36	2.412	2.984
26.	Manganese	mg/L	-	92.18	134.29	42.57	BQL	92.74	116.68	42.57	BQL
27.	Total Chromium	mg/L	-	BQL	BQL	BQL	BQL	BQL	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.	Particulate Organic Carbon	mg/L	-	1.08	0.68	0.55	0.72	0.98	1.18	0.65	0.72
31.	Total Coliforms	MPN/100ml	500/100 ml	16	15	10	24	10	15	10	24

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

10.3 Data Interpretation and Conclusion

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 monitoring period. The detailed interpretation of the parameters in comparison to the Class SW-IV for Harbour Waters is as follows:

- **Density** at Kandla was observed in the range of **1.20 to 1.023 kg/m³**, with the average of **1.021 kg/m³**. Whereas for the location of Vadinar, it was observed **1.020 kg/m³** at MW-7 and **1.021 kg/m³** at MW-8, with the average of **1.020 kg/m³**.
- **pH** at Kandla was observed in the range of **8.04 to 8.21**, with the average pH as **8.13**. Whereas for the locations of Vadinar, it was observed in the range of be **8.19 to 8.24**, with the average pH as **8.21**. For the monitoring location of both the study areas, pH was found to comply with the norms of 6.5-8.5.
- **Color** range varied from **5 Hazen** at all the monitoring locations in Kandla, and for Vadinar, it found **5 Hazen** for the both of the location.
- **Electrical conductivity (EC)** was observed in the range of **51,400 to 52,400 µS/cm**, with the average EC as **51,850 µS/cm** for the locations of Kandla, whereas for the locations of Vadinar, it was observed in the range of **54,100 to 54,300 µS/cm**, with the average EC as **54,200 µS/cm**.
- For all monitoring locations of Kandla the value of **Turbidity** was observed in the range of **97 to 210 NTU**, with average value of **137.08 NTU**. For Vadinar it ranges from **4.12 to 3.42 NTU**, with average of **3.77 NTU**. Materials that cause water to be turbid include clay, silt, finely divided organic and inorganic matter, soluble coloured organic compounds, plankton and microscopic organisms. Turbidity affects the amount of light penetrating to the plants for photosynthesis.
- For the monitoring locations at Kandla the value of **Total Dissolved Solids (TDS)** ranged from **32,189 to 37,182 mg/L**, with an average value of **34048.66 mg/L**. Similarly, at Vadinar, the TDS values ranged from **32,478 to 33,142 mg/L**, with an average value of **32,810 mg/L**.
- **TSS** values in the studied area varied between **289 to 421 mg/L** at Kandla and **115 to 195 mg/L** at Vadinar, with the average value of **363.5 mg/L** and **155 mg/L** respectively for Kandla and Vadinar.

- **COD** varied between **30.9 to 33.11 mg/L** at Kandla and **47.89 to 51.26 mg/L** at Vadinar, with the average value as **31.98 and 49.57 mg/L** respectively for Kandla and Vadinar.
- **DO** level in the studied area varied between **5.8 to 6.3 mg/L** at Kandla and **5.7 to 6.1 mg/L** at Vadinar, with the average value of **6.01 mg/L and 5.9 mg/L** respectively for Kandla and Vadinar. Which represents that the marine water is suitable for marine life.
- **BOD** observed was observed in the range of **8.15 to 10.2 mg/L**, with average of **8.95 mg/L** for the location of Kandla and for the locations of Vadinar, it was observed in the range of **7.42 to 7.13 mg/L**, with an average value of **7.27 mg/L**.
- **Sulphate** concentration in the studied area varied between **2364.6 to 3246.3 mg/L** at Kandla and **2897.4 to 3157.3 mg/L** at Vadinar. The average value observed at Kandla was **2680.63 mg/L**, whereas **3027.35 mg/L** was the average value of Vadinar. Sulphate is naturally formed in inland waters by mineral weathering or the decomposition and combustion of organic matter.
- **Nitrate** in the study area was observed in the range of **3.38 to 4.89 mg/L**, with the average of **4.06 mg/L**. Whereas for the Vadinar, recorded value was observed in the range of **2.98 to 3.41 mg/L**, with the average of **3.19 mg/L**.
- In the study area of Kandla the concentration of **Potassium** varied between **247.67 to 360.21 mg/L** and **391.40 to 421.70 mg/L** at Vadinar, with the average value as **324.88 mg/L and 406.55 mg/L** respectively for Kandla and Vadinar.
- **Silica** in the studied area varied between **2.71 to 3.83 mg/L**, with the average of **3.10 mg/L**, at Kandla. Vadinar, observed value was found to be **0.93 mg/L** at location MW-7 and **0.79 mg/L** at MS-8 location.
- **Sodium** in the study area varied between **9206 to 9887 mg/L**, with average of **9513.83 mg/L**, at Kandla whereas at Vadinar the sodium concentration value was observed in the range of **9541 to 9827 mg/L**, with the average value of **9684 mg/L**.
- **Odour** was observed **1** for all locations of Kandla and Vadinar.
- **Copper** at the Kandla and Vadinar location was detected **below the quantification limit (BQL)"** for the all-sampling location.
- **Iron** in the studied area varied between **1.749 to 2.431 mg/L**, with the average of **2.050 mg/L**, at Kandla, and for Vadinar value were recorded **0.586 mg/L** for location MW-7 and **0.378 mg/L** for location MW-8.
- **Lead** concentration varied **0.00241 to 0.00336 mg/L**, with an average of **0.00293 mg/L** at Kandla. At Vadinar location MW-7 observed **0.00241 mg/L** and MW-8 observed **0.00298 mg/L** with an average of **0.00269 mg/L**.
- **Manganese** in the studied area varied between **0.0921 to 0.134 mg/L**, with the average of **0.110 mg/L**, at Kandla. At Vadinar location MW-7 observed **0.0425 mg/L** and MW-8 observed **BQL**.
- **Particulate Organic Carbon** in the study area was observed in the range of **0.55 to 1.18**, with the average value of **0.86**. Whereas for the Vadinar, the value observed was **0.65** at MW-7 and **0.72** at MW-8, with the average of **0.68**.
- **Oil & Grease, Nitrite, Phosphate, Hexavalent Chromium, Arsenic, Cadmium, Total Chromium, Zinc, Mercury and Floating Material (Oil grease scum, petroleum**

products) were observed to have concentrations “**Below the Quantification Limits (BQL)**” for most of the locations of Kandla and Vadinar.

- **Total Coliforms** were detected complying with the specified norm of 500 MPN/100ml for all the locations of Kandla and Vadinar.

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).

However, as a safeguard towards marine water pollution prevention, 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 are 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.

Methodology

As defined in the scope by 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 (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 locations of Marine Sediment to be monitored under the study are mentioned in **Table 32** as follows:

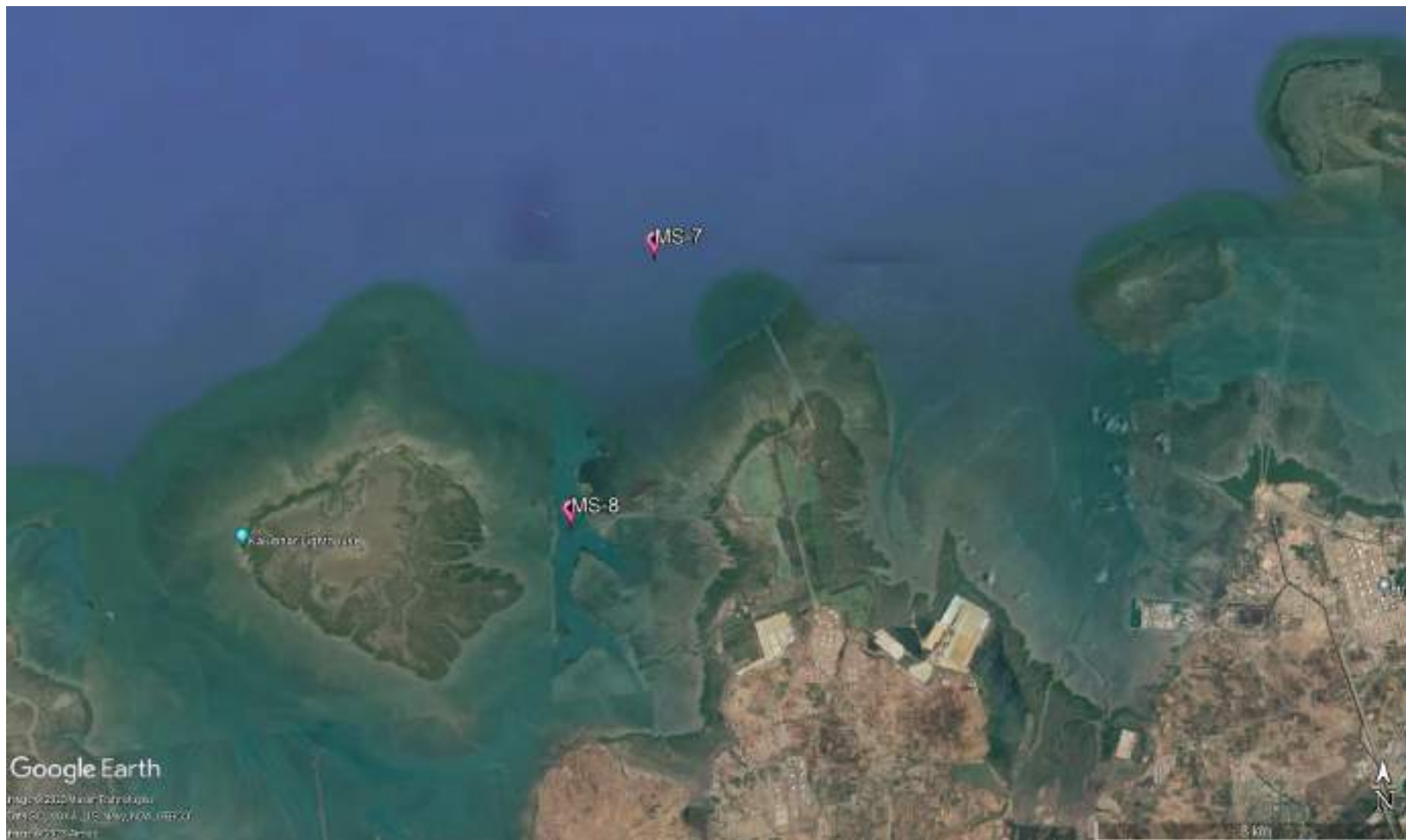
Table 32: Details of the sampling locations for Marine Sediment

Sr. No	Location Code	Location Name	Latitude Longitude
1.	Kandla	MS-1	Near Passenger Jetty One
2.		MS-2	Kandla Creek
3.		MS-3	Near Coal Berth
4.		MS-4	Khori Creek
5.		MS-5	Nakti Creek (near Tuna Port)
6.		MS-6	Nakti Creek (near NH-8A)
7.	Vadinar	MS-7	Near SPM
8.		MS-8	Near Vadinar Jetty

The map depicting the locations of Marine Sediment sampling at Kandla and Vadinar have been mentioned in **Map 18 and 19** as follows:



Map 18: Location of Marine Sediment Monitoring at Kandla



Map 19: Locations 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 33** as follows:

Table 33: 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 SO ⁴⁻	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	
12.	Potassium	mg/Kg	Methods Manual Soil Testing in India January, 2011	Flame Photometer
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 during the monitoring period has been summarized in the **Table 34**.

Table 34: Summarized result 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/ ha	4.41	10.27	22.43	8.63	15.6	14.5	3.16	2.17
2.	Phosphate	mg/Kg	1055.2	1862.2	1586.7	653.7	816.3	667.1	203.5	247.4
3.	Organic Matter	%	0.81	0.31	0.27	0.51	0.73	0.33	0.65	0.87
4.	Sulphate as SO ⁴⁻	mg/Kg	190.09	170.70	210.19	155.27	92.28	101.26	84.17	115.9
5.	Calcium as Ca	mg/Kg	2165.50	2439.90	1890.90	2947.40	1693.10	2368.70	2427.7	2389.6
6.	Magnesium as Mg	mg/Kg	1584.50	1725.00	1826.00	1623.00	1421.10	1089.30	1198.2	1478
7.	Silica	g/Kg	582.9	476.3	421.3	291.71	236.4	325.63	290.1	408.3
8.	Nitrite	mg/Kg	0.32	0.64	0.39	0.41	0.49	0.59	0.16	0.3
9.	Nitrate	mg/Kg	21.48	18.36	29.31	23.63	14.51	16.13	13.2	7.96
10.	Sodium	mg/Kg	3514	2453	2619	3219	3442	2916	6136	8643
11.	Potassium	mg/Kg	2084	1967.9	2819	3071.2	2741	2613.7	2938	2481
12.	Copper	mg/Kg	2283.3	1826.7	1278.5	2379.5	1628.3	1347.8	1493.78	1681.39
13.	Aluminium	mg/Kg	49.51	38.7	36.83	49.1	47.2	51.3	53.6	29.7
14.	Chromium	mg/Kg	3.11	3.57	4.07	3.91	4.97	5.27	4.58	3.78
15.	Nickel	mg/Kg	43.35	38.9	21.47	28.11	22.64	24.39	14.79	26.87
16.	Zinc	mg/Kg	61.16	54.6	49.3	47.7	51.26	40.65	23.68	42.96
17.	Cadmium	mg/Kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
18.	Lead	mg/Kg	4.97	5.02	3.84	5.11	4.76	4.26	4.76	5.22
19.	Arsenic	mg/Kg	4.47	2.55	5.2	3.63	2.98	3.21	2.83	3.42
20.	Mercury	mg/Kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
21.	Texture	-	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Loam

11.3 Data Interpretation and Conclusion

The Marine sediment quality at Kandla and Vadinar has been monitored for various physico-chemical parameters during the monitoring 2024. The detailed interpretation of the parameters is given below:

- **Inorganic Phosphate** for the sampling period was observed in range of **4.41 to 22.43** Kg/ha for Kandla. Whereas for Vadinar the value observed at location MS-7 (Nakti creek) is 3.16 Kg/ha and MS-8 (Near Vadinar Jetty) is 2.17 Kg/ha. For Kandla and Vadinar the average value of Inorganic Phosphate was observed 12.64 and 2.66 Kg/ha respectively.
- The concentration of **Phosphate** was observed in range of **653.7 to 1862.2 mg/Kg** for Kandla and for Vadinar the value observed at location MS-7 (Nakti creek) as 203.5 mg/Kg and MS-8 (Near Vadinar Jetty) as 247.4 mg/Kg. For Kandla and Vadinar the average concentration of Phosphate was observed 1106.86 and 225.45 mg/Kg respectively.

- The **Organic Matter** for the sampling period was observed in the range of **0.27 to 0.81 %** for Kandla with the average value of 0.49% and for Vadinar the value recorded at location MS-7 and MS-8 was observed 0.65% & 0.87% respectively, with average concentration as 0.76 %.
- The concentration of **Sulphate** was observed in the range of **92.28 to 210.19 mg/Kg** for Kandla and for Vadinar the value observed at MS-7 is 84.17 mg/Kg and at MS-8 is 115.9 mg/Kg. For Kandla and Vadinar the average value of Sulphate was observed 153.29 and 100.03 mg/Kg respectively.
- The value of **Calcium** was observed in the range of **1693.1 to 2947.4 mg/Kg** for Kandla and for Vadinar the value observed at MS-7 is 2427.7 mg/Kg and at MS-8, is 2389.65 mg/Kg. The average value of Calcium for the monitoring period was observed 2250.91 mg/Kg and 2408.65 mg/Kg at Kandla and Vadinar, respectively.
- The value of **Magnesium** for the sampling period was observed in the range of **1089.3 to 1826 mg/Kg** for Kandla and for Vadinar the value observed at MS-7 is 1198.2 mg/Kg and at MS-8, is 1478 mg/Kg. For Kandla and Vadinar the average value of Magnesium was observed 1544.81 mg/Kg and 1338.1 mg/Kg respectively.
- For the sampling period **Silica** was observed in the range of **236.4 to 582.9 mg/Kg** for Kandla with average value 389.04 mg/Kg and for Vadinar the value observed to be 290.1 and 408.3 mg/Kg at MS-7 and MS-8, respectively with average 349.2 mg/Kg.
- The value of **Nitrate** was observed in the range of **14.51 to 29.31 mg/Kg** for Kandla with average value 20.57 mg/Kg and for Vadinar the value observed to be 13.2 and 7.96 mg/Kg at MS-7 and MS-8, respectively with average 10.58 mg/Kg.
- The value of **Nitrite** was observed in the range of **0.32 to 0.64 mg/Kg** for Kandla with average value 0.47 mg/Kg and for Vadinar the value observed to be 0.16 and 0.30 mg/Kg at MS-7 and MS-8, respectively with average 0.23 mg/Kg.
- The value of **Sodium** was observed in the range of **2453 to 3514 mg/Kg** for Kandla with average value 3027.16 mg/Kg and for Vadinar the value observed to be 6136 and 8643 mg/Kg at MS-7 and MS-8, respectively with average 7389.5 mg/Kg.
- The value of **Potassium** was observed in the range of **1967.9 to 3071.2 mg/Kg** for Kandla with average value 2549.46 mg/Kg and for Vadinar the value observed to be 2938 and 2481 mg/Kg at MS-7 and MS-8, respectively with average 2709.5 mg/Kg.
- The value of **Aluminium**, was observed in the range of **1278.5 to 2379.5 mg/Kg** for Kandla with average value 1790.68 mg/Kg and for Vadinar the value observed to be 1493.78 and 1681.39 mg/Kg at MS-7 and MS-8, respectively with average 1587.58 mg/Kg.
- The value of **Mercury** was observed “Below the Quantification Limit” at all the eight-monitoring location of Kandla and Vadinar.
- Texture was observed to be “**Sandy Loam**” at location MS-1, MS-2, MS-3, MS-4, MS-5, MS-6 in Kandla. “**Sandy Loam**” at location MS-7 & “**loam**” at location MS-8 in Vadinar during sampling period.

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 35**.

Table 35: 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)

Table 36: Comparison of Heavy metals with Standard value in Marine Sediment

Sr. No.	Parameters	Unit	Kandla						Vadinar	
			MS-1	MS-2	MS-3	MS-4	MS-5	MS-6	MS-7	MS-8
1.	Arsenic	mg/Kg	4.47	2.55	5.2	3.63	2.98	3.21	2.83	3.42
2.	Copper	mg/Kg	3.11	3.57	4.07	3.91	4.97	5.27	4.58	3.78
3.	Chromium	mg/Kg	49.51	38.7	36.83	49.1	47.2	51.3	53.6	29.7
4.	Nickel	mg/Kg	43.35	38.9	21.47	28.11	22.64	24.39	14.79	26.87
5.	Lead	mg/Kg	4.97	5.02	3.84	5.11	4.76	4.26	4.76	5.22
6.	Zinc	mg/Kg	72.65	61.16	54.6	49.3	47.7	51.26	23.68	42.96
7.	Cadmium	mg/Kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL

- **Arsenic** was observed in the range of **2.55 to 5.20 mg/Kg** for Kandla with average value 3.67 mg/Kg and for Vadinar the value observed to be 2.83 and 3.42 mg/Kg at MS-7 and MS-8, respectively with average 3.12 mg/Kg. With reference to the guidelines mentioned in table 35, the sediment quality with respect to arsenic falls in moderately polluted class.
- **Copper** was observed in the range of **3.11 to 5.27 mg/Kg** for Kandla with average value 4.15 mg/Kg and for Vadinar the value observed to be 4.58 and 3.78 mg/Kg at MS-7 and MS-8, respectively with average 4.18 mg/Kg. With reference to the guidelines mentioned in table 35, the sediment quality with respect to copper falls in non-polluted class.
- **Chromium** was observed in the range of **36.83 to 51.3 mg/Kg** for Kandla with average Value 45.44 mg/Kg and for Vadinar the value observed to be 53.6 and 29.7 mg/Kg at MS-7 and MS-8, respectively with average 41.65 mg/Kg. With reference to the guidelines mentioned in table 35, the sediment quality with respect to chromium falls in moderately polluted class.

- **Nickel** was observed in the range of **21.47 to 43.35 mg/Kg** for Kandla with average value 29.81 mg/Kg and for Vadinar the value observed to be 14.79 and 26.87 mg/Kg at MS-7 and MS-8, respectively with average 20.83 mg/Kg. With reference to the guidelines mentioned in table 35, the sediment quality with respect to nickel falls in moderately polluted class.
- **Lead** was observed in the range of **3.84 to 5.11 mg/Kg** for Kandla with average value 4.66 mg/Kg and for Vadinar the value observed to be 4.76 and 5.22 mg/Kg at MS-7 and MS-8, respectively with average 4.99 mg/Kg. With reference to the guidelines mentioned in table 35, the sediment quality with respect to lead falls in Not polluted class.
- **Zinc** was observed in the range of **40.65 to 61.16 mg/Kg** for Kandla with average value 50.77 mg/Kg and for Vadinar the value observed to be 23.68 and 42.96 mg/Kg at MS-7 and MS-8, respectively with average 33.32 mg/Kg. With reference to the guidelines mentioned in table 35, the sediment quality with respect to zinc falls in non-polluted class.
- **Cadmium** was observed BQL for all locations at Kandla and Vadinar during sampling period. With reference to the guidelines mentioned in table 35, the sediment quality with respect to cadmium falls in non-polluted class.

Analysis of the sediments indicates moderate 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.

The presence of anthropic activity in the coastal areas has an effect upon the marine water and sediment. One of the primary risks associated with contaminated sediments is bioaccumulation in benthic organisms, which is a route of entry into the food chain. Generally adopted sediment remediation approaches include dredging, capping of contaminated areas, and monitored natural recovery (MNR). Dredging can remove contaminated sediments, but it requires large areas of land for sediment disposal. It is expensive and may cause secondary contamination of the water column during re-suspension. MNR relies on ongoing naturally occurring processes to decrease the bioavailability or toxicity of contaminants in sediment. These processes may include physical, biological, and chemical mechanisms that act together to reduce the environmental risks posed by contaminated sediments. MNR require longer monitoring time and can be even more expensive than for dredging and capping. Capping consists of in situ covering of clean or suitable isolating material over contaminated sediments layer to limit leaching of contaminants, and to minimize their re-suspension and transport. Hence appropriate remedial measures for the polluted sediment sites may be implemented, to reduce the concentration of the heavy metals.



CHAPTER 12: MARINE ECOLOGY MONITORING

12.1 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 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 37** as follows:

Table 37: 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 20 and 21** as follows:



Map 20: Locations of Marine Ecological Monitoring at Kandla



Map 21: Locations of Marine Ecological Monitoring at Vadinar

The various parameters to be monitored under the study for Marine Ecological Monitoring are mentioned in **Table 38** as follows:

Table 38: 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

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 Estimation**

Phytoplankton 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 Estimation**

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.

- **Benthic Organisms Estimation**

Benthic macroinvertebrates are small aquatic animals and the aquatic larval stages of insects. They include dragonfly and stonefly larvae, snails, worms, and beetles. Use of benthic macroinvertebrates has been in vogue as indicator organisms for water quality monitoring since long. Traditional methods of water quality monitoring incorporates mostly monitoring of physicochemical parameters. Benthic macroinvertebrates are

majorly insects that dwell on the floor of water bodies. They are found in all water bodies, as they have a wide range of pollution tolerance among various species. The benthic macro-invertebrate's community structure depends on the exposure to pollution it receives. Benthic macroinvertebrates have been used as indicator organisms to measure the water quality of water bodies across the world. Evaluating the abundance and variety of benthic macroinvertebrates in a waterbody gives us an indication of the biological condition of that waterbody. Generally, waterbodies in healthy biological condition support a wide variety and high number of macroinvertebrate taxa, including many that are intolerant of pollution. Samples yielding only pollution-tolerant species or very little diversity or abundance may indicate a less healthy waterbody. Biological condition is the most comprehensive indicator of waterbody health. When the biology of a waterbody is healthy, the chemical and physical components of the waterbody are also typically in good condition.

- **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.

1. **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, \sum = Summation symbol,

p_i = 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.

2. **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:

$$D = 1 - \sum (p_i^2)$$

Where, \sum = Summation symbol, p_i = Relative abundance of the species

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:

$$D_{Mg} = \frac{S-1}{\ln N}$$

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:

$$d = \frac{N_{max}}{\sum N_i}$$

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. 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

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.

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

The basic idea of 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.

12.2 Result and Discussion

The details of Marine Ecological Monitoring conducted for the locations of Kandla and Vadinar during the monitoring period has been summarized in the **Table 39**.

Table 39: Values of Biomass, Net Primary Productivity (NPP), Gross Primary Productivity (GPP), Pheophytin and Chlorophyll for Kandla and Vadinar

Sr. No.	Parameters	Unit	Kandla						Vadinar	
			ME-1	ME-2	ME-3	ME-4	ME-5	ME-6	ME-7	ME-8
1.	Biomass	mg/L	121	76	65	116	98	94	86	125
2.	Net Primary Productivity	mg/L/hr	BQL	BQL	BQL	BQL	0.91	BQL	BQL	BQL
3.	Gross Primary Productivity	mg/L/hr	1.12	0.79	1.21	1.63	1.18	0.69	0.88	1.23
4.	Pheophytin	mg/m ³	BQL	BQL	0.75	1.25	1.33	0.51	1.2	1.31
5.	Chlorophyll-a	mg/m ³	0.69	0.96	1.52	1.26	1.55	1.19	1.77	1.43
6.	Particulate Oxidisable Organic Carbon	mg/L	0.86	1.11	0.69	0.79	1.28	0.89	0.7	0.78
7.	Secchi Depth	ft	0.58	0.70	0.54	0.44	0.49	0.76	1.17	1.24

- Biomass:**

With reference to the **Table 39**, the concentration of **Biomass** reported from location ME-1 to ME-6 in range between **65-121 mg/L** where lowest biomass presents in ME-3 (Near Coal Berth) and highest biomass present in ME-1 (Near Passenger Jetty One) during sampling period. In Vadinar, the value of biomass was observed **86 mg/L** at ME-7 (Near SPM) and **125 mg/L** in ME-8 (Near Vadinar Jetty) monitoring station.

- 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 location of Kandla reported GPP value in range between **0.69 to 1.63 mg/L/48 Hr** where the highest value recorded for ME-4 (Khor Creek) and lowest recorded at ME-6(Nakti creek (near NH-8A)). In Vadinar, the value of **GPP** was observed **0.88** at ME-7 (Near SPM) and **1.23** at ME-8 (Near Vadinar Jetty) monitoring station.

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 recorded in as **BQL (Below Quantification Limit)**. While in Vadinar, the value of **NPP** was observed **BQL (Below Quantification Limit)**. at ME-7 (Near SPM) and ME-8 (Near Vadinar Jetty) monitoring station.

- Pheophytin**

The level of Pheophytin was detected in the range from **0.51 to 1.33 mg/m³** where the highest value observed at ME-5 (Nakti Creek (near Tuna Port)) and the lowest value observed at ME-6 (Nakti Creek (near NH - 8A)). While in Vadinar, the value of Pheophytin was observed **1.20 mg/m³** at ME-7 and **1.31 mg/m³** at ME-8 monitoring station.

- **Chlorophyll-a**

In the sub surface water, the value of Chlorophyll-a reported in range from **0.69 to 1.55 mg/m³**. The highest value observed at ME-5 (Nakti creek (near KPT Colony)) while the lowest value observed at ME-1 (Near Passenger Jetty One). In Vadinar, the value of chlorophyll-a was observed **1.77 mg/m³** at ME-7 (Near SPM) and **1.43 mg/m³** in ME-8 (Near Vadinar Jetty) monitoring station.

- **Particulate Oxidisable Organic Carbon**

During the sampling period, the particulate oxidisable organic carbon falls within the range of **0.69 to 1.28 mg/L** from monitoring location ME-1 to ME-6 at Kandla, whereas for Vadinar, the value of POC observed **0.70 mg/L** at ME-7 (Near SPM) and **0.78 mg/L** in ME-8 (Near Vadinar Jetty) monitoring station.

- **Secchi Depth**

In monitoring station of Kandla (ME-1 to ME-6) the level of Secchi Depth was observed between **0.44 to 0.76 ft** whereas at Vadinar, the value recorded at ME-7 i.e. Near SPM is **1.17 ft** and in Near Vadinar Jetty is **1.24 ft**.

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 during the study period. 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 40**.

Table 40: 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
<i>Bacillaria sp.</i>	212	-	-	202	-	436	-	187
<i>Biddulphia sp.</i>	-	315	235	137	118	-	268	159
<i>Chaetoceros sp.</i>	317	166	-	-	-	561	186	-
<i>Chlamydomonas sp.</i>	185	-	188	-	298	-	-	319
<i>Cyclotella sp.</i>	126	468	-	266	125	-	408	107
<i>Coscinodiscus sp.</i>	-	-	426	-	-	286	-	160
<i>Ditylum sp</i>	-	225	-	271	-	-	270	-
<i>Fragilaria sp.</i>	486	174	142	158	210	153	-	181
<i>Bacteriastrium sp.</i>	252	-	-	-	119	146	161	-
<i>Pleurosigma sp.</i>	-	-	308	-	-	-	125	212
<i>Navicula sp.</i>	147	-	-	147	374	252	-	183
<i>Merismopedia sp.</i>	-	156	177	-	-	-	-	-
<i>Synedra sp.</i>	-	-	-	-	-	-	232	-
<i>Skeletonema sp.</i>	239	-	-	256	415	118	-	329
<i>Oscillatoria sp.</i>	-	201	355	-	-	-	178	-
<i>Thalassiosira</i>	187	-	158	-	175	123	163	280
<i>Gomphonema sp.</i>	-	345	-	178	-	-	135	-
Density-Units/L	2151	2050	1989	1615	1834	2075	2126	2117
No. of genera	9	8	8	8	8	8	10	10

The phytoplankton community of the sub surface water in the Kandla and Vadinar was represented by, Diatoms, green algae and filamentous Cynobacteria. Diatoms were represented by 15 genera; green algae were represented by 1 genera and filamentous Cynobacteria were represented by 1 genera during the sampling period.

The density of phytoplankton of the sampling stations from ME-1 to ME-6 (Kandla) varying from **1615 to 2151 units/L**, while for Vadinar its density of phytoplankton observed **2126 units/L at ME-7 and 2117 units/L at ME-8**. During the sampling, phytoplankton communities were dominated, *Cyclotella sp*, *Fragilaria sp*, *Navicula sp* & *Thalassiosira* in Kandla, while *Cyclotella sp.* in Vadinar

The details of Species richness Index and Diversity Index in Phytoplankton is mentioned in **Table 41**.

Table 41: 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	9	8	8	8	8	8	10	10
Individuals	2151	2050	1989	1615	1834	2075	2126	2117
Shannon diversity	2.11	1.96	1.93	1.75	1.81	1.89	2.22	2.23
Simpson 1-D	0.87	0.86	0.86	0.87	0.85	0.83	0.89	0.89
Species Evenness	0.96	0.94	0.93	0.84	0.87	0.91	0.96	0.97
Margalef richness	1.04	0.92	0.92	0.95	0.93	0.92	1.17	1.18
Berger-Parker	0.23	0.23	0.21	0.17	0.23	0.27	0.19	0.16
Relative abundance	0.42	0.39	0.40	0.50	0.44	0.39	0.47	0.47

- **Shannon- Wiener's Index (H)** of phytoplankton communities was in the range of **1.75 to 2.11** between selected sampling stations from ME-1 to ME-6 with an average value of **1.91** at Kandla creek and its nearby creeks. While for Vadinar, Shannon Wiener's index of phytoplankton communities recorded to be **2.22** at location ME-7 and **2.23** at ME-8 with an average value of **2.23**. The apportionment of the numbers of individuals among the species observed higher stability at all monitoring location of Kandla.
- **Simpson diversity index (1-D)** of phytoplankton communities was ranged between **0.83 to 0.87** at all sampling stations in the Kandla creek and nearby creeks, with an average of **0.86**. Similarly, for Vadinar Simpson diversity index (1-D) of phytoplankton communities was **0.89** at location ME-7 and **0.89** at ME-8 with an average of **0.89**.
- **Margalef's diversity index (Species Richness)** of phytoplankton communities in Kandla and nearby creeks sampling stations was varying from **0.92 to 1.04** with an average of **0.95** during the sampling period. While for Vadinar, Margalef's diversity index (Species Richness) of phytoplankton communities observed **1.17** at ME-7 and **1.18** at ME-8 with an average value of **1.18**.
- **Berger-Parker Index (d)** of phytoplankton communities was in the range of **0.17 to 0.27** between selected sampling stations from ME-1 to ME-6 with an average value of **0.22** at Kandla creek and nearby creeks. Berger-Parker Index (d) of phytoplankton communities in the sampling stations of Vadinar, was in the range of **0.19 to 0.16** with an average value of **0.18**. All the monitoring station signifies a low diversity with an even distribution among the different species.
- The **Species Evenness** is observed in the range of **0.84 to 0.96** for all the six-monitoring station of Kandla and for the Vadinar the species evenness is observed **0.96** at location ME-7 & **0.97** at ME-8 location.
- During the sampling period, **Relative Abundance** of phytoplankton communities was in range of **0.39 to 0.50** between selected sampling stations from ME-1 to ME-6 with an average value of **0.42** at Kandla creek and nearby creeks. Whereas for Vadinar the Index value **0.47** at ME-7 and **0.47** at ME-8 with an average value **0.47**, thus it is concluded that the studied species can be stated as neither highly dominant nor rare.

The details of variation in abundance and diversity in zooplankton communities is mentioned in **Table 42**.

Table 42: 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
<i>Acartia sp.</i>	-	1	1	1	-	2	2	-
<i>Acrocalanus</i>	1	-	1	-	1	-	2	-
<i>Amoeba</i>	-	1	1	2	-	1	1	2
<i>Brachionus sp.</i>	2	1	-	-	1	2	-	1
<i>Calanus sp.</i>	2	1	1	2	2	-	-	-
<i>Cladocera sp.</i>	1	-	-	-	-	-	1	-
<i>Cyclopoid sp.</i>	-	1	3	2	1	1	1	3
<i>Copepod larvae</i>	1	2	-	1	-	1	1	1
<i>Diaptomus sp.</i>	-	-	1	-	2	-	1	-
<i>Eucalanus sp.</i>	2	1	-	1	-	1	-	2
<i>Mysis sp.</i>	-	-	2	-	1	-	-	1
<i>Paracalanus sp.</i>	1	1	-	-	-	1	1	1
Density Unit/L	10	9	10	9	8	9	10	11
No. of genera	7	8	7	6	6	7	8	7

A total of 12 groups/taxa of zooplankton were recorded in Kandla and Vadinar during the study period which mainly constituted by *Mysis*, *brachionus*, *Calanus*, fish and shrimp larval forms. *Cladocera*, *Mysis* and *Paracalanus* 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 **8 to 10 units/L**, while for Vadinar its density of zooplankton observed **10 units/L at ME-7** and **11 units/L at ME-8**. During the sampling, zooplankton communities were dominated by *Cyclopoid sp*, *Calanus sp*, *Amoeba* in Kandla, while *Cyclopoid sp* and *Calanus sp* had the largest representation at monitoring location of Vadinar.

The details of Species richness Index and Diversity Index in Zooplankton communities is mentioned in **Table 43**.

Table 43: 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	7	8	7	6	6	7	8	7
Individuals	10	9	10	9	8	9	10	11
Shannon diversity	1.89	1.93	1.83	1.66	1.56	1.8	2.03	1.93
Simpson (1-D)	0.93	0.97	0.91	0.92	0.93	0.94	0.96	0.91
Species Evenness	0.97	0.93	0.94	0.93	0.87	0.93	0.98	0.99
Margalef	2.61	3.19	2.61	2.28	2.4	2.73	3.04	2.5
Berger-Parker	0.2	0.22	0.3	0.22	0.25	0.22	0.2	0.27
Relative abundance	70	88.89	70	66.67	75	77.78	80	63.64

- **Shannon- Wiener's Index (H)** of zooplankton communities was in the range of **1.56 to 1.93** between selected sampling stations from ME-1 to ME-6 with an average value of **1.77** at Kandla creek and its nearby creeks. While for Vadinar, Shannon Wiener's index of zooplankton communities recorded to be **2.03** at ME-7 and **1.93** at ME-8 with an average

value of **1.98**. The apportionment of the numbers of individuals among the species observed higher stability at all monitoring location of Kandla and Near SPM (Vadinar).

- **Simpson diversity index (1-D)** of zooplankton communities was ranged between **0.91 to 0.97** at all sampling stations in the Kandla creek and nearby creeks, with an average of **0.93** Similarly, for Vadinar Simpson diversity index (1-D) of zooplankton communities was **0.96** at ME-7 and **0.91** at ME-8 with an average of **0.93**.
- **Margalef's diversity index** (Species Richness) of zooplankton communities in Kandla and nearby creeks sampling stations was varying from **2.28 to 3.19** with an average of **2.63** during the sampling period. While for Vadinar, Margalef's diversity index (Species Richness) of zooplankton communities observed **3.04** at ME-7 and **2.50** at ME-8 with an average value of **2.77**.
- **Berger-Parker Index (d)** of zooplankton communities was in the range of **0.20 to 0.30** between selected sampling stations from ME-1 to ME-6 with an average value of **0.23** at Kandla creek and nearby creeks. Berger-Parker Index (d) of zooplankton communities in the sampling stations of Vadinar, was observed **0.20** at ME-7 and **0.27** at ME-8 with an average value of **0.23**. All the monitoring station signifies a low diversity with an even distribution among the different species.
- The **Species Evenness** is observed in the range of **0.87 to 0.97** for all the six-monitoring station of Kandla whereas, for the Vadinar the species evenness was observed **0.98** at ME-7 and **0.99** at ME-8 the locations, during the monitoring month.
- During the sampling period, **Relative Abundance** of zooplankton communities was in range of **66.67 to 88.89** between selected sampling stations from ME-1 to ME-6 with an average value of **74.72** at Kandla creek and nearby creeks. Whereas for Vadinar the Index value **80** at ME-7 and **63.64** at ME-8 with an average value **71.82**, thus it can be concluded that the studied species is stated as neither highly dominant nor rare.

The details of variation in abundance and diversity in **Benthic organism** is mentioned in **Table 44**.

Table 44: Benthic Fauna variations in abundance and diversity in sub surface sampling

Family/Class	ME-1	ME-2	ME-3	ME-4	ME-5	ME-6	ME-7	ME-8
Thiaridae	-	1	1	-	-	-	-	1
Mollusca	1	-	-	1	1	-	1	-
Odonata	2	2	2	-	-	2	1	1
Lymnidae	1	1	1	-	2	1	-	-
Planorbidae	-	-	-	1	-	-	-	2
Talitridae	-	1	-	1	2	-	1	1
Trochidae	1	-	1	-	-	1	-	-

Family/Class	ME-1	ME-2	ME-3	ME-4	ME-5	ME-6	ME-7	ME-8
Atydae	1		1	2	-	-	1	1
Gammaridae	-	1	-	-	1	2	2	-
Portunidae	1	-	-	2	1	1	1	-
Turbinidae	1	1	-	-	-	-	-	-
Palaemonidae	-	-	-	-	-	-	-	-
Density-Units/l	8	7	6	7	7	7	7	6
No of Class	7	6	5	5	5	6	6	5

Few Benthic organisms were observed in the collected sample by using the Van-Veen grabs during the sampling conducted for DPA Kandla and Vadinar. Majority of the species were found under the Macro-benthic organisms during the sampling period were represented by *Odonta*, Lymnidae, etc. The No. of Family of benthic fauna was varying from 6 to 8. The dominating benthic communities at Near Passenger Jetty One were represented Talitridae, Atydae. While lowest number of benthic species was represented by Palaemonidae.

The details of Species richness Index and Diversity Index in Benthic Organisms is mentioned in **Table 45**.

Table 45: Species richness Index and Diversity Index in Benthic Organisms

Indices	ME-1	ME-2	ME-3	ME-4	ME-5	ME-6	ME-7	ME-8
Taxa S	7	6	5	5	5	5	6	5
Individuals	8	7	6	7	7	7	7	6
Shannon diversity	1.91	1.65	1.39	1.47	1.47	1.47	1.65	1.39
Simpson 1-D	0.96	0.95	0.93	0.95	0.9	0.9	0.95	0.93
Species Evenness	0.98	0.92	0.86	0.91	0.91	0.91	0.92	0.86
Margalef	2.89	2.57	2.23	2.06	2.06	2.06	2.57	2.23
Berger-Parker	0.25	0.29	0.33	0.29	0.29	0.29	0.29	0.33
Relative abundance	87.5	85.71	83.33	71.43	71.43	71.43	85.71	83.33

- **Shannon- Wiener's Index (H)** of benthic organism was in the range of **1.39 to 1.91** between selected sampling stations from ME-1 to ME-6 with an average value of **1.56** at Kandla creek and its nearby creeks. While for Vadinar, Shannon Wiener's index of benthic organism recorded to be **1.65** at ME-7 & **1.39** at ME-8 location with an average value of **1.52**. The apportionment of the numbers of individuals among the species observed higher stability at all monitoring location of Kandla and Vadinar.
- **Simpson diversity index (1-D)** of benthic organism was ranged between **0.90 to 0.96** at all sampling stations in the Kandla creek and nearby creeks, with an average of **0.93**. Similarly, for Vadinar Simpson diversity index (1-D) of benthic organism was **0.95** at ME-7 and **0.93** at ME-8 location with an average of **0.94**.
- **Margalef's diversity index (Species Richness)** of benthic organism in Kandla and nearby creeks sampling stations was varying from **2.06 to 2.89** with an average of **2.31** during the sampling period. While for Vadinar, Margalef's diversity index (Species Richness) of

benthic organism observed to be **2.57** at ME-7 and **2.23** at ME-8 location with an average of **2.4**.

- **Berger-Parker Index (d)** of benthic organism was in the range of **0.25 to 0.33** between selected sampling stations from ME-1 to ME-6 with an average value of **0.29** at Kandla creek and nearby creeks. Berger-Parker Index (d) of benthic organism in the sampling stations of Vadinar, was observed to be **0.29** at ME-7 and **0.33** at ME-8 location with an average value of **0.31**. All the monitoring station signifies a low diversity with an even distribution among the different species.
- The **Species Evenness** is observed in the range of **0.86 to 0.98** for all the six-monitoring station of Kandla and for the Vadinar the species evenness is observed in the range of **0.86 to 0.92** at both of the location.
- During the sampling period, **Relative Abundance** of Benthic organisms was **71.43 to 87.5** between selected sampling stations from ME-1 to ME-6 with an average value of **78.47** at Kandla creek and nearby creeks. Whereas for Vadinar the Index value **85.71** at ME-7 and **83.33** at ME-8 location, with an average value **84.52**, thus it is concluded that the studied species can be stated as neither highly dominant nor rare.

Annexure 1: Photographs of the Environmental Monitoring conducted at Kandla

STP Monitoring



Noise Monitoring



Soil Monitoring



Marine Monitoring



Air Monitoring



Drinking Water Monitoring



Annexure 2: Photographs of the Environmental Monitoring conducted at Vadinar

Air Monitoring



Noise Monitoring



STP Monitoring



Drinking water Monitoring



Marine Monitoring



Soil 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

Head Office

Plot No. B 246 & 247, G.I.D.C. Electronic Estate,
Sector-25, Gandhinagar-382024

Laboratory

Plot No. B-64, G.I.D.C. Electronic Estate,
Opp. I.P.R., Sector-25, Gandhinagar-382025

Tel: (+91) 79-23240964 (O), T: (+91) 79-23287758 (Lab), F: (+91) 79-23240965

E-mail: info-gemi@gujarat.gov.in | Website: www.gemi.gujarat.gov.in

"We Provide Environmental Solutions"

Annexure -F

Subject: Compliance of mitigation measures suggested in EIA report of the project “**Development of 3 Remaining Integrated Facilities (stage I) within the existing Deendayal Port Authority (Erstwhile: Kandla Port Trust) at Gandhidham, Kutch, Gujarat**”.

Reference: Specific Condition no. XXXII of Environmental and CRZ Clearance granted by MoEF&CC, GoI vide letter vide file no. 10-9/2017-IA-III dated 18/2/2020.

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

S. No.	Particulars	Location	Quantification	Proposed Measures	Compliance
2	Generation Noise	Along proposed projects	Not quantified	<p>Restricted operation in the night time</p> <p>Selection of machinery generating noise less than 72 db(A) Fitting on noise attenuation devices</p>	<p>DPA has issued Circular No. TF/SH/Circulars/2022/1341 dated 04/11/2022 considering the safety norms provided for smooth and continuous operation.</p> <p>For monitoring of environmental parameters, DPA has been appointing NABL Accredited laboratory and reports are being submitted from time to time to the GPCB, IRO, MoEF&CC, GoI, Gandhinagar. Recently, DPA appointed GEMI, Gandhinagar for regular monitoring of environmental parameters vide Work Order dated 15/02/2023. The work is in progress and the latest environmental monitoring report submitted by GEMI, Gandhinagar is enclosed with the EC compliance.</p> <p>Further, routine maintenance is being carried out to keep check on the efficiency and noise.</p>
Soil & Geology					
3	Soil erosion	Applicable to the proposed projects	Not quantified; initiates a chain of impacts	<p>Water bars; stabilization of slopes</p> <p>Controlled discharge of water</p> <p>Conducting construction</p>	<p>Topography at the site location is generally flat with average ground level of about 6.5 m CD with marshy topsoil. Kindly refer Section 3.4.1 Topography of the EIA report.</p> <p>Point noted</p>

S. No.	Particulars	Location	Quantification	Proposed Measures	Compliance
				activities in non-monsoon season Oil spill prevention measures	The area falls under arid/semi-arid region; thus the rainfall is very scanty. DPA has Oil Spill Contingency Plan in place. Copy of the same has been communicated with the last compliance report submitted..
Hydrology					
4	Surface water contamination	At the proposed projects Soil erosion prone area	Not quantified	Soil erosion control measures	For mitigating soil erosion, DPA entrusted work of green belt development in and around the Port area to the Forest Department, Gujarat at Rs. 352 lakhs (Area 32 hectares) and the work is already completed. DPA has undertaken Mangrove Plantation in an area of 1600 Hectares since the year 2005. The copy of the details has already been communicated with the earlier compliance reports submitted. For monitoring of environmental parameters, DPA has been appointing NABL Accredited laboratory and reports are being submitted from time to time to the GPCB, IRO, MoEF&CC, GoI, Gandhinagar. Recently, DPA appointed GEMI, Gandhinagar for regular monitoring of environmental parameters vide Work Order dated 15/02/2023. The work is in progress and the latest environmental monitoring report submitted by GEMI, Gandhinagar is

S. No.	Particulars	Location	Quantification	Proposed Measures	Compliance
	Spillage and sanitary wastes			Waste management and spill control	<p>enclosed with the EC compliance.</p> <p>For waste management, companies authorized by State Pollution Control Board (SPCB) have been awarded the work of collection, transporting and disposal of solid waste by the DPA.</p> <p>Further, DPA has assigned M/s Gujarat Environment Management Institute (GEMI) vide letter EG/WK/4751/Waste Management-1/217 dated 24/01/2023 for "Preparation of Plan for Management of Plastic Waste, Solid Waste, C&D Waste, E-waste, Hazardous Waste including Bio-medical Waste and Non-hazardous waste in the Deendayal Port Authority Area". The work is completed and the final report submitted by GEMI, Gandhinagar is enclosed with the EC compliance.</p> <p>DPA has Oil Spill Contingency Plan in place. Copy of the same has been communicated with the last compliance report submitted.</p>
5	Ground water contamination	Not expected			---
Land Use and Aesthetics					
6	Land use and Aesthetics	At project site	Not quantifiable	Contouring of the affected areas	Topography at the site location is generally flat with average ground level of about 6.5 m CD with marshy topsoil. Kindly refer Section 3.4.1 Topography of the EIA

S. No.	Particulars	Location	Quantification	Proposed Measures	Compliance
		At campsites At other utilities like scraper stations		Cleaning the stretch immediately after the construction activities are over Restoration and re-vegetation to the best possible extent	<p>report.</p> <p>DPA has included clause in tender/ Concession agreement for the contractor to undertake Clearance of site on completion and environmental protection measures. Copy of the relevant page of the tender has already been communicated with the last compliance report submitted.</p> <p>DPA entrusted work of green belt development in and around the Port area to the Forest Department, Gujarat at Rs. 352 lakhs (Area 32 hectares) and the work is already completed.</p> <p>Further, DPA has appointed the Gujarat Institute of Desert Ecology (GUIDE) for "Green belt development in Deendayal Port Authority and its Surrounding Areas, Charcoal site' (Phase-I)" vide Work Order No.EG/WK/4757/Part [Greenbelt GUIDE, dated 31st May 2022. The final report submitted by GUIDE, Bhuj is attached with the EC compliance report. Further, DPA assigned work to GUIDE, Bhuj vide work order dated 23/06/2023 for "Green belt development in Deendayal Port Authority and its Surrounding Areas (Phase II) (10000 plants). The work is completed and the final report submitted by GUIDE, Bhuj</p>

S. No.	Particulars	Location	Quantification	Proposed Measures	Compliance
					<p>is enclosed with the EC compliance.</p> <p>DPA has undertaken Mangrove Plantation in an area of 1600 Hectares since the year 2005. The copy of the details has already been communicated with the earlier compliance reports submitted.</p>
Biological Environment: Flora and Vegetation					
7	Due to dusting on floral cover	At project site & approach road	Limited	Sprinkling of water for dust suppression.	<p>–DPA has installed Mist Canon at the Port area to minimize the dust.</p> <p>–Further, to control dust pollution in other area, regular sprinkling through tankers on roads and other staking yards is being done.</p>
8	Removal of vegetation	At project site	Limited	Restoration and re-vegetation and plantation; Compensatory vegetation	<p>DPA entrusted work of green belt development in and around the Port area to the Forest Department, Gujarat at Rs. 352 lakhs (Area 32 hectares) and the work is already completed.</p> <p>Further, DPA has appointed the Gujarat Institute of Desert Ecology (GUIDE) for "Green belt development in Deendayal Port Authority and its Surrounding Areas, Charcoal site' (Phase-I)" vide Work Order No.EG/WK/4757/Part [Greenbelt GUIDE, dated 31st May 2022. The final report submitted by GUIDE, Bhuj is attached with the EC compliance report. Further, DPA assigned work to GUIDE, Bhuj vide work</p>

S. No.	Particulars	Location	Quantification	Proposed Measures	Compliance
					<p>order dated 23/06/2023 for "Green belt development in Deendayal Port Authority and its Surrounding Areas (Phase II) (10000 plants). The work is completed and the final report submitted by GUIDE, Bhuj is enclosed with the EC compliance.</p> <p>DPA has undertaken Mangrove Plantation in an area of 1600 Hectares since the year 2005. The copy of the details has already been communicated with the earlier compliance reports submitted.</p>
9	Due to Piling activity	At project site	Limited	Piling should be done in closed vessels to minimize the impact.	DPA has included clause in tender/ Concession agreement for the contractor to undertake piling installation in accordance with IS 2911. Copy of the relevant page of the tender has already been communicated with the last compliance report submitted.
10	Due to dredging	At project site in Sea	Not quantified	Silt curtain should be used to minimize the impact.	The possibility of providing silt curtains to minimize the impacts while dredging activities in a study for "Comprehensive study for the Deepening of Navigational channel to increase the draught of Navigational channel at Deendayal Port Trust including Capital & Maintenance dredging requirements and Preparation of Technical & Commercial Feasibility Report" has been awarded to IIT, Madras.

S. No.	Particulars	Location	Quantification	Proposed Measures	Compliance
11	Oil spillage & waste disposal from ships	Sea & creeks	Unlimited	Oily wastes and sewage should not be discharged directly; MARPOL norms should be followed.	DPA issued Grant of License/Permission to carry out the work of collection and disposal of "Hazardous Waste/Sludge/ Waste Oil" from Vessels calling at Deendayal Port" through DPA contractors. Further, it is to state that, all ships are required to follow DG Shipping circulars in line with MARPOL norm regarding the reception facilities at Swachh Sagar portal.
12	Fishes & Fishery	In project area	Limited	No legal fishery is in study area, major fish landing site is far from project site.	Since Kandla Port is one of the major port in India and major portion of the study area is occupied by the Kandla port, and other industrial activities, fishing activities are very limited in the study area. Kindly refer Section 3.7.4 Fisheries of the EIA report.
Fauna and Wildlife					
13	Loss of wildlife	No wildlife habitation in proximity	Not applicable	Strictly prohibiting hunting and similar activities Restricting the speed of movement of vehicles	It is a custom bonded area, therefore, no hunting or similar activities are permitted in the port area. In the study area of the KPT no National park, wildlife sanctuary or biosphere reserve is present. Kindly refer Section 3.5.5.4 Occurrence of National Park/Sanctuary/ Biosphere Reserve etc. of the EIA report. DPA has issued Circular No. TF/SH/Circulars/2022/1341 dated 04/11/2022 considering the safety norms provided for smooth and continuous operation.

S. No.	Particulars	Location	Quantification	Proposed Measures	Compliance
				Keeping "trench plugs" at strategic locations Shifting the nests, wherever possible	Point noted There is no considerable habitat of fauna in vicinity of the project site. Kindly refer 3 rd paragraph of Section 4.3.1. Noise generation during Construction Phase of the EIA report.
Socio-Economic and Cultural Environmental					
14	Human habitations affected	No habitation falling within the project site	Not quantified, but critical locations are identified	Villagers in the proximity will kept informed on the project activities	DPA has already given advertisement regarding grant of Environmental & CRZ Clearance in two local newspapers viz. KUTCH MITRA (In Gujarati) dated 23/2/2020 and in the Indian Express (In English) dated 22/02/2020 and also forwarded to the Regional Office, MoEF&CC, Bhopal vide letter dated 27/2/2020.
15	Economic implications	Along the project site	Not quantified. The implications with regard to loss of seasonal crops and plantations are identified	Compensation to the affected people; Employment, wherever possible, to the unskilled local people	The law of land will be followed by the BOT operator. The details of CSR Activities implemented as well as proposed are enclosed with EC compliance report.
16	Agriculture lands	At project site	No agriculture land involved	Restoration of the land; Management of topsoil	No agriculture land is involved. For topsoil management, DPA entrusted work of green belt development in and around the Port area to the Forest Department, Gujarat at Rs. 352 lakhs (Area 32 hectares) and the work is already

S. No.	Particulars	Location	Quantification	Proposed Measures	Compliance
					<p>completed.</p> <p>Further, DPA has appointed the Gujarat Institute of Desert Ecology (GUIDE) for "Green belt development in Deendayal Port Authority and its Surrounding Areas, Charcoal site' (Phase-I)" vide Work Order No.EG/WK/4757/Part [Greenbelt GUIDE, dated 31st May 2022. Copy of the final report submitted by GUIDE, Bhuj is attached with the EC compliance report. Further, DPA assigned work to GUIDE, Bhuj vide work order dated 23/06/2023 for "Green belt development in Deendayal Port Authority and its Surrounding Areas (Phase II) (10000 plants). The work is completed and the final report submitted by GUIDE, Bhuj is enclosed with the EC compliance.</p>
17	Infrastructure	Near human habitations; Road and railway crossings	Not quantified	Rehabilitation of the affected infrastructure components; Leaving behind the infrastructure facilities like approach roads and facilities at the campsites for the local inhabitants	N/A
18	Social conflicts	Surrounding the proposed project.	Not quantifiable	Keeping good relationship with the local people; Keeping them informed on the project and project development.	<p>The details of CSR Activities implemented as well as proposed are enclosed with EC compliance report.</p> <p>DPA has already given advertisement regarding grant of Environmental & CRZ Clearance in two local newspapers viz.</p>

S. No.	Particulars	Location	Quantification	Proposed Measures	Compliance
					KUTCHMITRA (In Gujarati) dated 23/2/2020 and in the Indian Express (In English) dated 22/02/2020 and also forwarded to the Regional Office, MoEF&CC, Bhopal vide letter dated 27/2/2020.
19	Political conflicts	-	Not quantifiable	Keeping the key players informed on the pros and cons of the project.	The key players shall be informed on the pros and cons of the project.
20	Historic and archaeological importance	Surrounding the 15.0 Km. radius from the proposed project.	No structure on the surface possibilities are there of sub-surface structure	Inform the concerned authority in case of coming across any structure of archaeological significance.	Point noted

Annexure -G



DEENDAYAL PORT AUTHORITY
(Erstwhile: 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/4751 (CCA Renewal)/ 92

Date: 19/07/2024

To,
The Member Secretary
Gujarat Pollution Control Board
Paryavaran Bhavan,
Sector 10A, Gandhinagar - 382010

Sub: Submission of Environmental statement in format form V for the financial year 2022-23 reg.
(Detailed Consent Order issued by GPCB vide letter no. GPCB/CCA-Kutch-812/(5)/ID -
28494/581914 dated 22/01/2021 - Consent no. AWH - 110594 & CCA amendment Order - WH-
130995).

- Ref.:** 1) KPT letter no. MR/GN/1527(Part I)/535 dated 16/6/2012
2) KPT letter no. MR/GN/1527(Part I)/2011 dated 20/5/2013
3) KPT letter no. MR/GN/1527(Part I)/337 dated 17/05/2014
4) KPT letter no. MR/GN/1527/ (Part I)/dated 27/04/2015
5) KPT letter no. EG/WK/EMC/CCA (Part II)/218 dated 27/6/2016
6) KPT letter no. EG/WK/EMC/CCA (Part II)/214 dated 19/6/2017
7) DPT letter no. EG/WK/EMC/CCA (Part II)/294 dated 13/6/2018
8) DPT letter no. EG/WK/EMC/CCA (Part II) dated 27/5/2019
9) DPT letter no. EG/WK/4751 (CCA Renewal) dated 22/5/2020
10) DPT letter no. EG/WK/4751 (CCA Renewal)/14 dated (30)04/(4)5/2021
11) DPA letter no. EG/WK/4751 (CCA Renewal)/132 dated 06/07/2022
12) DPA letter no. EG/WK/4751 (CCA Renewal)/326 dated 19/06/2023

Sir,

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

In this connection, it is to state that, the Deendayal Port Authority had obtained Renewal of Consolidated Consent & Authorization from the GPCB vide order no. AWH - 110594 dated 22/01/2021 valid up to 21/07/2025 for Port Area of Deendayal Port Authority and subsequently, the GPCB had issued correction in consent vide order dated 09/04/2021. Afterward, DPA has also obtained amendment in Consent Order from the GPCB vide order dated 11/01/2024 (CCA Amendment - WH-130995) **(Copy attached as Annexure I).**

In this regard, as per statutory requirement, the DPA has regularly submitted Annual Returns (as mentioned in reference above) in format Form V to the GPCB.

Now please find the enclosed herewith Environmental Statement in Form V for the year 2023-24 as **Annexure II.**

This is for kind information and record please.

Encl : As above

Yours faithfully

[Signature]
21/7/24

Dy. Chief Engineer & EMC (I/C)
Deendayal Port Authority



GUJARAT POLLUTION CONTROL BOARD

PARYAVARAN BHAVAN, SECTOR 10-A,

GANDHINAGAR - 382010,

(T) 079-23232152

CCA-Amendment

(WH-130995)

No. PC/CCA-KUTCH- 812(6)/ GPCB ID-28494/

Date: /01/2024

To,

M/s. Kandla Port Trust,

At Kandla, A.O Building Gandhidham,

Tal: Gandhidham,

Dist: Kutch - 370 201.

SUB: Amendment in the consolidated consent & Authorization of the Board.

REF. 1) CCA issued by this office vide order no- **AWH- 110594** dated 22/01/2021 valid up to 21/07/2025.

2) Your CCA Amendment Application Inward ID No.277270 dated 23/05/2023,

In exercise of the power conferred under section-25 of the Water (Prevention and Control of Pollution) Act-1974, under section-21 of the Air (Prevention and Control of Pollution)-1981 and Authorization under rule 8(2) of the Hazardous And Other Waste (Management and Transboundary) Rules, 2016 & framed under the Environment (Protection) Act-1986, The Board has granted CCA vide order No. **AWH- 110594** issued vide order dated 22/01/2021 valid up to 21/07/2025.

The Board has right to review and amend the conditions of the said CCA and its amendment orders. Now, considering your application for CCA amendment inward ID No.277270 dated 23/05/2023, the said CCA order is amended as below:

1. The order shall be read as CCA amendment Order No.: WH- 130995 Date of Issue: 14/12/2023, valid up to 21/07/2025.

SUBJECT TO THE FOLLOWING SPECIFIC CONDITIONS:

1. There shall be no change in existing production and its capacity, raw materials consumption, fuel consumption, flue gas emission & process gas emission. due to CCA Amendment.
2. Industry shall not carry out any activity which may attract the applicability of EIA notification-2006 & its amendment
3. No ground water shall be withdrawal without prior permission from CGWA as per Hon'ble NGT order.
4. Unit shall obtain fresh water from valid source have permission of the competent authority.
5. Industry shall manage Solid Wastes generated from industrial activities as per Solid Waste Management Rules-2016 (solid waste as defined in Rule-3(46)).
6. Industry shall renew Public Liability Insurance Policy time to time & submit a copy of the same to this office.
7. Industry shall comply with circular of the Board dated 27/08/2021 regarding retrofitting of emission control/ equipment in D.G. Set of capacity 125 KVA and above as per system & procedure for emission compliance testing of Retrofit Emission Control Devices (RECD) for D.G. Set issued by CPCB dated 01/02/2022 at the earliest and submit compliance.



2. The condition no. 3 of the said CCA is amended as below:

3. CONDITION UNDER THE WATER ACT:

3.1 Water Source: - GWIL

3.2 There shall be no industrial water consumption & waste water generation from manufacturing process & other ancillary operation.

3.3 The quantity of domestic water consumption shall be decreased from 1300 KL/Day to 3000 KL/Day, due to CCA-Amendment.

3.4 The quantity of domestic waste water shall not exceed 800 KL/Day.

3.5 Sewage shall be treated separately to conform to the following standards as per Hon.ble NGT order in the matter of OA No.1069/2018 dated 30/04/2019

PARAMETERS	GPCB NORMS
pH	5.5-9.0
Biochemical Oxygen Demand (BOD)	10 mg/L
Total suspended solids (TSS)	20 mg/L
Chemical Oxygen Demand (COD)	50 mg/L
Nitrogen -Total	10 mg/L
Phosphorous-Total	1.0 mg/L
(for discharge into Ponds, Lakes)	
Fecal Coliform	Desirable-100 MPN/100ml Permissible -230 MPN/100 ml

3.6 Treated domestic effluent conforming to above standard shall be discharged on land for gardening and plantation purpose within premises.

3.7 Industry shall provide fixed pipeline network with flow meter for even distribution of treated domestic effluent and maintain its record

3.8 Disposal system for storm water shall be provided separately. In no circumstances storm water shall be mixed with the industrial effluent

3. The condition no. 5.1 & 5.2 of the said CCA is amended as below:

5.1 Authorization order no. WH-130995 Date of issue. 14/12/2023.

5.2 **M/s. Kandla Port Trust** is hereby granted an authorization based on the enclosed signed inspection report for generation, collection treatment, storage, transport of hazardous waste on the premises situated at Kandla, A.O Building Gandhidham, Tal: Gandhidham, Dist. Kutch;

Sr. No.	Waste	Quantity per Annum		Schedule & Category	Facility
		Existing	After CCA- Amendment		
1	Used or Spent Oil	1125 MT	4250 MT	I-5.1	Collection, storage, transportation and disposal by selling out to registered recycler



GUJARAT POLLUTION CONTROL BOARD

PARYAVARAN BHAVAN, SECTOR 10-A,

GANDHINAGAR - 382010,

(T) 079-23232152

2.	Residue Containing Oil	3444 43 MT	8500 MT	1-5.2	Collection, storage, transportation and disposal by selling out to registered recycler.
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4. Rest of conditions of Consolidated Consent & Authorization (CC&A) order No: AWH-110594 issued vide this office letter no. GPCB/CCA-KUTCH-812(5)/ID: 28494/581914 dated 22/01/2021 shall remain unchanged and industry shall comply with the same judicially.

For and on behalf of
GUJARAT POLLUTION CONTROL BOARD

(T. C. Patel)
Unit Head

Outward No:781072,11/01/2024

Annexure II

Environmental Statement (Form V)
For Deendayal Port Authority, Kandla
For the FY @ 2023-2024

"FORM-V"
(See rule -14)

From:
Deendayal Port Authority,
Administrative Office Building,
Post Box No.: 50, Gandhidham,
Dist.: Kutch – 370 207. Gujarat State.
Tel No.: O: 02836-220038
Fax No.: 02836-220050

To,
The Member Secretary,
Gujarat Pollution Control Board,
Paryavaran Bhavan, Sector - 10A,
Gandhinagar – 382043

Environmental statement for the financial year ending the 31st March, 2024

"PART-A"

1) Name and Address of the owner/occupier of the industry or process		
➤ NAME	:	Shree V Raveendra Reddy Chief Engineer
➤ ADDRESS	:	Deendayal Port Authority Administrative Office Building, Post Box No.: 50, Gandhidham, Dist.: Kutch – 370 207. Gujarat State. Tel No.: O: 02836-220038 Fax No.: 02836-220050
➤ Industry Category Primary – (STC code) Secondary – (STC code)	:	Major port Authority under the administrative control of Ministry of Ministry of Ports, Shipping and waterways, GOI
➤ Year of Establishment	:	8th April 1955
➤ Date of the last Environment audit report submitted	:	27 th June, 2016

"PART-B"

WATER AND RAW MATERIAL CONSUMPTION

Sr.No.	WATER CONSUMPTION	KLD
1.	Process	1573
2.	Cooling	
3.	Domestic Purpose	
Total water consumption for the period from April 2023 to March 2024 was 574086 KL hence, average water consumption for per day – 1573 KLD		

I. Water Consumption

Sr. No.	Name of Products	Process Water Consumption per unit of products output	
		During the current financial year 2022-23	During the current financial year 2023-24
01.	Dry Cargo Handling	137.5 MT	132.37 MT
02.	Liquid Cargo Handling		
Deendayal Port Authority has only loading & unloading activities for dry cargo and liquid cargo. Hence consumption of process water consumption per unit of output with respective to production is not applicable.			
During FY 2023-24 Total Cargo Handled is 132.37 MMTPA			
However, Details of the Domestic water consumption for the financial year 2023-24 please refer Annexure-A			

II. Raw material Consumption

Sr.No.	Name of Raw Material	Name of Products	Consumption of Raw material per unit of output	
			During the current financial year 2022-23	During the current financial year 2023-24
1.	Deendayal Port Authority has only loading & unloading activities for dry cargo and liquid cargo. Hence consumption of raw material per unit of output with respective to production is not applicable			

"PART-C"

**POLLUTION DISCHARGED TO ENVIRONMENT/UNIT OF OUTPUT
(PARAMETERS AS SPECIFIED IN THE CONSENT)**

Pollutant	Quantity of Pollutant Discharged (mass/day)	Concentration of Pollution in Discharge (mass/volume)	% of Variation from prescribed standard with reasons
Please Refer Annexure -B for Environmental Monitoring Reports of <ul style="list-style-type: none">• Ambient Air Quality Monitoring• Drinking Water Quality Monitoring• Marine Water Monitoring• Noise Level Monitoring			

"PART-D"

**HAZARDOUS WASTE
[AS SPECIFIED UNDER HAZARDOUS WASTE (MANAGEMENT AND HANDLING) RULES -1989 & AMENDMENT RULES -2008]**

Sr.No.	Hazardous Waste	Total Quantity in MT/Year	
		During the current financial year 2022-23	During the current financial year 2023-24
1.	5.1- Used Spent Oil	4578.79	2431.39
2.	5.2- Waste Residue Containing Oil	9157.58	7294.17
<ul style="list-style-type: none">• Details of Hazardous Waste generated during the financial year 2022-23 please refer Annexure-C			
a. From Process: NA			
b. From Pollution Control facility: NA			

"PART-E"
SOLID WASTE

Sr.No.	Solid Waste	Total Quantity in MT/year	
		During the current financial year 2022-23	During the current financial year 2023-24
1.	From Process	Nil	Nil
2.	From pollution Control Facility	Nil	Nil
a.	Quantity Recycled or Reutilized within the unit	Nil	Nil
b.	Sold	Nil	Nil
c.	Disposed Off	2473.19 MT	2572.94
Details of Solid Waste (Non-Hazardous Waste) generated during the financial year 2023-24 please refer Annexure-C			

"PART-F"

PLEASE SPECIFY THE CHARACTERISTICS (IN TERMS OF CONCENTRATION AND QUANTUM) OF HAZARDOUS AS WELL AS SOLID WASTES AND INDICATE DISPOSAL PRACTICE ADOPTED FOR BOTH THESE CATEGORIES OF WASTES.

Hazardous Waste:

Companies authorized by Central Pollution Control Board (CPCB) and State Pollution Control Board (SPCB) have been awarded the work of collection, transporting and disposal of hazardous Waste by the Deendayal Port Authority. The same will be hand over to authorize parties for further Treatment & disposal.

Solid Waste:

Garbage facility is provided as per MARPOL Act 73/78 to the vessel berthed at Deendayal Port Authority. Companies authorized by Central Pollution Control Board (CPCB) and State Pollution Control Board (SPCB) have been awarded the work of collection, transporting and disposal of solid waste by the Deendayal Port Authority. The same will be hand over to authorize parties for further treatment and disposal.

"PART-G"

IMPACT OF THE POLLUTION ABATEMENT MEASURES TAKEN ON CONSERVATION OF NATURAL RESOURCES AND ON THE COST OF PRODUCTION.

DPA has awarded the work of "Preparing and Monitoring of Environmental monitoring and management plan for Deendayal Port Authority Kandla and Vadinar to Gujarat Environment Management Institute (GEMI), Gandhinagar (An autonomous Institute of Government of Gujarat).

Further for Pollution Abatement measures taken for Conservation of Natural Resources DPA appointed renowned agency i.e M/s. GUIDE, Bhuj for the following work.

1. Regular Monitoring of Mangrove Plantation.
2. Preparation of detailed marine Biodiversity management plan for the impact of the project activities as per the requirement of EC & CRZ Clearance accorded by the MoEF&CC, GOI for the project "Creation of water front facilities (Oil jetties 8,9,10,11) and development of land of area 554 acres for associated facilities for storage at old Kandla, Gandhidham, kutch, Gujarat by M/s Deendayal Port Authority"
3. Regular monitoring of marine ecology in and around the Deendayal Port Authority area and continuous monitoring programme covering all season on various aspects of the coastal environ covering physico-chemical parameters of marine sediments samples coupled with biological indices, as per the requirement of EC & CRZ clearance accorded by the MoEF&CC,GOI to the various projects of the Deendayal port Authority.
4. Study on dredged material for presence of contaminant as per EC and CRZ clearance accorded by the MoEF&CC, GOI dated 19/12/2016 – specific condition vii

"PART-H"

ADDITIONAL MEASURES / INVESTMENT PROPOSAL FOR ENVIRONMENTAL PROTECTION INCLUDING ABATEMENT OF POLLUTION, PREVENTION OF POLLUTION

The allocation made under the scheme of "Environmental Services & Clearance there of other related Expenditure" during BE 2024-2025 is Rs. 657 Lakhs

"PART-I"

ANY OTHER PARTICULAR FOR IMPROVING THE QUALITY OF THE ENVIRONMENT

1. DPA is ISO 14001:2015 certified port for "Providing port facility and related maritime services for vessel and Cargo handling including storage
2. DPA has appointed M/s GEMI, Gandhinagar for the work "Making Deendayal Port a Green Port- Intended Sustainable Development under the Green Port Initiatives". M/s GEMI, Gandhinagar had submitted the Final Report on 10/03/2021
3. DPA has accorded the work of Afforestation project in Deendayal Port Area to Forest Department, GoG which includes plantation and maintenance work of 1100 plants per ha.
4. DPA has accorded the work of green belt development in Deendayal port Authority and its Surrounding areas charcoal site to GUIDE for the plantation of 5000 saplings of suitable species.
5. DPA has planted 7500 trees in Deendayal port trust area during the year 2014-15 6000 trees during financial year 2016-17 and the same has been regularly maintained.
6. DPA has planted 4000 trees at A.O building, Gopalpuri residential colony and along the road side at Kandla. Further, approximately 885 no. of trees have been planted since September 2015 onwards.
7. Continuous water sprinkling has been carried out on the top of the heap of coal, at regular intervals to prevent dusting, fire and smoke. DPA already installed sprinkling system inside Cargo Jetty area for coal dust suppression in coal yard (40 Ha. Area) at the cost of Rs. 14.44 crores.
8. DPA has installed Mist Canon at the Port area to minimize the coal dust.
9. Deendayal port Authority (traffic department) issued a Circular (SOP) to the trade with regard to control of dust pollution arising out of coal handling and ensuring safety in coal handling. In case of any violations of SOP, provision of impose of penalty of Rs. 10000/- has been made and if violation is repeated thrice, the same will lead to ban of concerned party into port area. The DPA is taking all the measures to reduce coal dust by implementing the coal handling guidelines through port users.
10. All trucks before leaving the storage yard have been covered with tarpaulin and also trucks are also not over loaded as well as there is no spillage during transportation and there is adequate space for movement of vehicles at the surrounding area.
11. DPA has constantly improving the house keeping in the dry cargo storage yard and nearby approved areas leading to roads. Adequate steps under the

provisions of air prevention and control of pollution Act 1981, Environmental Protection Act 1986 are taken.

- 12.DPA commissioned STP of capacity 1.5 MLD for treatment of domestic waste water for entire DPA area. (Details of domestic waste water generation is attached herewith as **Annexure D**)
- 13.Deendayal Port Authority had carried out mangrove plantation in an area of 1600 ha. through various government agencies like Gujarat Ecology Commission, State Forest Department.
- 14.It is also relevant to mention here that, DPA entrusted work to Forest Department, GoG (Social Forestry Division, Bhuj) during August, 2019 for green belt development in and around port area 31.942 hectares (approx. 35200 plants at various locations) at a cost of Rs. 352.32 lakhs.
- 15.DPA is involved in various CER activities like providing the proper sanitation and development of better roads for connectivity
- 16.DPA is managing its plastic waste as per Plastic Waste Management Rules – 2016 and amendments made therein. In order to strictly implement the said rules, DPT had issued a circular regarding plastic waste minimization, source segregation, recycling etc. vide its Circular no. EG/WK/4751/Part 243(A) dated 03/09/2021
- 17.DPA has entrusted the work to GEMI, Gandhinagar for "Preparation of Plan for Management of Plastic Waste, Solid Waste, C&D Waste, E-waste, Hazardous Waste including Bio-medical Waste and Non-hazardous waste in the Deendayal Port Authority Area
- 18.DPA has assigned the work to TERI, New Delhi for "Transition of Business Operations to Water Neutrality – Water Neutrality of Deendayal Port, Kandla (Phase I- Study and assessment)
- 19.Recently, DPA has entrusted the work to GEMI, Gandhinagar for "Study of CO₂ Emission Estimation and Reduction Strategy under Maritime India Vision 2030.
- 20.Initiative for Installation of Continuous Ambient Air Quality Monitoring System (CAAQMS) for monitoring of Air quality is under process.

Statement Showing the quantity of water consumed from GWSSB from April 2023 to March 2024

Sr.No.	Month	Total Quantity Consumed in KL
1.	April 2023	47342.47
2.	May 2023	48920.55
3.	June 2023	47342.00
4.	July 2023	48920.55
5.	August 2023	48920.55
6.	September 2023	59980.00
7.	October 2023	48680.00
8.	November 2023	57820.00
9.	December 2023	52100.00
10.	January 2024	45566.00
11.	February 2024	30884.00
12.	March 2024	37610.00
Total		574086.12


XEN (PL)

Environmental Monitoring Annual Report
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: April 2023 - March 2024



Document Ref No.: GEMI/DPA/782(2)(3)/2024-25/103

Submitted to:
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Gujarat Environment Management Institute (GEMI)

(An Autonomous Institute of Government of Gujarat)

GEMI Bhavan, 246-247, GIDC Electronic Estate, Sector-25, Gandhinagar-382025

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



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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 (DPA) at Kandla and Vadinar for a period of 3 years” by DPA, Kandla. Under the said project the report titled “*Environment Monitoring Annual Report (Monitoring Period: April 2023 - March 2024)*” is prepared.

- **Name of the Report:** *Environment Monitoring Report (Monitoring Period April 2023-March 2024)*
- **Date of Issue:** 26/06/2024
- **Version:** 1.0
- **Report Ref.:** GEMI/DPA/782(2)(3)/2024-25/103

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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 near the city of Gandhidham in Gujarat state in western India. Located on the Gulf of Kachchh, it is one of major ports on the western coast, and is located at 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. 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. Deendayal Port Authority (DPA), India's busiest major port in recent years, is gearing up to add substantial cargo handling capacity with private sector participation. DPA has created new record by handling 137 MMTPA (at Kandla and Vadinar) during the financial year 2022-23. The 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, with a capacity of 54 MMTPA. Further, significant Quantum of infrastructural upgradation has been carried out & excellent maritime infrastructure has been created at Vadinar for the 32 MMTPA Essar Oil Refinery in Jamnagar District.

1.2 Green Ports Initiative

DPA 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.

DPA had also appointed GEMI as an Advisor for "Making Deendayal Port a Green Port-Intended Sustainable Development under the Green Port Initiatives. DPA 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 DPA. The plantation is being carried out by the Social Forestry division of Kachchh.

1.3 Importance of Environmental monitoring and management plan (EMMP)

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 should indicate the details of various measures are taken 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 not only during the construction and operational phases of the new port but also for operation of existing ports to ensure the effectiveness of the mitigation measures implemented and to further provide guidance as to the most appropriate way of dealing with any unforeseen impacts.

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 essential 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 environmental monitoring done during the period from April 2023-March 2024.

1.4 Objectives and scope of the Study

In line with the work order, the key objective of the study is to carry out the Environmental Monitoring and preparation the Management Plan for Kandla and Vadinar for a period of 3 years". Under the project, Environmental monitoring refers to systematic monthly monitoring and assessment of ambient air, water (drinking and surface), soil, sediment, noise and ecology in order to monitor the performance and implementation of a project in compliance with Environmental quality standards and/or applicable Statutory norms.

The scope of work includes not limited to following:

1. To review the locations/stations of Ambient Air, Ambient Noise, drinking water, and Marine Water, Soil and Sediments monitoring 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 locations (18 at Kandla and 2 at Vadinar) in terms of Physical, Chemical and Biological parameters viz., Color, Odor, turbidity, conductivity, pH, Total Dissolved Solids, chlorides, Hardness, total iron, sulphate, 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. Weekly sample collection and analysis of inlet & Outlet points of the Sewage Treatment Plant (STP) to check the water quality being discharged by DPA as per the CC&A.
9. Carrying out monthly Noise monitoring; 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, hence precise and continuous data collection is of utmost importance. Meteorological data on wind speed, wind direction, temperature, relative humidity, solar radiation and rainfall shall be collected from one permanent station at DPA, Kandla and one permanent station at Vadinar.
11. To suggest 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 based on Monitoring programme and findings of the study.

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 23°01'N and 70°13'E in Gujarat. The Major Port Authorities Act 2021 is the governing statute for Administration of Major Ports, under which, Deendayal Port Trust (DPT) has become Deendayal Port Authority (DPA). At Kandla, DPA has sixteen (16) cargo berths for handling various types of Dry Bulk Cargo viz, fertilizer, food grains, Coal, sulphur, etc.

- **Climatic conditions of Kandla**

Kandla has a semi-desert climate. Temperature varies from 25°C to 44°C during summer and 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 Gujarat state in India located at coordinates 22° 27' 16.20" N - 069° 40' 30.01". DPA 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, with a capacity of 54 MMTPA. The OOT of the DPA contributes in a large way to the total earnings of this port. Vadinar is now notable due to the presence of two refineries-one promoted by Reliance Industries and Essar Oil Ltd.

DPA also handled 43.30 MMT at Vadinar (which includes transshipment), the containerized cargo crossed 4.50 lakh TEU, grossing a total of 100 MMT overall. Major commodities handled by the Deendayal Port are Crude Oil, Petroleum product, Coal, Salt, Edible Oil, Fertilizer, etc.

- **Climatic conditions of Vadinar**

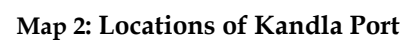
Vadinar has a hot semi-arid climate. The summer season lasts from March-to-May and is extremely hot, humid, but dry. The climatic conditions in Vadinar are quite similar to that recorded in its district head quarter i.e., Jamnagar. The annual mean temperature is 26.7 °C. Rainy season with extremely erratic monsoonal rainfall that averages around 630 millimetres. The winter season is from October-to-February remains hot during the day but has negligible rainfall, low humidity and cool nights.

The Kandla and Vadinar port have been depicted in the **Map 1 & 2** as follows:

SS



Map 1: Locations of Kandla and Vadinar Port





Map 3: Locations of Vadinar Port

2.2 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 identifying any deterioration in environmental conditions, thereby assist in recommending 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 a well-defined monitoring program. Environmental Monitoring is vital 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 have been mentioned below:

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

GEMI has been entrusted by DPA to carry out the monitoring of the various aforementioned environmental aspects at the port, so as to verify effectiveness of prevailing Environment Management plan, if it confirms to the statutory and/or 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, interpretation and communication of results. The analysis was carried out in GEMI's NABL/MoEF accredited/recognized laboratory.

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 whole process of management through effective decision-making and problem solving. The methodology adopted for the present study is shown in **Figure 1** as given below:

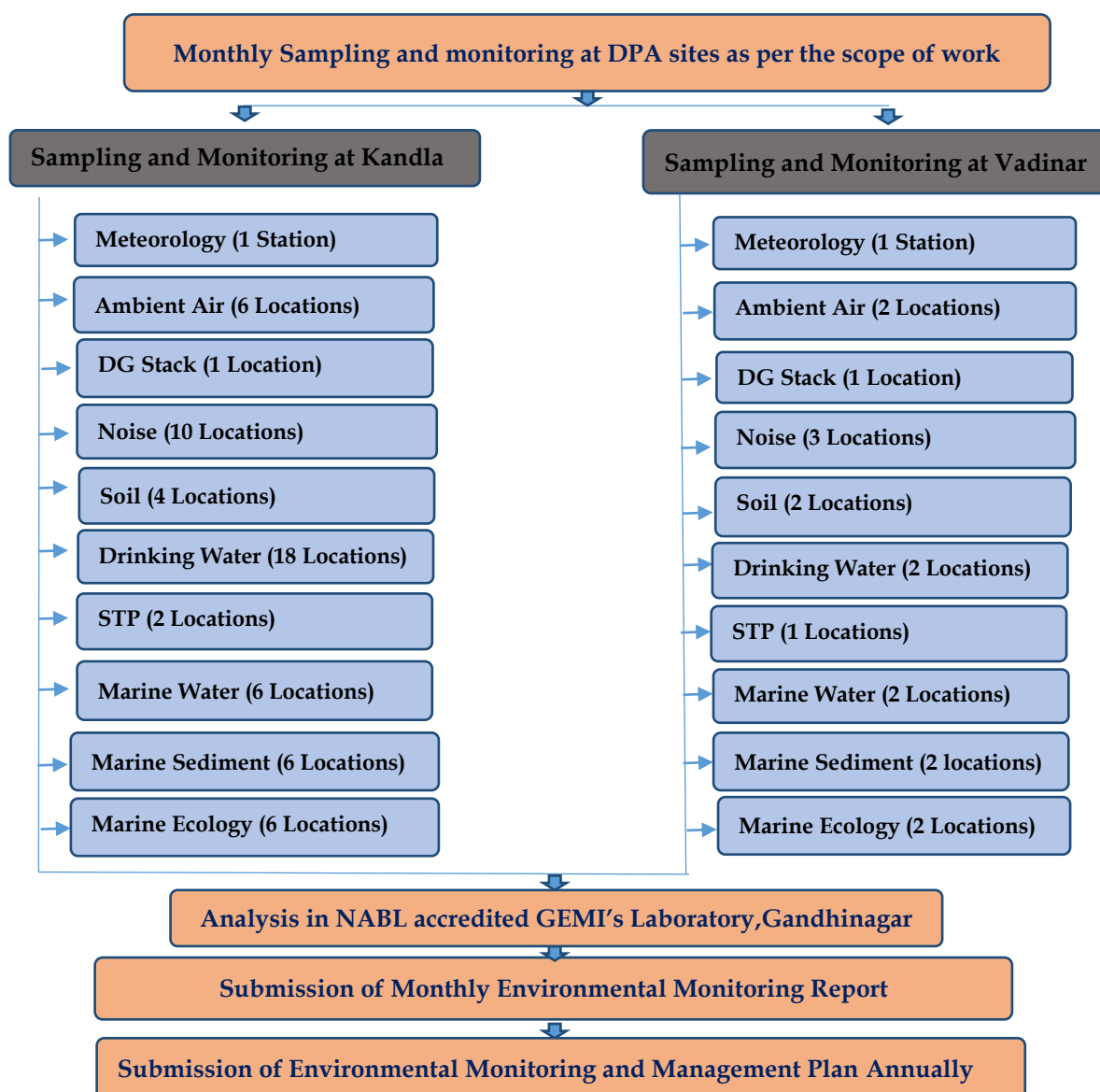


Figure 1: Methodology flow chart

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 as well as 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 make (Model: WM280) were installed at both the sites of Kandla and Vadinar at 10 m above the ground. The details of the AWS installed 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

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 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	°C		
6.	Solar Radiation	W/m ²		

Monitoring Frequency:

The Meteorological parameters were recorded at an interval of 1 hour in a day for the period of April 2023 to March 2024 and the average value for all the Meteorological parameters were summarized for the sampling period of at both the observatory site.

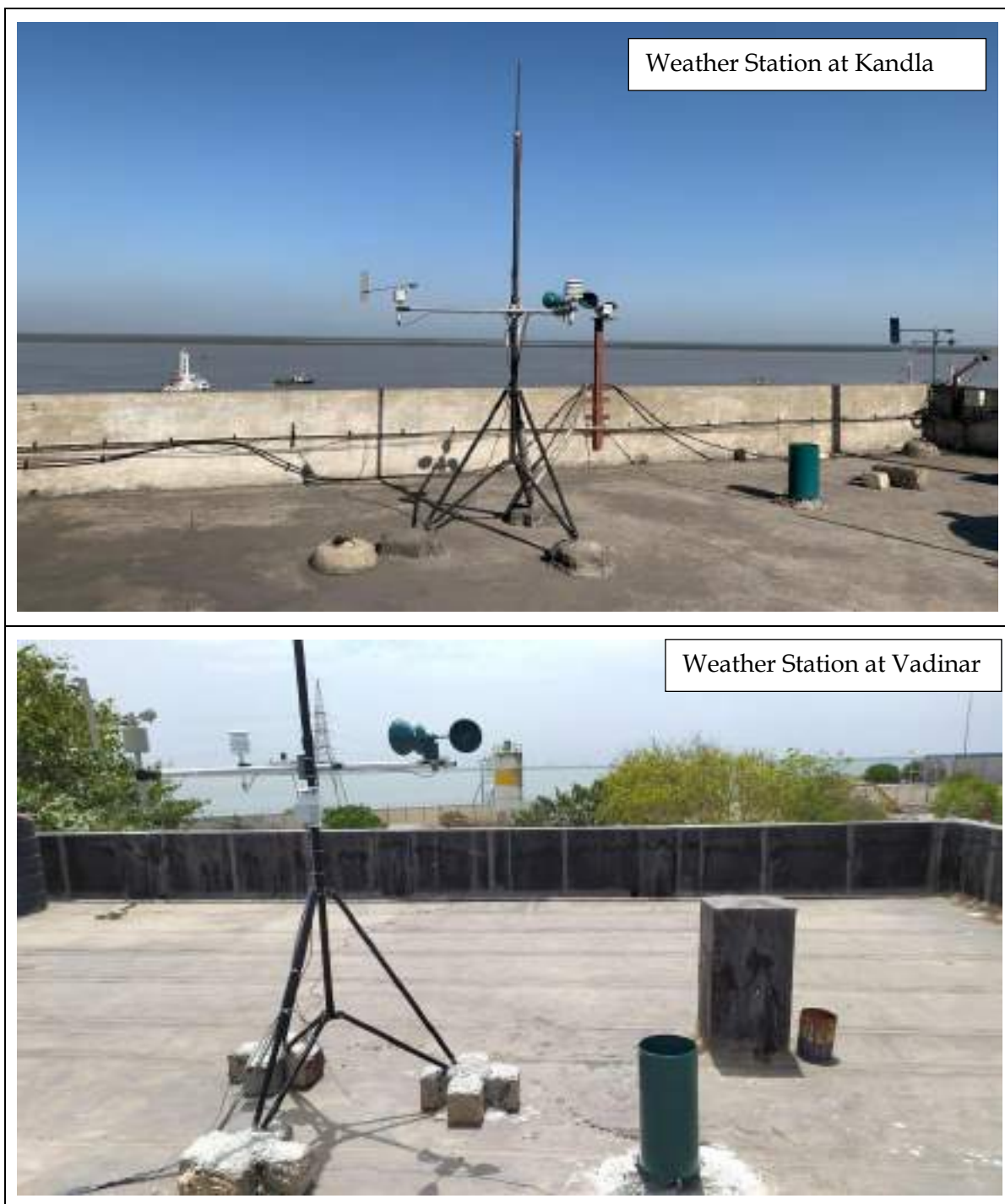


Figure 2: Photographs of Automatic Weather Monitoring Station at Kandla and Vadinar

3.2 Results and discussion

The summary of hourly climatological observations recorded at Kandla and Vadinar during the monitoring period of **April 2023 to March 2024**, with respect to significant parameters has been mentioned in **Table 3** as follows:

Table 3: Meteorological data for Kandla and Vadinar

Details of Micro-meteorological data at Kandla Observatory												
Monitoring Period	Wind Speed (Km/h)			Temperature (°C)			Relative humidity (%)			Solar Radiation (W/m ²)	Wind Direction (°)	Rainfall (mm)
	Max.	Min	Avg.	Max.	Min	Avg.	Max.	Min	Avg.			
April-May 23	27.02	1.54	8.78	32.21	30.4	31.31	64.12	61.07	57.76	105.42	S.S.E	0.05
May-June 23	48.85	3.07	12.94	32.64	31.23	31.93	70.33	65.93	68.17	90.14	N & N.N.W	0.37
June- July 23	38.99	1.23	9.71	31.54	30.27	30.89	76.32	72.43	74.47	67.76	E.W.E & W.S.W	3.56
July-Aug 23	35.4	1.47	7.67	30.51	29.32	29.91	77.72	73.87	75.78	57.4	W.S.W	14.94
Aug-Sep 23	37.52	0.63	6.55	48.44	30.33	38.43	84.57	69.18	75.59	73.28	W.S.W	21.89
Sep- Oct 23	20.36	0.16	4.75	31.01	29.66	30.32	71.62	66.85	69.32	74.08	W.S.W	2.87
Oct- Nov 23	9.85	0.025	1.15	31.24	29.63	30.41	55.4	49.02	52.18	65.11	North	0.012
Nov- Dec 23	14.72	0	2.09	25.76	24.32	25.03	59.69	54.6	57.1	54.28	N.E	0.96
Dec- Jan 24	15.75	0	1.87	23.22	21.68	22.44	56.5	51.11	53.78	60.66	North	0
Jan- Feb 24	15.29	0.131	3.147	24.83	23.18	24	56	50.51	53.19	65.32	North	0
Feb- Mar 24	22.41	0.44	5.12	26.7	25.06	25.86	51.55	45.91	48.64	78.46	North	0.04
Mar- Apr 24	33.09	0.025	5.43	48.44	26.87	30.08	73.25	30.59	55.06	89.43	W.S.W	0

Details of Micro-meteorological data at Vadinar Observatory

Monitoring Period	Wind Speed (Km/h)			Temperature (°C)			Relative humidity (%)			Solar Radiation (W/m ²)	Wind Direction (°)	Rainfall (mm)
	Max.	Min	Avg.	Max.	Min	Avg.	Mean	Max.	Min			
April-May 23	26.33	7.78	13.24	28.74	28.04	28.17	73.47	70	71.08	110.76	W & South	0.02
May-June 23	34.08	7.63	16.76	29.96	29.22	29.34	71.77	69.03	69.83	102.95	S.S.E	0.19
June- July 23	12.31	1.62	5.19	29.51	28.86	28.94	77.68	75.42	75.95	78.26	South	0.27
July-Aug 23	31.69	5.39	13.12	28.62	27.99	28.06	79.51	77.31	77.77	60.86	South	0.22
Aug-Sep 23	28.07	5.2	12.96	27.75	27.18	27.22	75.13	72.87	73.42	88.14	South & S.W	0
Sep- Oct 23	21.82	4.64	9.59	28.12	27.5	27.56	77.12	74.66	75.32	87.51	South	0.06
Oct- Nov 23	13.8	1.77	4.17	27.89	27.1	27.28	63.61	59.58	61.15	81.61	N.E	0.18
Nov- Dec 23	19.37	3	4.84	24.79	24.11	24.24	64.12	60.47	61.79	70.68	S.S.E	0.03
Dec- Jan 24	16.76	1	4.18	22.94	22.14	22.34	63.13	59.25	60.71	73.37	South	0
Jan- Feb 24	10.62	1.99	3.94	23.24	22.92	22.7	65.66	64.19	64.9	87.29	South	0
Feb- Mar 24	16.92	5.36	8.55	24.16	23.6	23.82	62.34	60.91	61.51	101.99	N.N.W	0
Mar- Apr 24	29.61	0.31	11.63	29.8	24.96	26.5	82.36	57.41	71.08	114.77	N.N.W	0

3.3 Data Interpretation and Conclusion

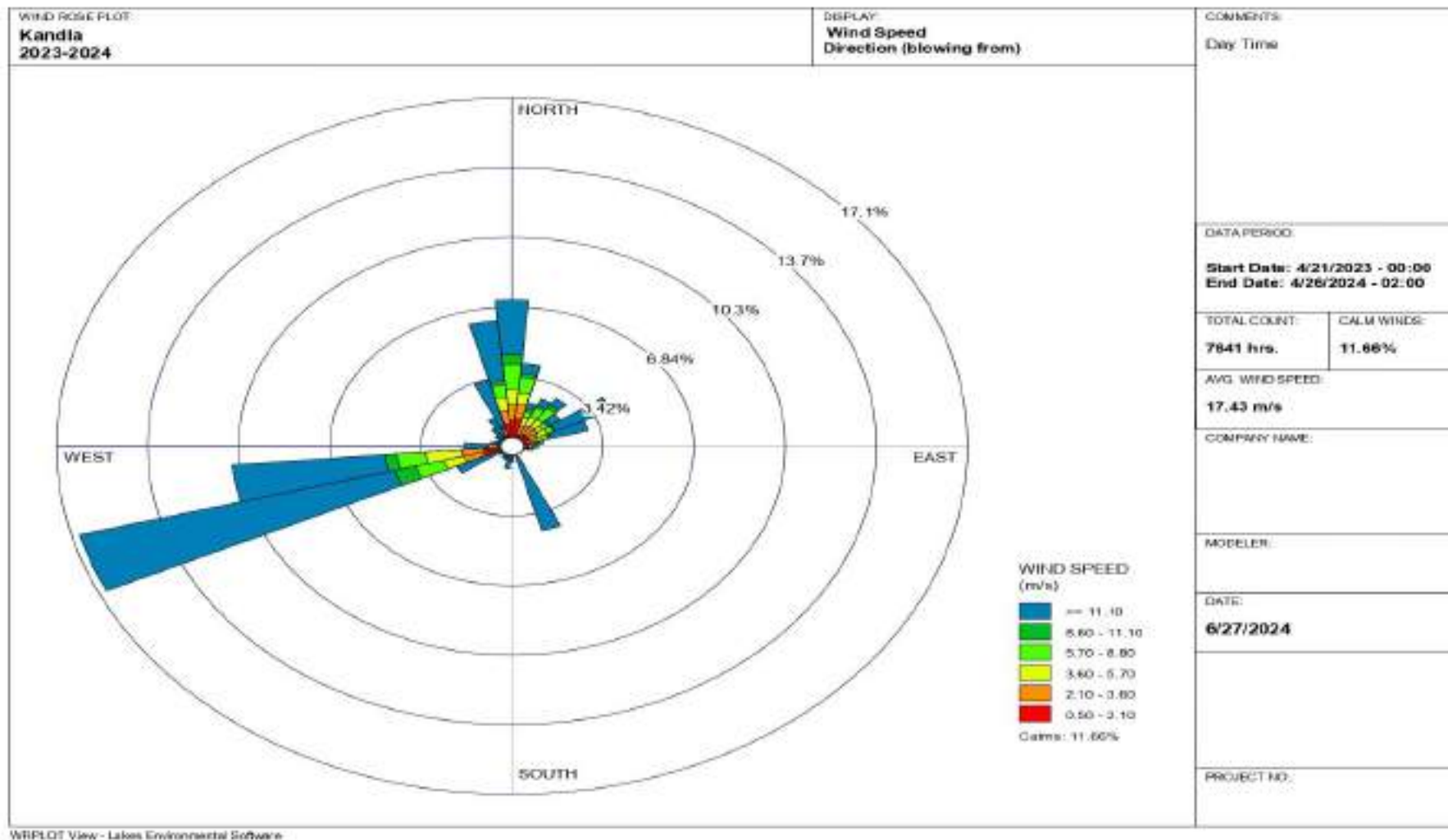
1) Kandla:

- a. The ambient temperature for the summer season varies in the range of **21.68** to **48.44** °C; in the monsoon season, the temperature varies between **29.32** and **33.38** °C; and in the winter season, the temperature varies between **21.68** and **31.24** °C. The yearly average temperature at Kandla is observed to be around **29.217** °C, with a standard deviation of 4.31.
- b. The relative humidity for the summer season was recorded in the range of **30.59%** to **76.32%**; in the monsoon season, relative humidity was recorded in the range of **66.85%** to **84.57%**; and in the winter season, relative humidity was recorded in the range of **49.02** to **59.69%**; the yearly average humidity at Kandla was **61.75%** with a standard deviation of **10.635**.
- c. The maximum rainfall at Kandla was observed at **21.89** mm for the monitoring period of August to September 2023; the yearly average rainfall was found to be **3.72** mm.
- d. Wind speed and direction play a significant role in transporting pollutants and thus determining the air quality. In the summer season, wind blew from the North and North North West directions; in the monsoon season, wind blew from the West South West; and in the winter season, wind blew from the North direction.
- e. The wind speed recorded ranges from **0.025** to **48.85** km/h in the summer season; in the monsoon season, the wind speed recorded ranges from **0.16** to **37.52** km/h; and in the winter season, the wind speed recorded ranges from **0** to **15.75** km/h. The yearly average wind speed at Kandla is **5.77** km/h, with a standard deviation of 3.55.
- f. The **maximum** solar radiation at Kandla was observed at **105.42** W/m² during the monitoring period **April to May 2023**; the **minimum** solar radiation at Kandla was observed at **54.28** W/m² for the monitoring period **November to December 2023**; and the yearly **average** solar radiation was found to be **73.445** W/m² with a standard deviation of 15.19.

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 Diagram reveals that at Kandla during the monitoring period, the prevailing winds predominantly blow from the West South West direction at Kandla, whereas, high speed winds were also observed to blow from North direction.



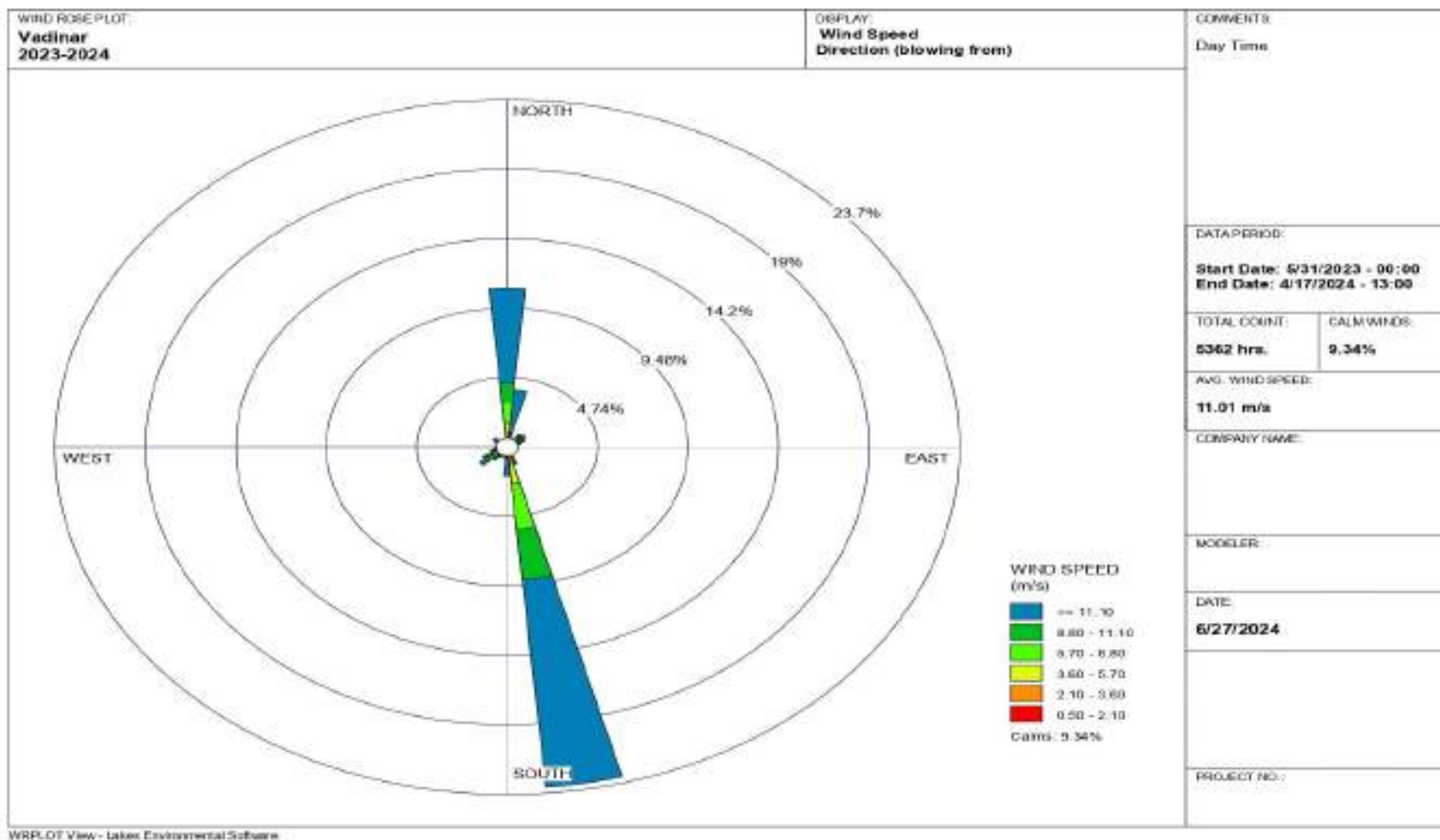
2) Vadinar:

- a. The ambient temperature for the summer season varies between **23.6** and **29.96** °C; in the monsoon season, it varies between **27.18** and **28.62** °C; and in the winter season, it varies between **22.14** and **27.89** °C. The yearly average temperature at Vadinar is **2.347** °C with standard deviation of **2.4**.
- b. The relative humidity for the summer season was recorded in the range of **57.41**% to **82.36**%; in the monsoon season, relative humidity was recorded in the range of **72.87**% to **79.51**%; and in the winter season, relative humidity was recorded in the range of **59.25**% to **65.66**%; the yearly average humidity at Vadinar was **68.7**% with a standard deviation of **6.38**.
- c. The **maximum** rainfall at Vadinar was observed at **0.27** mm for the monitoring period from **June to July 2023**; the yearly **average** rainfall was found to be **0.08** mm.
- d. In Summer Season wind blew from South Direction, in Monsoon season wind blew from South and in Winter Season wind blew from South and South West direction. The recorded wind speed ranges from **0.31** to **34.08** km/hr in the summer season, **4.64** to **31.69** km/hr, and in the monsoon season, the recorded wind speed ranges from **1** to **19.37** km/hr. The yearly average wind speed at Vadinar is **9.014** km/h with a standard deviation of **4.49**.
- e. The maximum solar radiation at Vadinar was observed at **114.77** W/m² for the monitoring period April to May 2024; the minimum solar radiation at Vadinar was observed at **60.86** W/m² for the monitoring period July to August 2023; and the yearly average solar radiation was found to be **88.182** W/m².

Wind rose diagram:

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

At Vadinar, the winds were observed to blow from Souths direction.



CHAPTER 4: AMBIENT AIR QUALITY MONITORING

4.1 Ambient Air Quality

It is necessary to monitor the ambient air quality of the study area, in order to determine the impact of the shipping activities and port operations on the ambient air quality. The prime objective of ambient air quality monitoring is to assess the present air quality and its conformity to National Ambient Air Quality Standards i.e. NAAQS, 2009⁽¹⁾.

Methodology

The study area represents the area occupied by DPA and its associated Port area. 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. Considering the below factors, under the study, as per the scope specified by DPA eight locations wherein, 6 stations at Kandla and 2 at Vadinar have been finalized within the study area

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

The description of various air quality stations monitored at Kandla and Vadinar have been specified 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	Liquid containers and emission from ship
2.		A-2	Oil Jetty No. 7	
3.		A-3	Kandla Port Colony	Vehicular activity and dust emission
4.		A-4	Marine Bhavan	
5.		A-5	Coal Storage Area	Coal Dust, Vehicular activity
6.		A-6	Gopalpuri Hospital	
7.	Vadinar	A-7	Admin Building	Vehicular activity
8.		A-8	Vadinar Colony	Residential Area, burning waste, vehicular activity

The monitoring locations at Kandla and Vadinar have been depicted in map in **Map 4 and 5** respectively.

Ambient Air monitoring photos

Kandla

A-1: Oil Jetty No. 1



A-2: Oil Jetty No. 7



A-3: Kandla Port Colony



A-4: Marine Bhavan



A-5: Coal Storage Area



A-6: Gopalpuri Hospital



Vadinar

A-7: Admin Building

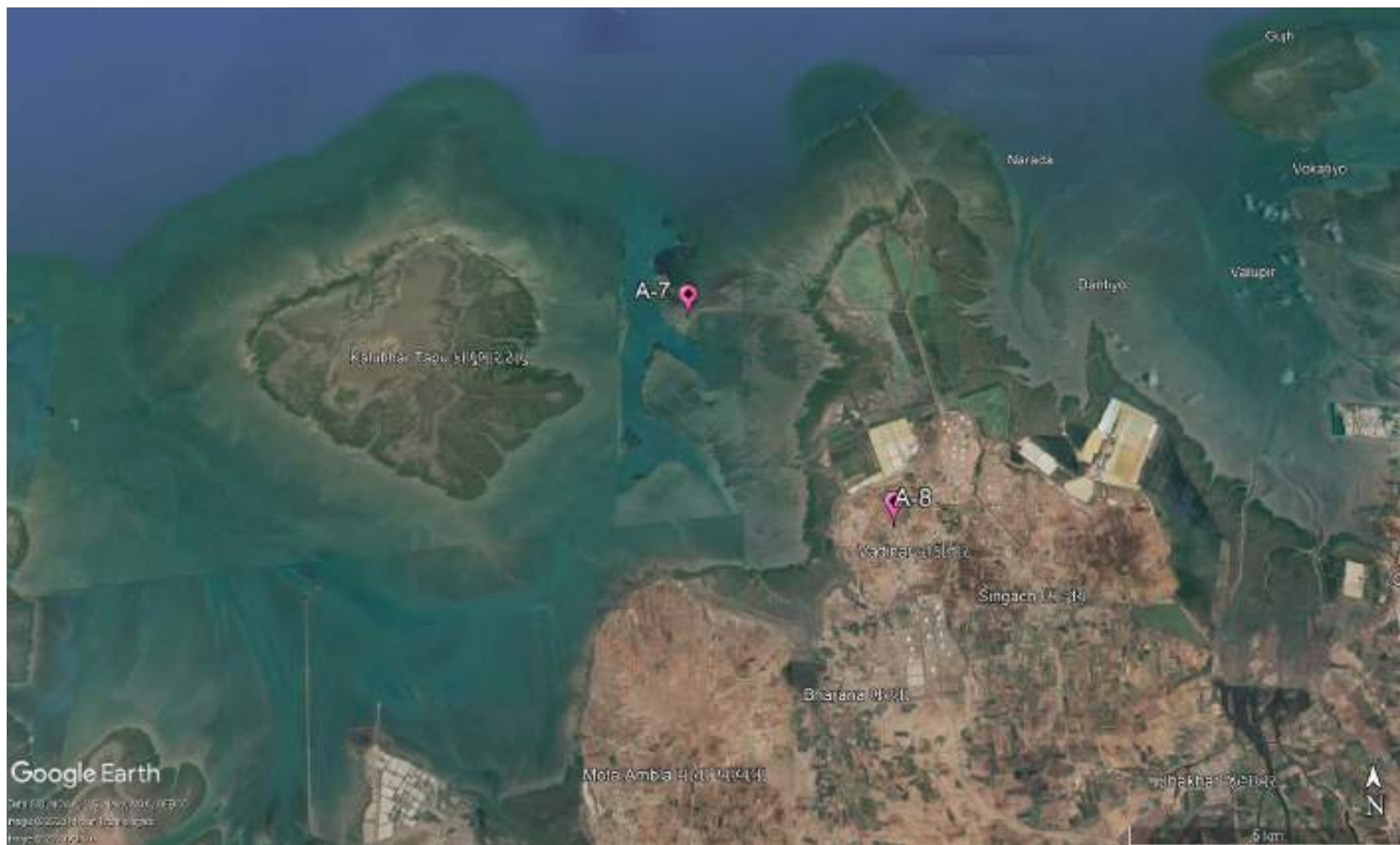


A-8: Vadinar Colony





Map 4: Ambient Air Monitoring locations at Kandla



Map 5: Ambient Air Monitoring locations at Vadinar

Monitoring Frequency

The sampling for Particulate matter, i.e., PM₁₀ and PM_{2.5}, and gaseous components like SO_x, NO_x, and CO, as well as the total VOCs, was monitored twice a week for a period of 24 hours a day. Whereas, the sampling for the components of PAH, benzene, and non-methane VOCs was conducted on a monthly basis. The monitoring period for this study is from April 15, 2023, to April 15, 2024. During this period, 95 air samples were taken from six locations in Kandla, and 97 samples were taken from two locations in Vadinar.

Sampling and Analysis

The Sampling of the Ambient Air Quality parameters and analysis is conducted as per the 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 PM₁₀, calibrated 'Respirable Dust Samplers' were used, where Whatman GF/A microfiber filter paper of size 8"x 10" were utilized, where the Gaseous attachment of the make Envirotech instrument was attached with Respirable Dust Sampler for the measurement of SO_x and NO_x. The Fine Particulate Sampler for collection of PM_{2.5} was utilized for the 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 SO₂ 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 measured flow rate of 1 liter/minute (L/min). Similarly, NO_x 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 PM₁₀, PM_{2.5}, SO_x and NO_x samples of 24-hour carried out twice a week. 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 (LVS) 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 LVS during two hours monitoring is approx. 24 L.

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, Benzene, 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/m ³	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/m ³	IS:5182 (Part:24):2019	Fine Particulate Sampler (FPS) conforming to IS:5182 (Part-24): 2019	
3.	Sulphur Dioxide (SO _x)	µg/m ³	IS 5182 (Part:2): 2001	Gaseous Attachment conforming to IS:5182 Part-2	
4.	Oxides of Nitrogen (NO _x)	µg/m ³	IS:5182 (Part-6): 2006	Gaseous Attachment conforming to IS:5182 Part-6	
5.	Carbon Monoxide (CO)	mg/m ³	GEMI/SOP/AAQM/11; Issue no 01, Date 17.01.2019: 2019	Sensor based Instrument	
6.	VOC	µg/m ³	IS 5182 (Part 17): 2004	Low Flow Air Sampler	
8.	PAH	µg/m ³	IS: 5182 (Part 12): 2004	Respirable Dust Sampler (RDS) conforming to IS:5182 (Part-12): 2004	Monthly
7.	Benzene	µg/m ³	IS 5182 (Part 11): 2006 RA: 2017	Low Flow Air Sampler	
9.	Non-methane VOC	µg/m ³	IS 5182 (Part 11): 2006	Low Volume Sampler	

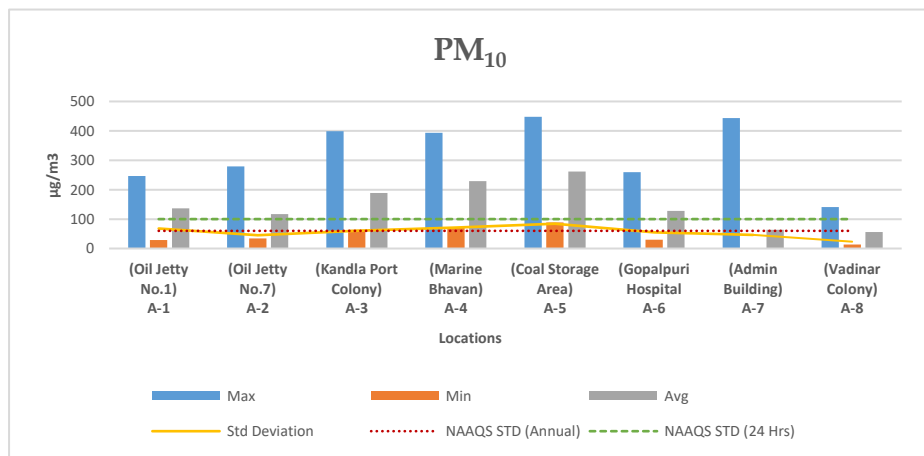
4.2 Result and Discussion

The summarized results of ambient air quality monitoring for the study period are presented in **Table-6 to 9** along with the graphical representation from **Graph 1 to Graph 6**. Various parameters monitored during the study have been presented by their maximum, minimum, average and Standard deviation.

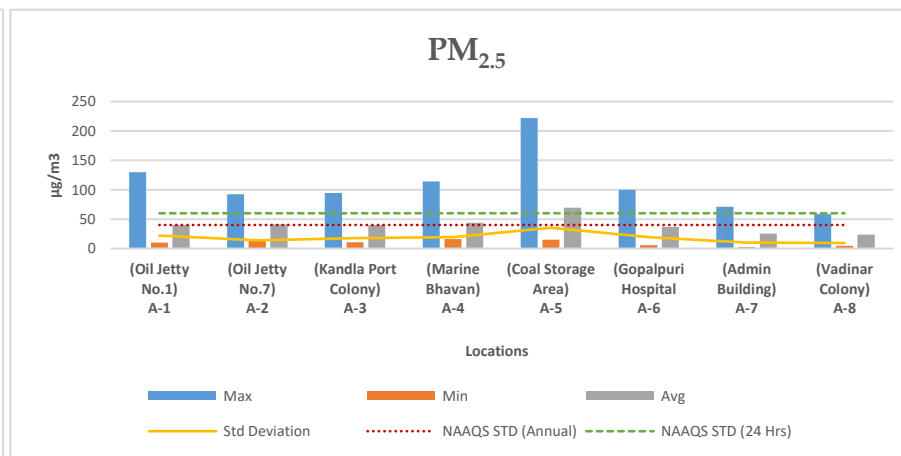
Table 6: Summarized results of PM₁₀, PM_{2.5}, SO₂, NO_x, VOC and CO for Ambient Air quality monitoring

Locations			(Oil Jetty No.1) A-1	(Oil Jetty No.7) A-2	(Kandla Port Colony) A-3	(Marine Bhavan) A-4	(Coal Storage Area) A-5	(Gopalpuri Hospital) A-6	(Admin Building) A-7	(Vadinar Colony) A-8
Parameters	NAAQS by CPCB									
PM ₁₀ (µg/m ³)	24 Hours -100 Annual -60	Max	247.03	279.33	399.25	393.74	448.12	259.88	443.2	140.7
		Min	28.68	34.39	63.28	71.77	89.21	30.3	1.45	13.89
		Avg	136.50	116.67	188.36	229.41	262.04	127.95	63.49	56.54
		Std Deviation	68.203	44.97	60.56	71.74	84.18	55.43	46.36	23.15
PM _{2.5} (µg/m ³)	24 Hours -60 Annual -40	Max	129.77	92.24	94.51	114.34	221.9	99.82	71.18	58.73
		Min	10.03	12.85	10.84	15.97	14.85	5.51	2.36	4.7
		Avg	40.27	41.2	40.26	43.70	69.70	36.95	25.11	23.73
		Std Deviation	22.049	13.87	17.52	19.15	35.36	19.04	10.06	9.33
SO ₂ (µg/m ³)	24 Hours -80 Annual -50	Max	51.87	151.58	79.24	55.04	283	49.89	59.69	69.81
		Min	0.65	1.18	1.1	1.19	1.1	1.12	0.52	1.4
		Avg	11.076	20.01	14.63	11.82	16.82	11.56	12.59	13.69
		Std Deviation	12.142	28.41	17.15	12.25	30.85	12.08	13.35	14.90
NO _x (µg/m ³)	24 Hours -80 Annual -40	Max	54.33	52.54	80.67	55.39	80.94	79.88	52.76	33.79
		Min	2.29	1.11	2.36	1.29	1.97	1.01	2.89	0.9
		Avg	14.75	14.58	22.91	20.52	28.12	15.24	12.84	9.70
		Std Deviation	11.68	9.85	14.98	10.53	17.98	13.59	8.62	5.73
VOC (µg/m ³)	-	Max	4.85	5.67	17.43	4.41	3.97	4.12	4.52	6.62
		Min	0.01	0.01	0.01	0.02	0.04	0.01	0.01	0.01
		Avg	1.20	1.226	1.52	0.98	0.94	0.96	0.96	0.95
		Std Deviation	1.155	1.298	2.275	0.99	0.94	0.99	0.93	1.12
CO (mg/m ³)	8 Hours -2 1 Hour -4	Max	0.98	4.21	2.91	3.16	3.21	2.18	3.14	2.74
		Min	0.08	0.09	0.14	0.39	0.36	0.32	0.03	0.45
		Avg	0.73	0.848	0.89	0.95	1.13	0.74	0.78	0.94
		Std Deviation	0.194	0.557	0.41	0.39	0.53	0.32	0.46	0.36

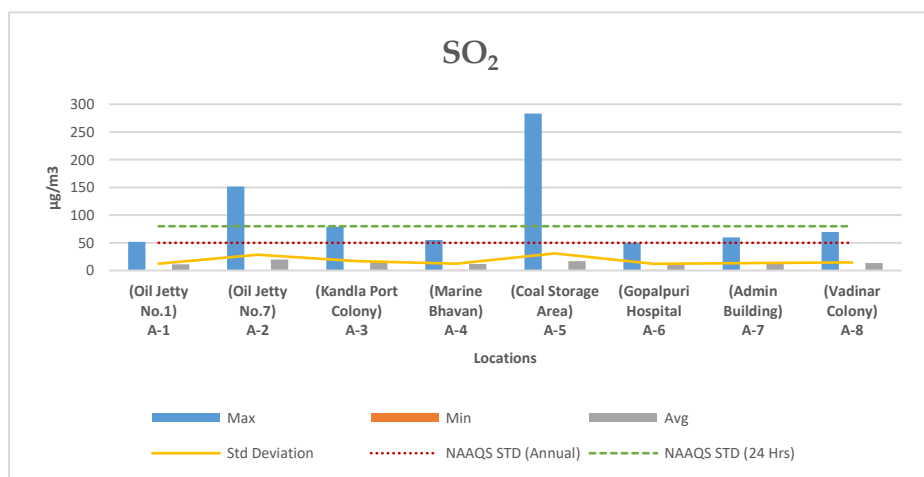
Graphs 1-6 shows spatial trend of ambient air parameter at all the eight-monitoring location (six at Kandla and 2 at Vadinar)



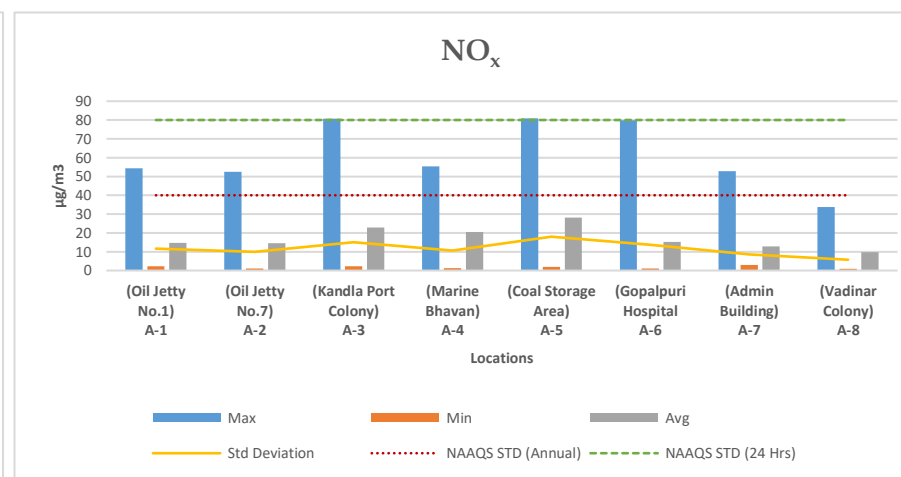
Graph 1 Spatial trend in Ambient PM₁₀ Concentration



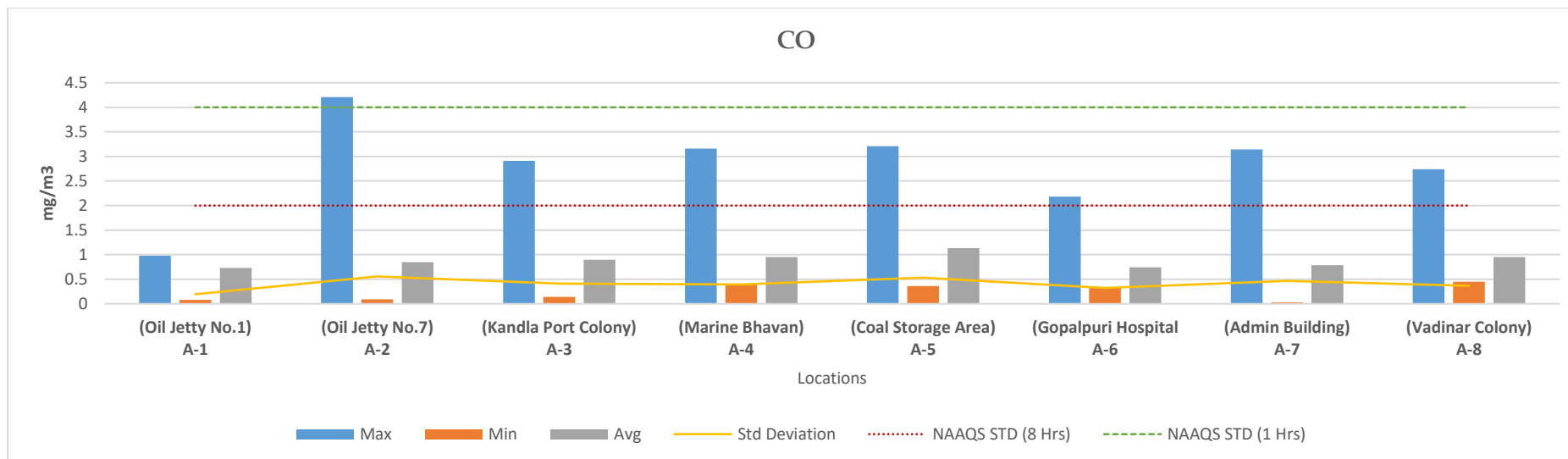
Graph 2 Spatial trend in Ambient PM_{2.5} Concentration



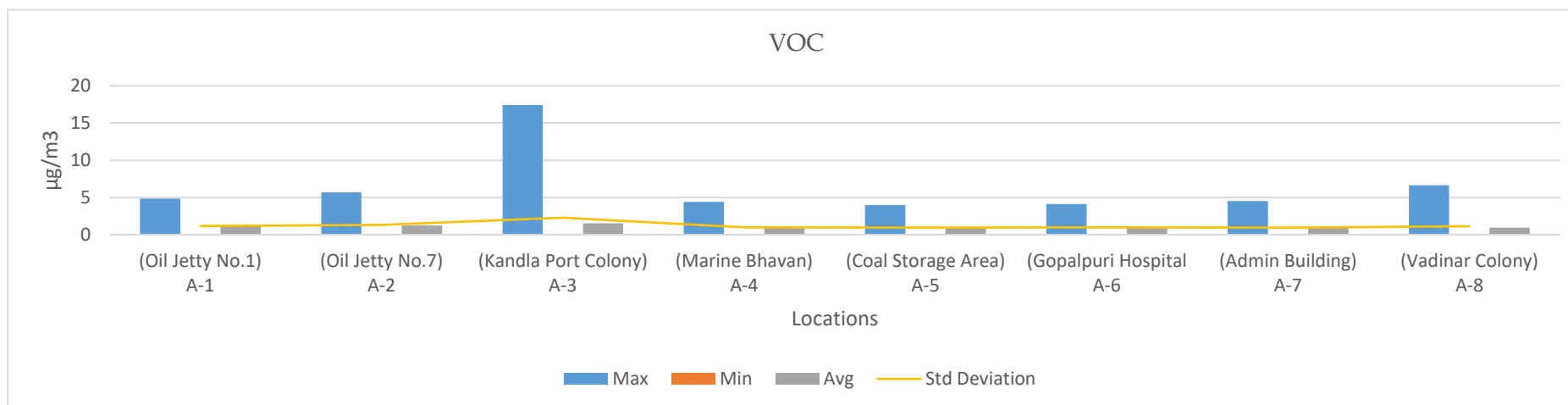
Graph 3 Spatial trend in Ambient SO_x Concentration



Graph 4 Spatial trend in Ambient NO_x Concentration



Graph 5 Spatial trend in Ambient CO Concentration



Graph 6 Spatial trend in Ambient Total VOCs

Table 7: Summarized results of Benzene for Ambient Air quality monitoring

Locations			(Oil Jetty No.1) A-1	(Oil Jetty No.7) A-2	(Kandla Port Colony) A-3	(Marine Bhavan) A-4	(Coal Storage Area) A-5	(Gopalpuri Hospital) A-6	(Admin Building) A-7	(Vadinar Colony) A-8
Parameters	NAAQS by CPCB									
Benzene (µg/m ³)	Annual - 5	Max	3.8	1.84	1.43	1.95	1.11	1.97	1.03	0.95
		Min	0.03	0.02	0.02	0.02	0.03	0.02	0.02	0.01
		Avg	0.83	0.46	0.42	0.32	0.41	0.49	0.33	0.229

Table 8: Summarized results of Polycyclic Aromatic Hydrocarbons

Locations		(Oil Jetty No.1) A-1	(Oil Jetty No.7) A-2	(Kandla Port Colony) A-3	(Marine Bhavan) A-4	(Coal Storage Area) A-5	(Gopalpuri Hospital) A-6	(Admin Building) A-7	(Vadinar Colony) A-8
Parameters									
Napthalene (µg/m ³)	Max	1.57	17.31	5.24	5.55	7.8	39.82	1.98	1.84
	Min	0.02	0.21	0.04	0.14	0.37	0.02	0.1	0.13
	Avg	0.40	3.29	0.58	1.05	2.01	4.96	0.45	0.42
Acenaphthylene (µg/m ³)	Max	0.8	0.67	0.54	0.95	0.53	0.86	0.84	0.65
	Min	0.01	0.01	0.01	0.02	0.007	0.02	0.005	0.005
	Avg	0.15	0.20	0.17	0.31	0.15	0.18	0.19	0.17
Fluorene (µg/m ³)	Max	0.39	0.39	22.99	178.72	10.88	27.22	7.57	11.64
	Min	0.01	0.05	0.04	0.11	0.01	0.06	0.01	0.01
	Avg	0.14	0.19	3.435	19.99	1.25	3.52	0.82	1.18
Anthracene (µg/m ³)	Max	0.87	0.91	1.25	5.05	2.02	3.78	0.85	0.57
	Min	0.09	0.09	0.07	0.09	0.03	0.01	0.02	0.02
	Avg	0.3	0.42	0.40	0.94	0.94	0.69	0.23	0.19
Phenanthrene (µg/m ³)	Max	0.9	0.82	0.84	0.91	1	0.99	0.82	0.74
	Min	0.01	0.009	0.01	0.01	0.01	0.01	0.07	0.06
	Avg	0.23	0.20	0.15	0.22	0.33	0.20	0.25	0.22
Fluoranthene (µg/m ³)	Max	2.65	0.84	1.59	19.54	4.16	20.36	0.68	1.71
	Min	0.06	0.15	0.2	0.24	0.2	0.01	0.01	0.01
	Avg	0.43	0.36	0.74	3.61	1	2.12	0.24	0.30
Pyrene (µg/m ³)	Max	3.52	1.13	2.4	42.23	40.25	51.22	0.87	0.74
	Min	0.01	0.14	0.23	0.15	0.02	0.01	0.01	0.01
	Avg	0.54	0.48	0.90	7.46	4.37	7.98	0.16	0.14
Chrycene (µg/m ³)	Max	4.59	1.03	3.01	6.27	5.51	5.82	0.61	0.79



	Min	0.08	0.15	0.44	0.42	0.08	0.06	0.05	0.05
	Avg	0.78	0.51	1.01	1.50	1.47	1.22	0.19	0.22
Banz(a)anthracene (µg/m3)	Max	5.64	2.84	3.7	15.42	6.57	16.73	1.01	0.97
	Min	0.17	0.17	0.04	0.14	0.05	0.06	0.01	0.01
	Avg	0.89	0.65	0.88	2.66	1.44	2.93	0.25	0.31
Benzo[k]fluoranthene (µg/m3)	Max	7.67	1.99	5.98	4.81	4.06	6.89	0.84	0.69
	Min	0.15	0.38	0.14	0.48	0.05	0.06	0.03	0.03
	Avg	1.32	0.99	1.34	1.21	0.89	1.76	0.35	0.21
Benzo[b]fluoranthene (µg/m3)	Max	7.89	1.93	6.15	5.12	4.73	7.29	0.59	0.71
	Min	0.12	0.04	0.21	0.17	0.07	0.01	0.06	0.01
	Avg	1.09	0.62	1.053	1.43	1.06	1.65	0.17	0.20
Benzopyrene (µg/m3)	Max	10.9	2.79	8.42	7.25	8.91	9.19	0.96	0.69
	Min	0.24	0.08	0.39	0.39	0.01	0.04	0.01	0.01
	Avg	1.64	0.87	1.66	1.75	1.58	1.31	0.30	0.27
Indeno [1,2,3-cd] fluoranthene (µg/m3)	Max	2.39	6.67	0.95	2.46	1.68	4.61	0.52	0.98
	Min	0.13	0.07	0.42	0.26	0.11	0.09	0.07	0.06
	Avg	0.71	1.02	0.57	0.72	0.70	1.25	0.22	0.42
Dibenz(ah)anthracene (µg/m3)	Max	1.82	1.2	0.91	1.25	2.24	0.99	1.34	2.48
	Min	0.11	0.08	0.16	0.1	0.07	0.04	0.08	0.05
	Avg	0.47	0.32	0.35	0.46	0.54	0.24	0.31	0.4
Benzo[ghi]perylene (µg/m3)	Max	16.3	9.7	27.2	13.6	9.4	12.2	8	2.3
	Min	0.1	0.07	0.04	0.06	0.06	0.17	0.07	0.13
	Avg	2.049	2.63	2.95	2.55	1.61	2.13	0.83	0.47
Acenaphthene (µg/m3)	Max	0.69	0.45	15.1	119.08	2.54	11.8	0.67	2
	Min	0.01	0.05	0.04	0.11	0.01	0.06	0.01	0.01
	Avg	0.14	0.22	2.63	11.34	0.369	1.55	0.14	0.33

Table 9: Summarized results of Non-methane VOC

Parameters \ Locations		(Oil Jetty No.1) A-1	(Oil Jetty No.7) A-2	(Kandla Port Colony) A-3	(Marine Bhavan) A-4	(Coal Storage Area) A-5	(Gopalpuri Hospital) A-6	(Admin Building) A-7	(Vadinar Colony) A-8
Non- Methane VOC (µg/m3)	Max	2.11	2.67	3.54	1.35	1.8	2.01	2.15	1.67
	Min	0.12	0.09	0.1	0.08	0.13	0.11	0.07	0.1
	Avg	0.73	0.79	0.87	0.79	1.09	0.93	0.91	0.74s

4.3 Data Interpretation and Conclusion

The results were compared with the National Ambient Air Quality Standards (NAAQS), 2009 of Central Pollution Control Board (CPCB).

1) Kandla:

Particulate matter:

- The concentration of PM₁₀ varies very widely and is reported in the range of **28.68** to **448.12** µg/m³, with a yearly average value of **176.83** with standard deviation **64.185** µg/m³. As shown in Graph 1, the highest concentration (value) of PM₁₀ is reported at location A-5 (coal storage area) during the winter. It can be seen that PM₁₀ exceeds the NAAQS annual limit, i.e., 60 µg/m³, in all locations. It can be seen that location A-5 (coal storage area) had the maximum percentage exceedance, and location A-1 (oil jetty No. 1) had the minimum percentage exceedance while comparing with the NAAQS 24-hour limit, i.e., 100 µg/m³.
- The concentration of PM_{2.5} varies in the range of 5.51 to 221.9 µg/m³, with a yearly average value of 45.35 with standard deviation 21.16 µg/m³. As shown in Graph 2, the highest concentration of PM_{2.5} is at location A-5 (the coal storage area) in winter. It can be seen that PM_{2.5} exceeds the NAAQS annual limit, i.e., 40 µg/m³, on five locations, and location A-6, i.e., Gopalpuri hospital, falls within the NAAQS annual limit. It can be seen that location A-5 (coal storage area) had the maximum percentage exceedance, and location A-6 (Gopalpuri hospital) had the minimum percentage exceedance while comparing with the NAAQS 24-hour limit, i.e., 60 µg/m³.
- The highest concentration of Particulate matter at locations **A-5, (the coal storage area)**, could be attributed to the presence of heavy vehicular traffic in upwind areas, which have a higher impact, causing the dispersion of emitted particulate matter in the ambient air. Ther activities observed in the surrounding such as The unloading of coal directly into the truck using grabs, construction in the vicinity causes the dust to disperse in the air as well as coal dust to fall and settle on the ground. This settled coal dust again mixes with the air while trucks travel through it. Also, the coal-loaded trucks are generally not always covered with tarpaulin sheets, and this might result in increased suspension of coal from trucks or dumpers during their transit from vessel to yard or storage site. This might increase the PM in and around the coal storage area and Marine Bhavan.

Gaseous Pollutants:

- The concentration of SO_x varies from **0.52** to **283** µg/m³, with a yearly average concentration of **14.029** with standard deviation **18.85** µg/m³. As shown in Graph 3, the highest concentration of SO_x is at location **A-5 (the coal storage area)** in winter. It can be seen that at all locations, SO_x are within the NAAQS annual limit, i.e., 50 µg/m³. It can be seen that location A-2 (**Oil Jetty No. 7**) had the maximum percentage exceedance, i.e., **7.36%**, which is about 7 days out of 95 days of monitoring, and the other five locations comply with the standards (compliance more than 98% times) while comparing with the NAAQS 24-hour limit, i.e., 80 µg/m³. The concentration of NO_x varies from **1.01** to **80.94** µg/m³, with a yearly average concentration of **19.35** with standard deviation **13.10**

$\mu\text{g}/\text{m}^3$. As shown in Graph 4, the highest concentration of NO_x is at location A-5 (the coal storage area) in winter. It can be seen that on all locations's NO_x within the NAAQS annual limit, i.e., $40 \mu\text{g}/\text{m}^3$, it can be seen that all locations comply with the standards (complied more than 98% times) while comparing with the NAAQS 24-hour limit, i.e., $80 \mu\text{g}/\text{m}^3$.

- The concentration of CO varies from **0.08** to **4.21** mg/m^3 , with a yearly average concentration of **0.884** with standard deviation **0.40** mg/m^3 . As shown in Graph 5, the highest concentration of CO is at location A-2 (Oil Jetty No. 7) in winter. It can be seen that at all locations, they're complying (more than 98% of the time) with the NAAQS 1 hour limit, i.e., $4 \text{ mg}/\text{m}^3$. Location A-5 (the coal storage area) had the maximum percentage exceedance, i.e., **7.36%**, which is about 7 days out of 95 days of monitoring, and other locations such as Location A-2 (Oil Jetty No. 7), Location A-3 (Kandla Port Colony), Location A-4 (Marine Bhavan), and Location A-6 (Gopalpuri Hospital) had percentage exceedances of **5.26**, **5.26**, **2.85**, and **2.85**, respectively. And location A-1 (oil jetty no. 1) comply with the standards (compliance more than 98% times) while comparing with the NAAQS 8-hour limit, i.e., $2 \text{ mg}/\text{m}^3$.
- The concentration of total VOC levels was recorded in the range of **0.01** to **17.43** $\mu\text{g}/\text{m}^3$, with a yearly average value of **1.14** with standard deviation **1.21** $\mu\text{g}/\text{m}^3$ at Kandla. As shown in graph 6, the highest concentration of VOCs is at location **A-3, (Kandla port colony)**; this is the only spike observed in the whole monitoring period for VOCs at this location. The main source of VOCs in the ambient air may be attributed to the burning of gasoline and natural gas in vehicle exhaust, burning fossil fuels, and garbage that releases VOCs into the atmosphere. During the monitoring period, the wind flows in the south direction at Kandla, and hence the wind direction and speed also contribute to increased dispersion of pollutants from the upward areas towards the downward areas.

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. These locations are commercial areas where Vehicular activity and dust emission is common. PAHs are a class of chemicals that occur naturally in coal, crude oil, and gasoline. The higher concentration which results from burning coal, oil, gas, road dust, etc. Other outdoor sources of PAHs may be the industrial plants in-and-around the DPA premises.

- The concentration of Benzene levels was recorded in the range of **0.02** to **3.8** $\mu\text{g}/\text{m}^3$, with a yearly average value of **0.84** with standard deviation **0.64** $\mu\text{g}/\text{m}^3$. The highest concentration of Benzene is at location **A-1, (Oil Jetty No. 1)** in summer. It can be seen that at all locations, Benzene within the NAAQS annual limit, i.e., $5 \mu\text{g}/\text{m}^3$.
- The ambient air monitoring location of Kandla recorded the non-methane VOC (NM-VOC) concentration in the range of **0.08** to **3.54** $\mu\text{g}/\text{m}^3$, with a yearly average value of **0.86** $\mu\text{g}/\text{m}^3$ at Kandla. The highest concentration is at location **A-3, (Kandla Port Colony)** in Winter.

2) Vadinar:

Particulate matter: The concentration of PM₁₀ at Vadinar varies in the range of **1.45 to 443.2** $\mu\text{g}/\text{m}^3$, with a yearly average value of **63.49** with a standard deviation of **34.76** $\mu\text{g}/\text{m}^3$. As shown in Graph 1, the highest concentration of PM₁₀ is at location A-7 (Admin Building Vadinar) in the winter. It can be seen that at location A-7 (Admin Building Vadinar), PM₁₀ exceeds the NAAQS annual limit, i.e., 60 $\mu\text{g}/\text{m}^3$, and at location A-8 (Vadinar Colony), it falls within the annual standards. It can be seen that locations A-7 (Admin Building Vadinar) and A-8 (Vadinar Colony) had a 5.15% percentage exceedance while comparing with the NAAQS 24-hour limit, i.e., 100 $\mu\text{g}/\text{m}^3$.

- The concentration of PM_{2.5} varies in the range of **2.36 to 71.18** $\mu\text{g}/\text{m}^3$, with a yearly average value of **24.42** with a standard deviation of **9.69** $\mu\text{g}/\text{m}^3$. As shown in Graph 2, the highest concentration of PM_{2.5} is at location **A-7 (Admin Building Vadinar)** in winter. It can be seen that in all two locations, PM_{2.5} is within the NAAQS annual limit, i.e., 40 $\mu\text{g}/\text{m}^3$. It can be seen that on both locations, **A-7 (Admin Building Vadinar)** and **A-8 (Vadinar Colony)** comply with the standards (compliance more than 98% times) while comparing with the NAAQS 24-hour limit, i.e., 60 $\mu\text{g}/\text{m}^3$.

Gaseous Pollutants:

- The concentration of SO_x varies from **0.52 to 69.91** $\mu\text{g}/\text{m}^3$, with a yearly average concentration of 13.146 with a standard deviation of 14.14 $\mu\text{g}/\text{m}^3$. As shown in Graph 3, the highest concentration of SO_x is at location A-8 (Vadinar Colony) in the winter. It can be seen that in all locations, SO_x are within the NAAQS annual limit, i.e., 50 $\mu\text{g}/\text{m}^3$. It can be seen that both locations comply with the standards (compliance more than 98% times) while comparing with the NAAQS 24-hour limit, i.e., 80 $\mu\text{g}/\text{m}^3$.
- The concentration of NO_x varies from **0.9 to 52.76** $\mu\text{g}/\text{m}^3$, with a yearly average concentration of **11.28** with a standard deviation of **7.17** $\mu\text{g}/\text{m}^3$. As shown in Graph 4, the highest concentration of NO_x is at location A-7 (Admin Building Vadinar) in the winter. It can be seen that in all locations, NO_x is within the NAAQS annual limit, i.e., 40 $\mu\text{g}/\text{m}^3$. It can be seen that all locations comply with the standards (compliance more than 98% of the time) while comparing with the NAAQS 24-hour limit, i.e., 80 $\mu\text{g}/\text{m}^3$.
- The concentration of CO varies from **0.03 to 3.14** mg/m^3 , with a yearly average concentration of **0.87** with a standard deviation **0.41** mg/m^3 . As shown in Graph 5, the highest concentration of CO is at location **A-7, (Admin Building Vadinar)** in winter. It can be seen that at all locations they are complying (Compliance more than 98% times) with the NAAQS 1 hour limit, i.e., 4 mg/m^3 . Both **locations A-7, (Admin building Vadinar)** and **A-8, (Vadinar Colony)** had **5.16%** exceedance, which is about 5 days out of 97 days of monitoring, while comparing with the NAAQS 8-hour limit, i.e., 2 mg/m^3 .
- The concentration of **Total VOCs** levels was recorded in a range of **0 to 6.62** $\mu\text{g}/\text{m}^3$ with a yearly average value of **0.96** with a standard deviation of **1.051** $\mu\text{g}/\text{m}^3$ at Vadinar. As shown in graph 6, the **highest** concentration of **VOCs** is at

location A-8, (Vadinar Colony), this is the only spike observed in the whole monitoring period for VOCs at this location.

Polycyclic Aromatic Hydrocarbons (PAHs):

- The concentration of **Benzene** levels was recorded in a range of **0.01 to 1.03** $\mu\text{g}/\text{m}^3$ with a yearly average value of **0.28** with a standard deviation of 0.36 $\mu\text{g}/\text{m}^3$. the **highest** concentration of Benzene is at **location A-7, (Admin building Vadinar)** in Winter. It can be seen that in all locations **Benzene** within the NAAQS annual limit, i.e., 5 $\mu\text{g}/\text{m}^3$.
- **Non-methane VOC (NM-VOC)** concentration at Vadinar was observed in the range of **0.07 to 2.15** $\mu\text{g}/\text{m}^3$ with a yearly average value of **0.82** with a standard deviation **0.085** $\mu\text{g}/\text{m}^3$. the **highest** concentration is at **A-7, (Admin building Vadinar)** in Winter.

With reference to the Ambient Air Quality monitoring conducted under the study, it may be concluded that the particulate matter PM_{10} , were reported in higher concentration and apparently exceeds the NAAQS particularly at locations of Kandla., whereas $\text{PM}_{2.5}$ complies with the NAAQS at majority of the locations. For both the ambient air monitoring parameters (PM_{10} and $\text{PM}_{2.5}$), the major exceedance was observed at location A-5 i.e. Coal Storage Area. The gaseous pollutants (NO_x , SO_x , CO, VOCs etc.) falls within the permissible limit. The probable reasons contributing to these emissions of pollutants into the atmosphere in-and-around the port area are summarized as follows: -

1. **Port Machinery:** Port activities involve the use of various machinery and equipment, including cranes, for lifts, tugboats, and cargo handling equipment. These machines often rely on diesel engines, which can emit pollutants such as NO_x , Particulate matter, and CO. Older or poorly maintained equipment tends to generate higher emissions.
2. **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.
3. **Coal Handling:** Resuspension of dust occurs due to the transportation of coal and the handling of coal.
4. **Construction Activities:** Another reason for the high particulate matter content in this area is due to high construction activities in the surrounding area.

4.4 Remedial Measures:

Efficient mitigation strategies need to be implementation for substantial environmental and health co-benefits. To improve air quality, DPA has implemented a number of precautionary measures, such as maintaining Green zone, initiated Inter-Terminal Transfer 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 unpaved 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 that can be implemented are as follows:

- 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 will help to reduce the suspension of pollutants in air.
- Ensuring maintenance of engines and machinery to comply with emission standards.
- Frequent water sprinkling on roads to reduce dust suspension due to vehicular movement, this can be use during transporting coal to avoid suspension of coal dust.
- Use of proper transport methods, such as a conveyor belt, for excavated material and screens around the construction site.
- End to End pavement of roads in construction site could considerably reduce dust emission. Prohibition of use of heavy diesel oil as fuel could be possibly reduce pollutants. Encouraging use of low-sulfur fuels (viz. Marine Gas Oil (MGO)/Liquefied Natural Gas (LNG), can significantly reduce sulfur and PM emissions from ships.
- Retrofitting ships with exhaust gas cleaning systems can help reduce sulfur emissions. Engine upgrades, such as optimizing fuel combustion and improving engine efficiency, can reduce overall emissions.
- 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.
- 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.
- 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.
- 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.
- Periodic vacuum-sweeping mechanisms shall be adopted.

CHAPTER 5: DG STACK MONITORING

5.1 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, SO₂, 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 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 10 as follows:

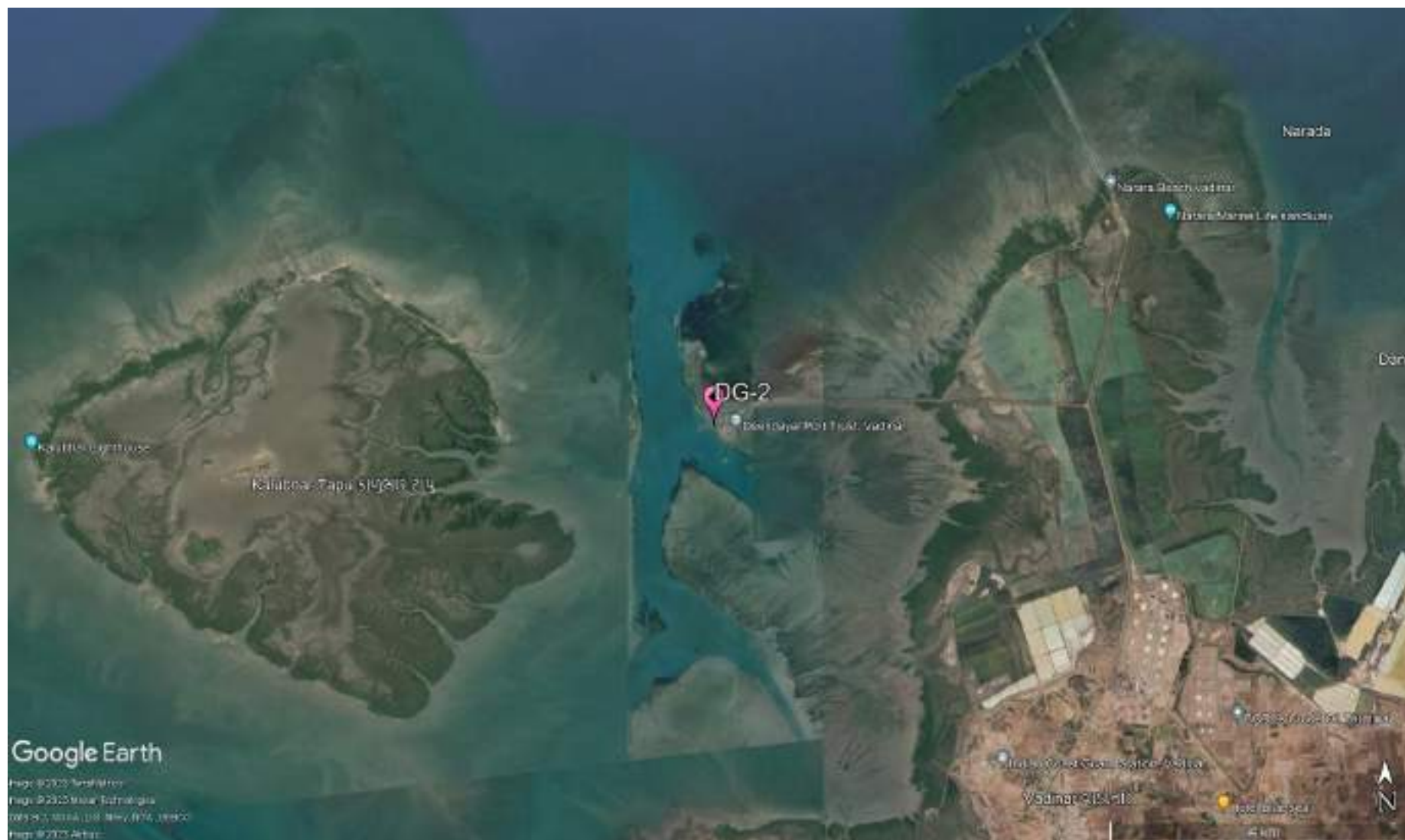
Table 10: Details of DG Stack monitoring locations

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 6 and 7** as follows:



Map 6: DG Stack monitoring Locations at Kandla



Map 7: DG Stack monitoring Locations at Vadinar

Methodology:

Under the study, the list of parameters to be monitored under the projects for DG Stack Monitoring has been mentioned in **Table 11** as follows:

Table 11: DG stack parameters

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

The methodology for monitoring of DG Stack 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 (NO_x), Carbon Monoxide and Carbon Dioxide, the monitoring is carried out by using the sensor-based Flue Gas Analyzer.

Monitoring Frequency

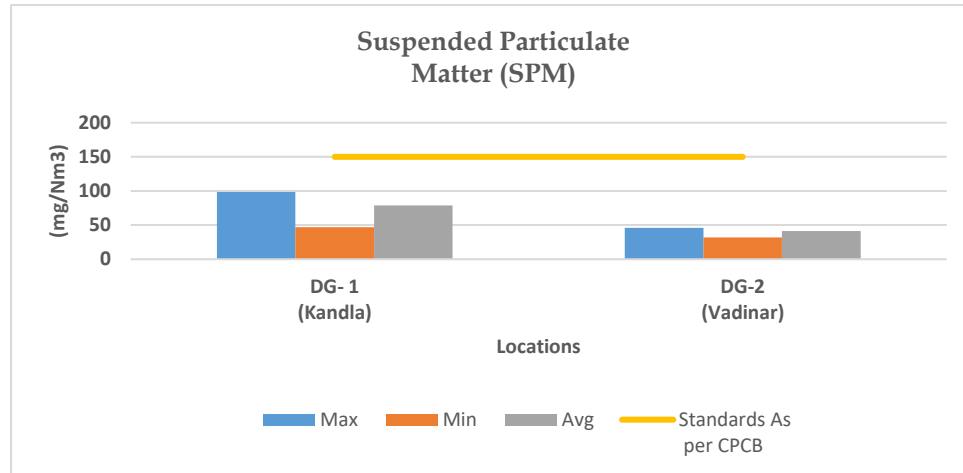
Monitoring is required to be carried out once a month for both the locations of Kandla and Vadinar for a period of April 2023 to March 2024.

5.2 Result and Discussion

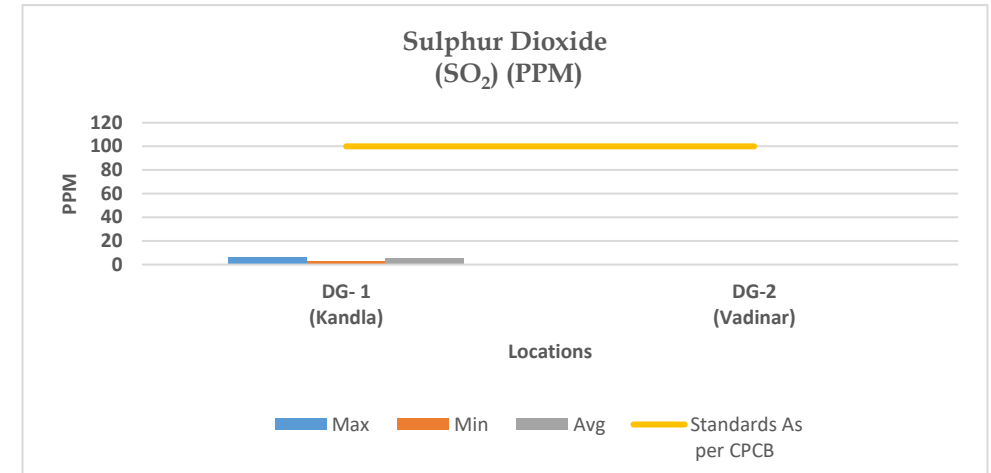
The sampling and monitoring of DG stack emission was carried out for monitoring period at Kandla and Vadinar and its comparison with CPCB or Indian standards for Industrial Stack Monitoring the flue gas emission from DG set has given in **Table 12**.

Table 12: DG monitoring data

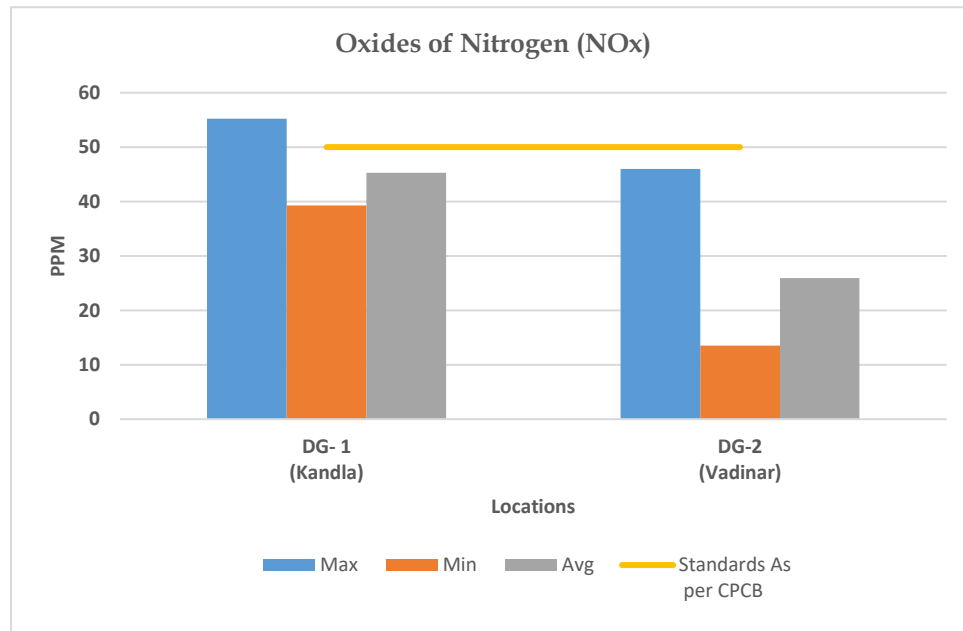
Sr. No.	Stack Monitoring Parameters for DG Sets		DG- 1 (Kandla)	DG-2 (Vadinar)	Stack Monitoring Limits /Standards As per CPCB
1.	Suspended Particulate Matter (SPM) (mg/Nm ³)	Max	98.47	45.32	150
		Min	46.82	31.85	
		Avg.	78.96	41.33	
2.	Sulphur Dioxide (SO ₂) (PPM)	Max	6.45	N.D.	100
		Min	3.25	N.D.	
		Avg.	4.95	N.D.	
3.	Oxides of Nitrogen (NO _x) (PPM)	Max	55.2	46	50
		Min	39.27	13.52	
		Avg.	45.31	25.92	
4.	Carbon Monoxide (CO) (%)	Max	0.34	0.016	1
		Min	0.007	0.002	
		Avg.	0.16	0.01	
5.	Carbon Dioxide (CO ₂) (%)	Max	3.09	1.42	-
		Min	1.21	1.03	
		Avg.	1.92	1.19	



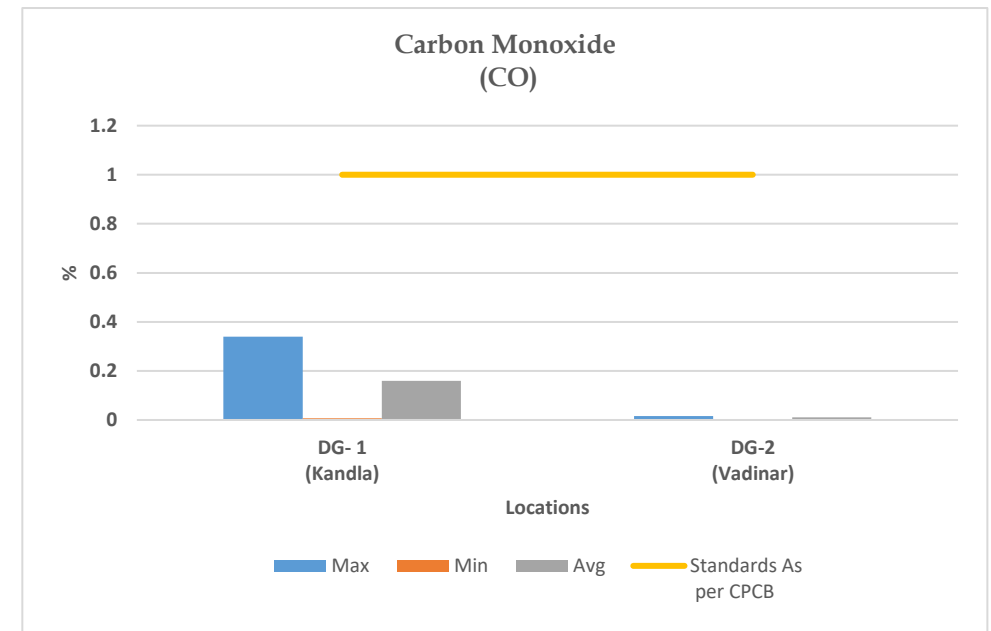
Graph 7 Spatial trend in SPM Concentration



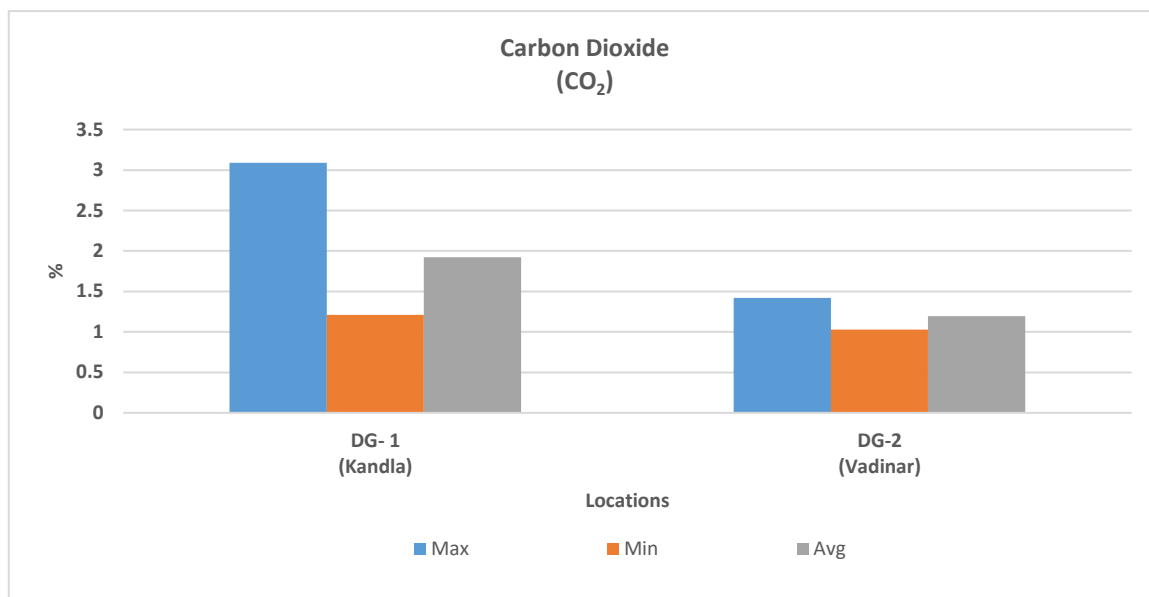
Graph 8 Spatial trend in SO_x Concentration



Graph 9 Spatial trend in NO_x Concentration



Graph 10 Spatial trend in CO Concentration



Graph 11 Spatial trend in CO₂ Concentration

5.3 Data Interpretation and Conclusion

1) Kandla:

The Suspended Particulate Matter (SPM) varies in the range of **46.82** to **98.47** mg/m³. The yearly average SPM of D.G stack-1 is **78.96** mg/m³. The maximum concentration for SPM was observed in the monitoring period of October to November 2023. The Sulphur dioxide (SO_x) varies in the range of **3.25** to **6.45** PPM. The yearly average SO_x of D.G stack-1 is **4.95** PPM. The maximum concentration of SO_x observed in the monitoring period of October to November 2023.

The NO_x varies in the range of **39.27** to **55.2** PPM. The yearly average of NO_x of D.G stack-1 at Kandla is **45.31** PPM. The maximum concentration of NO_x observed in the monitoring period of July to August 2023.

The CO at Kandla varies in the range of **0.007** to **0.34** %. The yearly average of CO of D.G stack-1 at Kandla is **0.16** %. The maximum concentration of CO observed in the monitoring period of March to April 2024.

The CO₂ at Kandla varies in the range of **1.21** to **3.09** %. The yearly average of CO₂ of D.G stack-1 at Kandla is **1.92** %. The maximum concentration of CO₂ observed in the monitoring period of March to April 2024.

The results of all the above parameters of DG stack-1 at Kandla emission are compared with the permissible limits mentioned in the consent issued by GPCB, and have been found within the prescribed limit for all the monitored parameters.

2) Vadinar:

The Suspended Particulate Matter (SPM) in the range of **31.85** to **45.32** mg/m³. The yearly average SPM of D.G stack-2 at Vadinar is **41.33** mg/m³. The maximum concentration of SPM was observed in the monitoring period of March to April 2024. There is no Sulphur dioxide (SO_x) concentration detected at Vadinar.

The NO_x at Vadinar varies in the range of **13.52** to **46** PPM. The yearly average of NO_x of D.G stack-2 at Vadinar is **25.928** PPM. The maximum concentration of NO_x observed in the monitoring period of June to July 2023.

The CO at Vadinar varies in the range of **0.002 to 0.016** %. The yearly average of CO of D.G stack-2 at Vadinar is **0.0106** % The maximum concentration of CO observed in the monitoring period of October to November 2023.

The CO₂ at Vadinar varies in the range of **1.03 to 1.42** %. The yearly average in CO₂ of D.G stack-2 at Vadinar is **1.92** % The maximum concentration of CO₂ observed in the monitoring period of June to July 2024.

The results of all the above parameters of DG stack-2 at Vadinar emission are compared with the permissible limits mentioned in the consent issued by GPCB, and have been found within the prescribed limit for all the monitored parameters.

CHAPTER 6: NOISE MONITORING

6.1 Noise Monitoring

Noise can be defined as an unwanted sound, and 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 the subsequent activities may affect surrounding environment impacting the fauna and as well as the human population. 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 not only confined to commercial areas of DPA but also the residential areas of DPA.

The details of the noise monitoring stations are mentioned in **Table 13** and locations have been depicted in the **Map 8 and 9** as follow:

Table 13: 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



Map 8: Locations for Noise Monitoring at Kandla



Map 9: Locations for Noise Monitoring at Vadinar

Methodology:

The intensity of sound energy in the environment is measured in a logarithmic scale and is expressed in a decibel (dB(A)) scale. The 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). Whereas, 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. Noise levels were measured using an integrated sound level meter of the make Envirotech Sound Level Meter (Class-I) (model No. SLM-109). 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.

Monitoring Frequency

Monitoring was carried out at each noise monitoring station for Leq. noise level (Day and Night), which was recorded for 24 hours continuously at a monthly frequency with the help of Sound/Noise Level Meter (Class-1). The details of the noise monitoring have been mentioned in **Table 14**.

Table 14: Details of the Noise Monitoring

Sr. No.	Parameters	Units	Reference Method	Instrument
1.	Leq (Day)	dB(A)	IS 9989: 2014	Noise Level Meter (Class-I) model No. SLM-109
2.	Leq (Night)	dB(A)		

Standard for Noise

Ministry of Environment & Forests (MoEF) has notified the noise standards vide the Gazette notification dated February 14, 2000 for different zones under the Environment Protection Act (1986). The day time noise levels have been monitored from 6.00 AM to 10.00 PM and night noise levels were measure from 10.00 PM to 6.00 AM at all the thirteen locations (10 at Kandla and 3 at Vadinar) monthly. The specified standards are as mentioned in **Table 15** as follows:

Table 15: Ambient Air Quality norms in respect of Noise⁽²⁾

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

6.2 Result and Discussion

The details of the Noise monitoring conducted during the monitoring period April 2023 to March 2024 have been summarized in the **Table 16** as below:

Table 16: The Results of Ambient Noise Quality

Sr. No.	Station Code	Station Name	Category of Area	Standard	Day Time in dB(A)			Standard	Night Time in dB(A)		
					Max.	Min.	Avg.		Max.	Min.	Avg.
1	N-1	Oil Jetty 7	A	75	65.7	36.5	47.75	70	57.5	33	41.801
2	N-2	West Gate No.1	A	75	68.4	36.5	54.35	70	54.2	36.1	47.02
3	N-3	Canteen Area	B	65	66.2	38	52.61	55	52.1	33	43.46
4	N-4	Main Gate	A	75	61.4	35.3	50.69	70	50.8	36.1	43.33
5	N-5	Main Road	A	75	66.1	33.5	51.67	70	55.5	33.6	43.7
6	N-6	Marin Bhavan	B	65	62.3	38.9	52.52	55	52.3	31.9	43.23
7	N-7	Port & Custom Building	B	65	66.3	37.6	50.89	55	54.3	33.9	38.91
8	N-8	Nirman Building	B	65	60.8	40.9	51	55	58.9	35.2	43.02
9	N-9	ATM Building	B	65	65.1	35.1	49.7	55	53.4	34.1	39.25
10	N-10	Wharf Area/ Jetty	A	75	74.5	36.9	52.9	70	52.7	36	42.3
11	N-11	Near Main Gate	A	75	72.3	34	62.51	70	71.2	34.3	55.71
12	N-12	Near Vadinar Jetty	A	75	76.3	39.2	64.98	70	68.5	34.7	56.38
13	N-13	Port Colony Vadinar	C	55	77.5	37.7	50.05	45	65.9	36.2	49.5

6.3 Data Interpretation and Conclusion

- 1) **Kandla:** The noise level was compared with the standard limits specified in NAAQS by CPCB. During the Day Time, the average noise level at all 10 locations at Kandla ranged from **33.5 dB(A)** to **74.5 dB(A)** while, during Night Time the average Noise Level ranged from **31.9 dB(A)** to **58.9 dB(A)**, of which six locations out of ten locations, noise level were within the permissible limits for the industrial, commercial area and residential zone for Day time and night time. Other Four locations such as i.e., **N-3 (Canteen Area)**, **N-7 (Port & Custom Building)**, **N-8 (Nirman Building)** and **N-9 (ATM building)** which are Commercial areas, slightly exceed the standard limits prescribed by NAAQS by CPCB, in the monitoring period of **April to May 2023 and May to June 2023**.
- 2) **Vadinar:** The noise level was compared with the standard limits specified in NAAQS by CPCB. During the Day Time, the average noise level at all 3 locations at Vadinar ranged from **34 dB(A)** to **77.5 dB(A)** while, during Night Time the average Noise Level ranged from **34.3 dB(A)** to **71.2 dB(A)** at Vadinar, on location **N-11 (Near main gate)** noise level was within the permissible limits for the industrial zone for Day time and night time. On locations of Vadinar such as i.e., **N-12 (Near Vadinar jetty)**, which are considered as industrial area slightly exceed the standard limits prescribed by NAAQS by CPCB, in the monitoring period of **June to July 2023**. And on location **N-13 (Port Colony Vadinar)**, most frequently exceed the permissible limit during the day time as well as night time.

6.4 Remedial Measures

The noise levels detected at the locations of Kandla and Vadinar, are found within the prescribed norms. The noise can further be considerably reduced by adoption of low noise equipment or installation of sound insulation fences. Green belt of plants can be a good barrier. If noise exceeds the applicable norms, then the working hours may be altered as a possible means to mitigate the nuisances of construction activities.

CHAPTER 7: SOIL MONITORING

7.1 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 17**:

Table 17: Details of the Soil quality monitoring

Sr. No.	Location Code	Location Name	Latitude Longitude
1.	Kandla	S-1	Oil Jetty 7
2.		S-2	IFFCO Plant
3.		S-3	Khori Creek
4.		S-4	Nakti Creek
5.	Vadinar	S-5	Near SPM
6.		S-6	Near Vadinar Jetty

Methodology

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 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 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, Gandhinagar 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 18** as follows:

Monitoring Frequency

Monitoring is required to be carried out once a month for both the locations of Kandla and Vadinar. The monitoring was done from April 2023, to March, 2024.

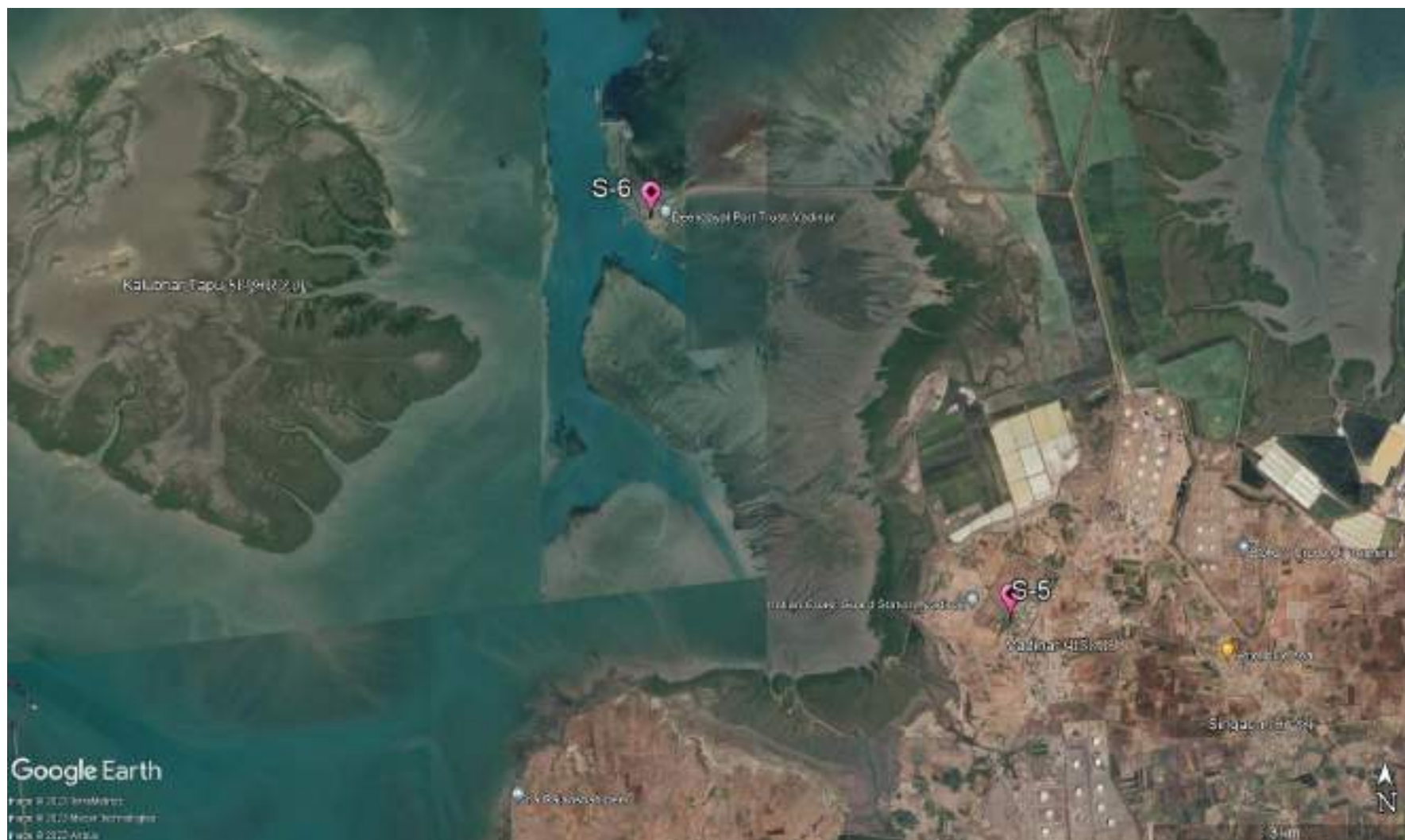
Table 18: Soil parameters

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	Kg/Hectare	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, 6 th Edition 2002 13-5.5.3 Sodium Absorption Ratio (SAR), Soluble cations	Flame Photometer
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		

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



Map 10: Soil Quality Monitoring Locations at Kandla



Map 11: Soil Quality Monitoring Locations at Vadinar

7.2 Result and Discussion

The analysis results of physical analysis of the soil samples collected during environmental monitoring period during April 2023 to March 2024 mentioned in **Table 19** are shown below:

Table 19: Soil Quality for the Monitoring period

Sr. No	Location Parameters		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	Max	9.53	8.8	8.88	9.48	8.69	9.36
		Min	7.3	6.48	6.52	7.86	7.19	8.16
		Avg.	8.24	8.20	7.96	8.52	8.14	8.55
2	Conductivity (μS/cm)	Max	71500	36500	75700	17850	501	625
		Min	587	526	586	204	63	127
		Avg	26881.17	11442	20646.33	5470	177.13	281.54
3	Inorganic Phosphate (Kg/ha)	Max	13.32	619.89	20.31	15.87	5.64	8.67
		Min	0.39	0.43	1.24	0.32	0.35	0.26
		Avg	4.21	57.15	5.64	4.71	2.39	2.25
4	Organic Carbon (%)	Max	2.83	2.54	3.83	3.35	0.85	2.48
		Min	0.03	0.08	0.14	0.27	0.06	0.14
		Avg	0.91	0.79	1.06	0.92	0.33	0.59
5	Organic Matter (%)	Max	4.88	4.38	6.6	5.78	1.47	4.28
		Min	0.06	0.14	0.24	0.32	0.09	0.241
		Avg	1.57	1.36	1.82	1.48	0.57	1.01
6	SAR (meq/L)	Max	41.45	22.91	31.51	10.01	0.25	0.45
		Min	0.81	0.36	0.5	0.36	0.05	0.09
		Avg	13.24	6.56	11.71	2.57	0.10	0.17
7	Aluminium (mg/Kg)	Max	8643.04	9065.97	10298.7	9286.91	15921.7	14806.19
		Min	812.75	830.95	840.71	916.4	735.77	754.58
		Avg	2223.8	2322.3	2517.4	2470.4	2848.2	2762.2
8	Chromium (mg/Kg)	Max	92.23	90.7	86.18	87.07	106	91.88
		Min	28.213	28.91	31.57	24.7	71.68	60.93
		Avg	52.28	58.79	59.005	53.30	82.46	70.91
9	Nickel (mg/Kg)	Max	33.32	36.66	38.1	45.41	41.425	42.68
		Min	13.17	11.82	11.91	10.43	27.14	25.52
		Avg	19.17	19.22	22.72	21.72	33.29	32.353
10	Copper (mg/Kg)	Max	92.51	88.31	150.7	192.72	123.18	104.64
		Min	12.42	14.71	14.74	12.8	81.14	60.57
		Avg	49.94	61.10	84.93	56.708	103.06	82.37
11	Zinc (mg/Kg)	Max	210.35	1755.44	188.29	142.71	88.14	97.36
		Min	16.46	42.93	29.9	23.57	37.03	15.33
		Avg	73.75	283.57	99.49	81.77	62.53	49.70
12	Cadmium (mg/Kg)	Max	0.397	23.47	0.59	0	3	0
		Min	0.397	0.5	0.59	0	3	0
		Avg	0.397	6.608	0.59	0	3	0
13	Lead (mg/Kg)	Max	50.28	277.82	47.87	26.48	1.58	21.07
		Min	3.79	2.58	1.29	2.26	0.59	0.89
		Avg	12.09	32.75	15.59	8.88	1.08	6.66

Sr. No	Location Parameters		Kandla				Vadinar	
			S-1 (Oil Jetty 7)	S-2 (IFFCO Plant)	S-3 (Khorī Creek)	S-4 (Nakti Creek)	S-5 (Near SPM)	S-6 (Near Vadinar Jetty)
14	Arsenic (mg/Kg)	Max	4.87	8.4	5.28	6.62	0.4	5.05
		Min	0.1	0.29	0.88	0.3	0.099	0.59
		Avg	2.38	3.04	2.97	2.26	0.22	2.82
15	Mercury (mg/Kg)	Max	0	0	0	0	0	0
		Min	0	0	0	0	0	0
		Avg	0	0	0	0	0	0
16	Water Holding Capacity (%)	Max	54	77.92	61.99	75.84	60	66
		Min	35.8	34	23.74	15.9	39.85	44
		Avg	42.66	46.48	43.95	48.34	47.70	60.01
17	Sand (%)	Max	77.61	77.7	85.46	82.36	62.4	78.46
		Min	44.4	46.57	48.27	13.39	42.26	42.25
		Avg	59.26	65.74	62.96	65.03	51.61	60.59
18	Silt (%)	Max	53.28	47.28	41.25	57.98	49.27	53.27
		Min	9.77	9.28	9.93	9.28	12.24	12
		Avg	30.41	26.40	28.84	24.13	34.72	29.17
19	Clay (%)	Max	19.53	14.32	22.35	28.63	35.92	21.02
		Min	2.32	0.63	0.64	0.48	1.75	1.74
		Avg	10.29	7.86	8.19	10.83	13.66	10.23
20	Texture		Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Loam	Sandy Loam

7.3 Data Interpretation and Conclusion

Soil samples were collected from 6 locations (4 at Kandla and 2 at Vadinar) and further analysed for its physical & chemical characteristics. Each of the parameters have been given an interpretation based on the observations as follows:

1) Kandla:

- The value of **pH** ranges from **6.48** to **9.53**, with the highest at location **S-1 (Oil Jetty 7)** and the lowest at **location S-2 (IFFCO plant)**, while the average pH for Kandla was observed to be **8.23**. The pH in Kandla varies from **Slightly alkaline to strongly alkaline**
- At all monitoring locations, the value of **Electrical Conductivity** ranges from **204 to 75,700 $\mu\text{S}/\text{cm}$** , with the highest at **location S-3 (Khorī Creek)** and the lowest at **S-4 (Nakti Creek)**. The average Electrical Conductivity is **16,109.87 $\mu\text{S}/\text{cm}$** .
- The concentration of inorganic phosphate varied from **0.32 to 619.89 kg/ha**, with an average of **17.93 kg/ha**. The highest concentration of inorganic phosphate was found at **S-2 (IFFCO plant)** and the lowest concentration was found at **S-4 (Nakti Creek)**. The availability of phosphorus in the soil solution is influenced by several factors, such as organic matter, clay content, pH, temperature, and more.

- The concentration of **Total Organic Carbon** ranges from **0.03% to 3.86%**, with an average TOC of **0.92%** detected. The highest concentration was found at **location S-3 (Khorī Creek)**, and the minimum concentration was found at **S-1 (Oil Jetty 7)**.
- The **Sodium Adsorption Ratio** ranges from **0.36 to 41.45 meq/L**, with an average value of **8.25 meq/L** at Kandla. The highest concentration of SAR is found at **S-1 (Oil Jetty 7)** and the lowest concentration at **S-4 (Nakti Creek)**.
- The **Water Holding Capacity (WHC)** in the soil samples of Kandla varies from **15.9% to 77.92%**, with an average of **45.36%**. The highest concentration of WHC was observed at **S-2 (IFFCO plant)** and the lowest concentration at **S-4 (Nakti Creek)**.
- The Soil Texture was observed as “**Sandy loam**” to “**loamy sand**” at all the monitoring locations in Kandla.

Heavy Metals

- During the sampling period, the concentration of **Aluminium** varied from **812.75 to 10,298.7 mg/kg**. The average **Aluminium** concentration was observed to be **2,383.475 mg/kg** at the Kandla monitoring station. The **highest concentration** was observed at **S-3 (Khorī Creek)**, and the **lowest concentration** was observed at **S-1 (Oil Jetty 7)**.
- The concentration of **Chromium** varied from **24.7 to 92.23 mg/kg**, with an average value of **55.848 mg/kg** observed at the Kandla monitoring station. The highest concentration was observed at **S-1 (Oil Jetty 7)**, and the lowest concentration was observed at **S-4 (Nakti Creek)**.
- The concentration of **Nickel** varied from **10.43 to 45.41 mg/kg** at Kandla, with an average value of **20.71 mg/kg** at the Kandla monitoring station. The highest concentration was observed at **S-4 (Nakti Creek)**, while the lowest concentration was also observed at **S-4 (Nakti Creek)**.
- The concentration of **Zinc** varied from **16.46 to 1755.4 mg/kg** at Kandla, with an average value of **134.64 mg/kg** at the Kandla monitoring station. The highest concentration was observed at **S-2 (IFFCO plant)**, which was the only spike observed during the entire monitoring period at Kandla. The lowest concentration was observed at **S-1 (Oil Jetty 7)**.
- The concentration of **Copper** varied from **12.42 to 192.72 mg/kg**, with an average value of **13.667 mg/kg** observed at the Kandla monitoring station. The highest concentration was observed at **S-4 (Nakti Creek)** and the lowest concentration was observed at **S-1 (Oil Jetty 7)**.
- The concentration of **Lead** varied from **1.29 to 277.82 mg/kg**, with an average value of **17.33 mg/kg**. The highest concentration was observed at **S-2 (IFFCO plant)**; this was the only spike observed during the entire monitoring period, while the lowest concentration was observed at **S-3 (Khorī creek)**.
- The concentration of **Arsenic** varied from **0.1 to 8.4 mg/kg**, with an average value of **2.67 mg/kg**. The highest concentration was observed at **S-1 (Oil Jetty 7)**, and the lowest concentration was observed at **S-3 (Khorī Creek)**.
- The concentration of **Cadmium** varied from **0 to 23.47 mg/kg**, with an average value of **1.89 mg/kg**. The highest concentration was observed at **S-2 (IFFCO plant)**. During the monitoring period, it was observed that cadmium was mostly found **Below**

Quantification Limit (BQL) at all locations, with only one spike observed at **S-2 (IFFCO plant)** throughout the entire monitoring period.

- During the monitoring period, it was observed that the concentration of **Mercury** was mostly found **below the quantification limit (BQL)** at all locations.

2) Vadinar:

- The value of **pH** ranges from **7.675** to **9.36**, with the highest at location **S-6 (Near Vadinar jetty)** and the lowest at **location S-5 (Near SPM)**, while the average pH for Vadinar was observed to be **8.34**. pH of Soil at Vadinar was found to be **moderately alkaline**.
- At all monitoring locations in Vadinar, the value of **Electrical Conductivity** ranges from **63** to **625** $\mu\text{S}/\text{cm}$, with the highest at **S-6 (Near Vadinar jetty)** and the lowest at **location S-5 (Near SPM)**. The average Electrical Conductivity is **229.33** $\mu\text{S}/\text{cm}$.
- The concentration of **inorganic phosphate** varied from **0.26** to **8.67** kg/ha, with an average of **2.32** kg/ha. The highest concentration of inorganic phosphate was found at **S-6 (Near Vadinar jetty)** and the lowest concentration was found at **location S-5 (Near SPM)**.
- The concentration of **Total Organic Carbon** ranges from **0.06%** to **2.48%**, with an average TOC of **0.46%** detected at Vadinar. The highest concentration was found at **S-6 (Near Vadinar jetty)**, and the minimum concentration was found at **S-5 (Near SPM)**.
- The **Sodium Adsorption Ratio** ranges from **0.05** to **0.45** meq/L, with an average value of **0.143** meq/L at Vadinar. The highest concentration of SAR is found at **6 (Near Vadinar jetty)** and the lowest concentration at **S-5 (Near SPM)**.
- The **Water Holding Capacity (WHC)** in the soil samples of Vadinar varies from **39.85%** to **66%**, with an average of **53.85%**. The highest concentration of WHC was observed at **S-6 (Near Vadinar jetty)** and the lowest concentration at **S-5 (Near SPM)**.
- The soil texture of Vadinar varies from “loam” to “slit loam”.

Heavy Metals

- During the sampling period, the concentration of **Aluminium** varied from **735.77** to **15921.72** mg/kg. The average **Aluminium** concentration was observed to be **2,805.2** mg/kg at the Vadinar monitoring station. The **highest concentration** was observed at **S-5 (Near SPM)**, and the **lowest concentration** was observed at **S-5 (Near SPM)** but during different months.
- The concentration of **Chromium** varied from **60.93** to **106** mg/kg, with an average value of **76.69** mg/kg observed at the Vadinar monitoring station. The highest concentration was observed at **S-5 (Near SPM)**, and the lowest concentration was observed at **S-6 (Near Vadinar jetty)**.
- The concentration of **Nickel** varied from **25.62** to **42.68** mg/kg, with an average value of **32.825** mg/kg at the Vadinar monitoring station. The highest concentration was observed at **S-6 (Near Vadinar jetty)**, and the lowest concentration was also observed at **S-6 (Near Vadinar jetty)** but during different months.

- The concentration of **Zinc** varied from **15.33** to **97.36** mg/kg, with an average value of **56.118** mg/kg at the Vadinar monitoring station. The highest concentration was observed at **S-6 (Near Vadinar jetty)**, and the lowest concentration was also observed at **S-6 (Near Vadinar jetty)** but during different months.
- The concentration of **Copper** varied from **60.57** to **123.18** mg/kg, with an average value of **92.71** mg/kg observed at the Vadinar monitoring station. The highest concentration was observed at **S-5 (Near SPM)** and the lowest concentration was observed at **S-6 (Near Vadinar jetty)**.
- The concentration of **Lead** varied from **0.59** to **21.07** mg/kg, with an average value of **3.875** mg/kg. The highest concentration was observed at **S-6 (Near Vadinar jetty)**; this was the only spike observed during the entire monitoring period at Kandla, while the lowest concentration was observed at **S-5 (Near SPM)**.
- The concentration of **Arsenic** varied from **0.099** to **0.59** mg/kg, with an average value of **5.05** mg/kg. The highest concentration was observed at **S-6 (Near Vadinar jetty)**, and the lowest concentration was observed at **S-5 (Near SPM)**.
- The concentration of **Cadmium** varied from **0** to **3** mg/kg, with an average value of **3** mg/kg. The highest concentration was observed at **S-5 (Near SPM)**. During the monitoring period, it was observed that cadmium was mostly found **Below Quantification Limit (BQL)** at all locations.
- During the monitoring period, it was observed that the concentration of **Mercury** was mostly found **below the quantification limit (BQL)** at all locations.

CHAPTER 8: DRINKING WATER MONITORING

8.1 Drinking Water Monitoring

It is necessary to check with the drinking water sources regularly so as to know whether water quality conforms to the prescribed standards for drinking. Monitoring the drinking water quality is essential to protect human health and the environment. With reference to the scope specified by DPA, a total of 20 locations (18 at Kandla and 2 at Vadinar) were monitored to assess the Drinking Water quality.

The details of the drinking water sampling stations have been mentioned in **Table 20** and the locations have been depicted through Google map in **Map 12 and 13**.

Table 20: Details of Drinking Water Sampling Locations

Sr. No.	Location Code	Location Name	Latitude/ Longitude
1.	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.	DW-19	Near Vadinar Jetty	22.440759N 69.675210E
20.	DW-20	Near Port Colony	22.401619N 69.716822E



Map 12: Drinking Water Monitoring Locations at Kandla



Map 13: Drinking Water Monitoring Locations at Vadinar

Methodology

The water samples were collected from the finalized sampling locations and analyzed for physico-chemical and microbiological parameter, for which the analysis 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 parameters finalized to assess the drinking water quality have been mentioned in **Table 21** as follows:

Table 21: List of parameters for Drinking Water Quality monitoring⁽³⁾

Sr. No.	Parameters	Units	Reference method	Instrument
1.	pH	-	APHA, 23 rd Edition (Section-4500-H ⁺ B):2017	pH Meter
2.	Colour	Hazen	APHA, 23 rd Edition, 2120 B:2017	Color Comparator
3.	EC	μS/cm	APHA, 23 rd Edition (Section-2510 B):2017	Conductivity Meter
4.	Turbidity	NTU	APHA, 23 rd Edition (Section -2130 B):2017	Nephlo Turbidity Meter
5.	TDS	mg/L	APHA, 23 rd Edition (Section-2540 C):2017	Vaccum Pump with filtration assembly and Oven
6.	TSS	mg/L	APHA, 23 rd Edition, 2540 D: 2017	
7.	Chloride	mg/L	APHA, 23 rd Edition (Section-4500-Cl-B):2017	Titration Apparatus
8.	Total Hardness	mg/L	APHA, 23 rd Edition (Section-2340 C):2017	
9.	Ca Hardness	mg/L	APHA, 23 rd Edition (Section-3500-Ca B):2017	
10.	Mg Hardness	mg/L	APHA, 23 rd Edition (Section-3500-Mg B):2017	
11.	Free Residual Chlorine	mg/L	APHA 23 rd Edition, 4500	
12.	Fluoride	mg/L	APHA, 23 rd Edition (Section-4500-F-D):2017	UV- Visible Spectrophotometer
13.	Sulphate	mg/L	APHA, 23 rd Edition (Section 4500-SO ₄ -2-E):2017	
14.	Sodium	mg/L	APHA, 23 rd Edition (Section-3500-Na-B):2017	Flame Photometer
15.	Potassium	mg/L	APHA, 23 rd Edition, 3500 K-B: 2017	
16.	Salinity	mg/L	APHA, 23 rd Edition (section 2520 B, E.C. Method)	Salinity /TDS Meter
17.	Nitrate	mg/L	APHA, 23 rd Edition, 4500 NO ₃ - B: 2017	UV- Visible Spectrophotometer
18.	Nitrite	mg/L	APHA, 23 rd Edition, 4500 NO ₂ -B: 2017	
19.	Hexavalent Chromium	mg/L	APHA, 23 rd Edition, 3500 Cr B: 2017	
20.	Manganese	mg/L	APHA, 23 rd Edition, ICP Method 3120 B: 2017	ICP-OES

Sr. No.	Parameters	Units	Reference method	Instrument
21.	Mercury	mg/L	EPA 200.7	
22.	Lead	mg/L	APHA ICP 23 rd Edition (Section-3120 B):2017	
23.	Cadmium	mg/L	APHA ICP 23 rd Edition (Section-3120 B):2017	
24.	Iron	mg/L	APHA ICP 23 rd Edition (Section-3120 B):2017	
25.	Total Chromium	mg/L	APHA ICP 23 rd Edition (Section-3120 B):2017	
26.	Copper	mg/L	APHA, 23 rd Edition, ICP Method 3120 B: 2017	ICP-OES
27.	Zinc	mg/L	APHA ICP 23 rd Edition (Section-3120 B):2017	
28.	Arsenic	mg/L	APHA ICP 23 rd Edition (Section-3120 B):2017	
29.	Total Coliforms	MPN/100ml	IS 15185: 2016	LAF/ Incubator

Monitoring Frequency

Monitoring is required to be carried out once a month for both the locations of Kandla and Vadinar. Sample Collected from this location during the monitoring period April/2023 to March/2024.

8.2 Result and Discussion

The drinking water quality of the locations at Kandla and Vadinar and its comparison with the to the stipulated standard (Drinking Water Specifications i.e., IS: 10500:2012) ⁽⁴⁾ have been summarized in **Table 22A, 22B, 22C** as follows:

Table 22A: Drinking Water Quality for the Monitoring period

Parameters	Standard values as per IS-		DW-1 (Oil Jetty 7)			DW-2 (Port & Custom Building)			DW-3 (North Gate)			DW-4 (Workshop)			DW-5 (Canteen Area)			DW-6 (West Gate 1)			DW-7 (Sewa Sadan -3)		
	A	P	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
pH	6.5-8.5		7.9	6.6	7.4	8.4	6.8	7.3	8.0	6.8	7.3	8.1	7.1	7.4	8.2	7.3	7.7	8.4	7.2	7.7	8.2	7.2	7.5
Colour (Hazen)	5	15	5.0	1.0	1.7	5.0	1.0	1.3	5.0	1.0	1.3	5.0	1.0	1.3	5.0	1.0	3.3	5.0	1.0	1.7	5.0	1.0	1.3
EC (µS/ cm)			370	19.4	195.6	600.	36.0	153.8	1653	27.0	259.7	401	12.8	85.6	2200	42.0	1056	1470	28.0	336.3	150	22	57.8
Salinity (PSU)			1.0	0.0	0.2	0.3	0.0	0.1	0.8	0.0	0.1	0.2	0.0	0.0	1.1	0.0	0.5	0.7	0.0	0.2	0.1	0	0.0
Turbidity (NTU)	1	5	1.2	1.1	1.1	2.0	1.5	1.8	1.9	0.7	1.2	3.7	0.9	2.3	3.1	0.9	1.9	1.5	1.0	1.2	5.9	1.1	3.5
Chloride (mg/L)	250	1000	81	5.8	41.6	92	7.5	34.1	354.9	8.0	56.9	110	3	22.9	437.4	10.3	192.0	329.9	9.0	78	42.5	6.5	15.7
Total Hardness (mg/L)	200	600	42	3	13.3	148	3	24.8	320	2.0	33.4	20.0	2	7.5	310	10	181	230	5.0	53.2	10	2	4.1
Ca Hardness (mg/L)			27	2	6.3	92	2	13.9	200	1.0	20.3	8.0	1	3.3	210.0	5	103.9	120.0	2.5	28.9	5.0	1	2.2
Mg Hardness (mg/L)			15	1	6.8	56	1	10.1	120	1.0	13.1	12	1	3.9	120.0	5	76.6	110.0	2.0	24.4	5.0	1	2
Free Residual Chlorine (mg/L)	0.2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TDS (mg/L)	500	2000	184	10	101.7	306	20	81.8	840	14	132.7	204	8.0	44.7	928	22	452.4	752	20.0	171.6	78	14	30.8
TSS (mg/L)			0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	0	0	0	0	0	0
Fluoride (mg/L)	1	1.5	0.4	0.4	0.4	0.5	0.4	0.5	0.7	0.3	0.4	0.0	0.0	0.0	0.9	0.3	0.5	0.9	0.7	0.8	0.4	0.4	0.4
Sulphate (mg/L)	200	400	15.7	15.7	15.7	35.7	35.7	35.7	73.9	73.9	73.9	0.0	0.0	0.0	113.3	2.2	64.0	97.3	2	55.3	0	0	0



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Parameters	Standard values as per IS-		DW-1 (Oil Jetty 7)			DW-2 (Port & Custom Building)			DW-3 (North Gate)			DW-4 (Workshop)			DW-5 (Canteen Area)			DW-6 (West Gate 1)			DW-7 (Sewa Sadan -3)		
	A	P	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
Nitrate (mg/L)	45		26	3.7	12.5	4.2	0.5	1.8	7.5	1.3	4.6	2.4	2.4	2.4	8.8	3.4	5.8	5.7	1.3	2.8	2.1	2.1	2.1
Nitrite (mg/L)			0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.1	0.1	0.2	0.2	0.2	0	0	0
Sodium (mg/L)			86	5	34.5	38.5	7	21.2	178.6	9.7	38.0	42.6	5.7	18.0	319.6	12.0	118.4	197.5	8.8	44.1	15.1	5.5	9.6
Potassium (mg/L)			0	0	0	0	0	0	0	0	0	0	0	0	5.8	5.8	5.8	0	0	0	0	0	0
Hexavalent Chromium (mg/L)			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odour (TON)	Agreeable			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Arsenic (mg/L)	0.01	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cadmium (mg/L)	0.003		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper (mg/L)	0.05	1.5	17.3	0	5.8	8.4	0.0	2.8	6.2	0.0	3.1	11.1	0.0	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Iron (mg/L)	0.3		0.6	0	0.3	0.2	0.2	0.2	0.2	0.0	0.1	0.2	0.2	0.2	0.2	0.0	0.1	0.2	0.0	0.1	0.1	0.1	0.1
Lead (mg/L)	0.01		3.1	0	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manganese (mg/L)	0.1	0.3	0.1	0	0.1	0	0	0	0.5	0.5	0.5	0.1	0.1	0.1	0	0	0	0.5	0	0.2	0	0	0
Mercury (mg/L)	0.001		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Chromium (mg/L)	0.05		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zinc (mg/L)	5	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Coliform* (MPN/ 100ml)	Shall not be detected		630.0	5.0	118.0	12500.0	5.0	1629.3	250.0	10.0	100.7	50.0	5.0	24.0	144500	5.0	17137	4350	5.0	1407	23500	2.0	3963.3



Table 22B: Drinking Water Quality for the Monitoring period

Parameters	Standard values as per IS		DW-8 (Nirman Building)			DW-9 (Custom Building)			DW-10 (Port Colony Kandla)			DW-11 (Wharf Area/ Jetty)			DW-12 (Hospital Kandla)			DW-13 (A.O. Building)			DW-14 (School Gopalpuri)		
	A	P	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
pH	6.5-8.5		8	7	7.5	8	6.2	7.3	7.9	6.82	7.31	8.3	6.85	7.71	7.75	6.62	7.224	8.5	7.2	7.61	8.2	7.08	7.56
Colour (Hazen)	5	15	5.0	1.0	2.3	5.0	1.0	2.0	5.0	1	2	10	1	3.083	5	1	1.67	5	1	1.33	10	1	3.28
EC ($\mu\text{S}/\text{cm}$)			2000	40.0	403.8	2900.0	48.0	492.9	3100	105.4	554.9	2460	55	980.1	269	47	141.2	1412	23.2	187.2	1467	43.3	412.15
Salinity (PSU)			1.0	0.0	0.2	1.5	0.0	0.2	1.6	0.05	0.283	1.2	0.02	0.42	0.13	0.03	0.072	0.71	0.02	0.151	0.73	0.03	0.22
Turbidity (NTU)	1	5	3.6	1.1	1.8	4.7	1.0	2.8	2.2	0.95	1.575	3.79	1	2.09	2	1.02	1.57	9.9	0.9	3.67	13.9	0.5	5.48
Chloride (mg/L)	250	1000	499.9	10.0	93.1	689.8	12.5	108.7	504.8	21.99	75.52	404.8	13.54	173.9	67.98	12.5	31.79	307.4	7.5	44.28	332.4	11.5	93.83
Total Hardness (mg/L)	200	600	280.0	4.0	61.8	480	6.0	80.2	340.0	3	62.83	320	15	176.4	30	3	17.84	240	1.5	70.3	270	2	82.64
Ca Hardness (mg/L)			140.0	2.0	31.8	240	3.0	38.7	190.0	2	33.5	170	5	91.30	17	2	9.67	120	1	31.12	140	1.5	42.96
Mg Hardness (mg/L)			140.0	2.0	30.1	190	3.0	37.5	150.0	1	29.32	150	10	84.76	14	1	8.167	120	0.5	33.15	130	2	43.6
Free Residual Chlorine (mg/L)	0.2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TDS (mg/L)	500	2000	1012	22.0	205.2	1522	24.0	255.8	1064	54	165.4	872	29	403.8	138	24	73.17	718	14	101.9	742	22	218
TSS (mg/L)			2.0	2.0	2.0	12.0	2.0	7.0	2.0	2	2	2	2	2	0	0	0	0	0	0	12	8	10
Fluoride (mg/L)	1	1.5	0.0	0.0	0.0	1.5	0.6	1.1	0.5	0.416	0.433	1.06	0.367	0.57	1.108	1.108	1.108	0	0	0	0.35	0.15	0.25
Sulphate (mg/L)	200	400	100.8	45.5	73.2	142.0	41.5	80.0	115.6	3.17	59.39	134.7	1.97	59.51	0	0	0	108.7	108.77	108.7	113.4	11.55	56.304
Nitrate (mg/L)	45		4.5	1.1	2.6	5.6	2.4	3.8	7.5	1.04	3.68	8.49	3.78	5.929	2.023	1.42	1.752	3.392	1.524	2.585	4.48	1.382	2.38



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Parameters	Standard values as per IS		DW-8 (Nirman Building)			DW-9 (Custom Building)			DW-10 (Port Colony Kandla)			DW-11 (Wharf Area/ Jetty)			DW-12 (Hospital Kandla)			DW-13 (A.O. Building)			DW-14 (School Gopalpuri)		
	A	P	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
Nitrite (mg/L)			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0.201	0.11	0.147	0	0	0	0	0	0	0	0	0
Sodium (mg/L)			109.5	9.2	39.4	396.2	8.0	75.4	105.8	11.98	37.65	356.5	12.8	106.5	31.35	11.59	20.22	83.91	8.66	21.44	173.5	6.24	46.666
Potassium (mg/L)			0	0	0	13.6	13.6	13.6	7.0	2.6	4.8	0	0	0	0	0	0	0	0	0	0	0	0
Hexavalent Chromium (mg/L)			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odour (TON)	Agreeable			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Arsenic (mg/L)	0.01	0.05	0	0	0	0	0	0	0	0.007	0.007	0.005	0.0039	0.004	0	0	0	0	0	0	0.015	0.015	0.015
Cadmium (mg/L)	0.003		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.005	0.005	0.005	0.006	0.006	0.006
Copper (mg/L)	0.05	1.5	6.8	0	3.4	0	0	0	10.2	0.005	2.049	0	0	0	9.257	0.005	3.57	0.008	0.0079	0.008	0	0	0
Iron (mg/L)	0.3		0.1	0.1	0.1	0	0	0	0.3	0.0001	0.16	0.17	0.0001	0.092	0	0	0	0.13	0.13	0.13	0.0001	0.0001	0.0001
Lead (mg/L)	0.01		0.2	0	0.1	0	0	0	0	0.0033	0.003	0.004	0.0038	0.004	0.0028	0.003	0.003	0.002	0.002	0.002	4.27	4.27	4.27
Manganese (mg/L)	0.1	0.3	0.2	0.2	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0.05	0.05	0.05	0	0	0
Mercury (mg/L)	0.001		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Chromium (mg/L)	0.05		0	0	0	0	0	0	0	0	0	0	0	0	0.0122	0.012	0.012	0.006	0.006	0.006	0	0	0
Zinc (mg/L)	5	15	0	0	0	0.6	0.6	0.6	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Coliform* (MPN/ 100ml)	Shall not be detected		240.0	2.0	114.7	12050	4.0	1826	37080	35	5374	25550	5	3329	140	4	47.2	685	20	166.7	4900	15	636.4



Table 22C: Drinking Water Quality for the Monitoring period

Parameters	Standard values as per IS		DW-15 (Guest House)			DW-16 (E- Type Quarter)			DW-17 (F- Type Quarter)			DW-18 (Hospital Gopalpuri)			DW-19 (Near Vadinar Jetty)			DW-20 (Near Port Colony)		
	A	P	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
pH	6.5-8.5		7.99	6.87	7.35	7.68	6.93	7.28	8.19	6.78	7.46	8.27	7.12	7.6	8.38	7.21	7.685	8.07	7.05	7.435
Colour (Hazen)	5	15	5	1	1.67	5	1	1.67	5	1	1.67	10	1	3.5	5	1	2.333	20	1	6
EC (μ S/ cm)			264	34.3	120.22	746	17.79	116.84	1337	15.93	298.6	7930	30.2	1037	537	30	199.7	1736	88.4	427.7
Salinity (PSU)			0.7	0.02	0.113	0.38	0.02	0.06	0.67	0.02	0.16	4.39	0.02	0.55	0.26	0.02	0.100	0.87	0.05	0.235
Turbidity (NTU)	1	5	2.29	0.63	1.27	2.8	0.52	1.50	1.97	1.1	1.66	3.98	0.7	2.03	1.5	1.2	1.35	5.3	0.7	3.25
Chloride (mg/L)	250	1000	60.98	10.5	26.98	124.96	4	24.58	287.41	4	61.99	163.9	9	75.28	66.98	9	27.20	407.37	13	73.15
Total Hardness (mg/L)	200	600	20	2	11.97	180	1.5	22.86	230	2	52.6	195	4	96.25	160	2	44.58	240	20	88.5
Ca Hardness (mg/L)			10	1.5	6.25	80	1	10.77	120	1	28.5	102	2	49.43	80	1.5	21.54	140	10	44.08
Mg Hardness (mg/L)			12.5	1	6.136	100	0.5	13.25	110	1	24.1	100	1	46.79	80	1	25.09	100	8	44.41
Free Residual Chlorine (mg/L)	0.2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TDS (mg/L)	500	2000	138	18	62.75	382	10	60.5	682	8	157.5	448	16	198.8	272	15	100.9	882	46	218.5
TSS (mg/L)			0	0	0	0	0	0	0	0	0	2	2	2	2	2	2	12	4	8
Fluoride (mg/L)	1	1.5	0.34	0.34	0.34	0	0	0	0.5	0.37	0.43	0.51	0.38	0.44	0.35	0.35	0.35	1.06	1.06	1.06
Sulphate (mg/L)	200	400	10.62	10.3	10.46	34.35	34.35	34.35	104.64	8.37	41.20	59.94	1.81	40.82	42.2	13.07	31.87	102.92	25.4	48.22
Nitrate (mg/L)	45		5.63	1.12	2.53	1.97	1.97	1.97	6.06	1.19	3.20	16.51	1.17	5.1	15.79	1.82	5.55	18.54	1.06	6.45
Nitrite (mg/L)			0	0	0	0	0	0	0	0	0	0.20	0.11	0.16	0	0	0	1.89	1.89	1.89



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Parameters	Standard values as per IS		DW-15 (Guest House)			DW-16 (E- Type Quarter)			DW-17 (F- Type Quarter)			DW-18 (Hospital Gopalpuri)			DW-19 (Near Vadinar Jetty)			DW-20 (Near Port Colony)		
	A	P	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
Sodium (mg/L)			40.46	14.3	19.38	74.46	7.06	24.85	82.61	5.75	35.30	185.2	7.08	55.81	58.37	6.08	20.49	204.04	7.18	46.23
Potassium (mg/L)			0	0	0	0	0	0	0	0	0	3.2	3.2	3.2	0	0	0	5.85	5.85	5.85
Hexavalent Chromium (mg/L)			0	0	0	0	0	0	0	0	0	0	0	0	0.041	0.041	0.041	0.01	0.01	0.01
Odour (TON)	Agreeable			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Arsenic (mg/L)	0.01	0.05	0.007	0.007	0.007	0	0	0	0.008	0.008	0.008	0.015	0.01	0.012	0.08	0.08	0.08	0	0	0
Cadmium (mg/L)	0.003		0.007	0.007	0.007	0.006	0.006	0.006	0.007	0.007	0.007	0.008	0.008	0.008	0	0	0	0	0	0
Copper (mg/L)	0.05	1.5	7.24	0.006	2.42	0	0	0	0.012	0.012	0.012	7.3	0.006	3.65	16.25	0.006	7.99	15.403	0.01	3.09
Iron (mg/L)	0.3		0.25	0.0002	0.13	0	0	0	0.52	0.0001	0.213	0.11	0.0003	0.055	1.47	1.47	1.47	0	0	0
Lead (mg/L)	0.01		2.21	0.002	1.10	0	0	0	0	0	0	0	0	0	10.53	0.003	5.26	0.002	0.002	0.002
Manganese (mg/L)	0.1	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.13	0	0.08
Mercury (mg/L)	0.001		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Chromium (mg/L)	0.05		0	0	0	0	0	0	0	0	0	0.006	0.006	0.006	0	0	0	0	0	0
Zinc (mg/L)	5	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Coliform* (MPN/ 100ml)	Shall not be detected		200	5	57.75	7650	5	1669	57000	9	6635	310	5	131	2850	120	1485	130000	10	16647

A: Acceptable, P: Permissible, BQL: Below Quantification limit Turbidity (QL=0.5 NTU), Free Residual Chlorine (QL=2 mg/L), Total Suspended Solids (QL=2 mg/L), Fluoride (QL=0.3 mg/L), Sulphate (QL=10 mg/L), Nitrate as NO₃ (QL=1 mg/L), Nitrite as NO₂ (QL=0.1mg/L), Sodium as Na (QL=5mg/L), Potassium as K (QL=5mg/L), Hexavalent Chromium (QL=0.01 mg/L), Arsenic (QL=0.005 mg/L), Cadmium (QL=0.002 mg/L), Copper (QL=0.005 mg/L), Iron (QL=0.1mg/L), Lead (QL=0.002 mg/L), Manganese (QL=0.04 mg/L), Mercury (QL=0.0005 mg/L), Total Chromium (QL=0.005 mg/L), Zinc (QL=0.5 mg/L), Total Coliforms (QL=1 MPN/ 100ml)

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

8.3 Data Interpretation and Conclusion

Drinking water samples were taken from 20 locations (18 at Kandla and 2 at Vadinar), and their physical and chemical properties were analyzed. The analysis's results were compared with standard values as prescribed in IS 10500:2012 Drinking Water Specification.

Physico-Chemical Parameters:

- **pH:** The pH values of drinking water samples in Kandla were reported to be in the range of **6.24 to 8.5**, with an average pH of **7.5**. In Vadinar, its values ranged from **7.05 to 8.38**, with an average pH of **7.36**. Notably, the pH levels at both project sites fall within the acceptable range of 6.5 to 8.5, as specified under IS:10500:2012.
- **Colour:** The colour varies from 1 to 10 at the monitoring locations in Kandla. Locations DW-11, DW-14 and DW-10 showed the value of 10 Hazen at Kandla. At Vadinar, the color was observed within the range of 1 to 20 Hazen. the Colour levels at both project sites fall within the acceptable range of 1 to 15, as specified under IS:10500:2012, except of one location DW-20 within the monitoring period of April to May 2023
- **Electrical Conductivity (EC):** It is a measure of the ability of a solution to conduct electric current, and it is often used as an indicator of the concentration of dissolved solids in water. During the monitoring period, the EC values for samples collected in Kandla were observed to range from **12.83 to 7930 $\mu\text{S/cm}$** , with an average value of **708.65 $\mu\text{S/cm}$** . In Vadinar, the EC values showed variation from **30 to 1736 $\mu\text{S/cm}$** , with an average value of **503.14 $\mu\text{S/cm}$** . It's important to regularly monitor EC levels in drinking water as it can provide valuable information about water quality and presence of dissolved substances.
- **Salinity:** Salinity at Kandla varies from **0.02 to 4.39 PSU** with an average of **0.396 PSU**, while at Vadinar, salinity was observed within the range of **0.02 to 0.87 PSU**.
- **Turbidity:** The Turbidity values of drinking water samples in Kandla were reported to be in the range of **0.5 to 13.9 NTU**, with an average of **2.32**. In Vadinar, its values ranged from **0 to 5.3**, with an average **2.21**. Notably, the Turbidity levels at both project sites fall within the acceptable range of 1 to 5 NTU, as specified under IS:10500:2012, except DW-7, in the monitoring period of July to August 2023, DW-13 in the monitoring period of May to June 2023 and DW-14 in the monitoring period of September to October and October to November 2023. On all this location most of the time Turbidity observed Below Quantification Limit
- **Chlorides:** The chloride concentrations in Kandla varied from **3 to 689.78 mg/L**, with an average value of **116.85 mg/L**. At Vadinar the chloride concentration was observed within the range of **9 mg/L to 407.37 mg/L**, with an average value of **99.45 mg/L**. Thus, the chloride levels at both project sites fall within the Permissible limit of 1000 mg/L, as specified under IS:10500:2012.
- **Total Hardness (TH):** The concentration of Total Hardness varies from **1.5 to 480 mg/L**, with an average concentration of **88.68 mg/L**. While at Vadinar, the observed values were within range of **2 to 240 mg/L**. at both study areas Total Hardness found

to be within the Permissible limit norm of 600 mg/L as specified by IS:10500:2012 and is not harmful for local inhabitants.

- **Total Dissolved Solids (TDS):** Monitoring TDS is crucial because it provides an indication of overall quality of the water. During the monitoring period, the TDS concentrations in Kandla were observed to vary in a wide range i.e., between 8 to **1522** mg/L, with an average concentration of **264.4** mg/L. which is within the permissible limit. while in Vadinar, it ranged from 6 to **882** mg/L, with an average of **255.75** mg/L. It is important to note that the TDS concentrations in both Kandla and Vadinar fall well within the Permissible limit of 2000 mg/L.
- **Fluoride:** The concentration Fluoride varies from 0 to **1.477** mg/L, with an average concentration of **0.44** mg/L. While at Vadinar Fluoride concentration was varies within range of 0 to **1.06** mg/L, with an average concentration of **0.708** mg/L. The Fluoride concentration was found to be **BQL** in majority of the monitoring location at Kandla and Vadinar. at both study areas Fluoride found to be within the Permissible limit norm of 1.5 mg/L as specified by IS:10500:2012
- **Sulphate:** The concentration Sulphate varies from 0 to **141.99** mg/L, with an average concentration of **45.67** mg/L. While at Vadinar Sulphate concentration was varies within range of **13.07** to **102.92** mg/L, with an average concentration of **43.94** mg/L. During monitoring period in Kandla and Vadinar, the sulphate concentrations were found to be within the acceptable limits i.e., 200 mg/L as per the specified norms.
- **Nitrate:** The concentration Nitrate varies from 0 to **25.96** mg/L, with an average concentration of **4.08** mg/L. While at Vadinar Nitrate concentration was varies within range of 0 to **18.54** mg/L, with an average concentration of **8.20** mg/L. The Nitrate concentration was found to be **BQL** in majority of the monitoring location at Kandla and Vadinar. at both study areas Nitrate found to be within the Acceptable limit norm of 45 mg/L as specified by IS: 10500:2012.
- **Nitrite:** The concentration Nitrite varies from 0 to **0.2** mg/L. While at Vadinar Nitrite concentration was varies within range of 0 to **1.89** mg/L, with an average concentration of **0.945** mg/L. The Nitrite concentration was found to be **BQL** in majority of the monitoring location at Kandla and Vadinar.
- **Sodium:** During the monitoring period, at Kandla variation in the concentration of Sodium was observed to be in the range of **5.01** to **396.2** mg/L, with the average concentration of **63.71** mg/L. While at Vadinar, the concentration recorded between **6.08** to **204.4** mg/L, with the average concentration of **57.067** mg/L.
- **Odour:** Odour values recorded 1 TON at all monitoring locations of Kandla and Vadinar.

Metals:

- **Arsenic:** The Arsenic concentrations in Kandla varied from 0 to **0.042** mg/L. At Vadinar the Arsenic concentration was observed within the range of 0 mg/L to **0.08** mg/L. Thus, the Arsenic levels at both project sites fall within the Permissible limit of 0.05 mg/L, as specified under IS:10500:2012, except on one location at Vadinar DW-19 where Arsenic Concentration found 0.08 mg/L in the monitoring period of November to December 2023. In Kandla and Vadinar, the Arsenic concentrations were recorded

BQL for majority of the locations except the locations DW-2, DW-12, and DW-18 in Kandla and DW-20 In Vadinar.

- **Copper:** The Copper concentrations in Kandla varied from **0 to 17.3 mg/L**. At Vadinar the Copper concentration was observed within the range of **0 mg/L to 16.25 mg/L**. Thus, the Copper levels at both project sites fall within the Permissible limit of **1.5 mg/L**, as specified under IS:10500:2012, except for locations DW-1, DW-2, DW-4, DW-8, DW-10, DW-12, DW-15, DW-18 in Kandla and on both Locations DW-19 and DW-20 of Vadinar for some samples taken during whole monitoring period. The Copper concentrations were recorded BQL for majority of the locations in Kandla and Vadinar.
- **Iron:** The Iron concentrations in Kandla varied from **0 to 0.64 mg/L**, with an average concentration of **0.10 mg/L**. At Vadinar the Iron concentration was observed within the range of **0 mg/L to 1.478 mg/L**. Thus, the Iron levels at both project sites fall within the Acceptable limit of **0.3 mg/L**, as specified under IS:10500:2012, except for locations DW-1, DW-10, and DW-17 in Kandla and on Location DW-19 of Vadinar for some samples taken during the whole monitoring period. The Iron concentrations were recorded by BQL for the majority of the locations in Kandla and Vadinar.
- **Lead:** The Lead concentrations in Kandla varied from **0 to 4.279 mg/L**, with an average concentration of **0.37 mg/L**. While at Vadinar the Lead concentration was observed within the range of **0 mg/L to 10.53 mg/L**, with an average concentration of **2.6344**. Thus, the Lead levels at both project sites fall within the Acceptable limit of **0.01 mg/L**, as specified under IS:10500:2012, except for locations DW-1, DW-8, DW-14 and DW-15 in Kandla and on Location DW-19 of Vadinar for some samples taken during the whole monitoring period. The Lead concentrations were recorded in BQL for the majority of the locations in Kandla and Vadinar.
- **Manganese:** The Manganese concentrations in Kandla varied from **0 to 0.51 mg/L**, with an average concentration of **0.1 mg/L**. While at Vadinar, the Manganese concentration was observed within the range of **0 mg/L to 0.13 mg/L**. Thus, the Manganese levels at both project sites fall within the Acceptable limit of **0.3 mg/L**, as specified under IS:10500:2012, except for locations DW-3, and DW-6 in Kandla and on Location DW-20 of Vadinar for some samples taken during the whole monitoring period. The Manganese concentrations were recorded BQL for the majority of the locations in Kandla and Vadinar.
- The concentrations of parameters such as **Free Residual Chlorine, Total Suspended Solid, Potassium Hexavalent Chromium and the metals (Cadmium, Mercury, Total Chromium and Zinc)** were observed to fall within the Permissible limit at both project sites. Observed “Below the Quantification Limit (BQL)” at majority of the locations during the monitoring period.
- Bacteriological Analysis of the drinking water reveals that **Total Coliforms (TC)** were detected in the range of **0 to 144500 MPN/100ml**, with the average of **6964.8 MPN/100ml**. While at Vadinar the observed within the range of **0 MPN/100ml to 1,30,000 MPN/100ml**, with the average concentration of **25,185 MPN/100ml**. And for the rest of the monitoring locations of Kandla and Vadinar were detected “Below the Quantification Limit (BQL)”. Reporting such concentration of Coliforms indicates

certain external influx may contaminate the source. Hence, it should be checked at every distribution point. The higher concentration of total coliforms were observed on locations DW-2, DW-5, DW-7, DW-10, DW-11, and DW-17 in Kandla and DW-20 location in Vadinar.

8.4 Remedial Measures

Appropriate water treatment processes should be administered to eradicate coliform bacteria. The methods of disinfection such as **chlorination, ultraviolet (UV), or ozone** etc, apart from that, filtration systems can also be implemented to remove bacteria, sediment, and other impurities.

The following steps can be implemented to ensure that the water being supplied is safe for consumption:

- Regular monitoring should be carried out to assess 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 contaminants in the drinking water.
- It is necessary to carry out a system assessment to determine whether the drinking-water supply chain (up to the point of consumption) as a whole can deliver water of a quality that meets identified targets. This also includes the assessment of design criteria of the treatment systems employed.
- Identifying control measures in a drinking-water system that will collectively control identified risks and ensure that the health-based targets are met. For each control measure identified, an appropriate means of operational monitoring should be defined that will ensure that any deviation from required performance (water quality) is rapidly detected in a timely manner.
- Management and communication plan should be formulated describing actions to be taken during normal operation as well as during incident conditions (such as drinking water contamination) and documenting the same.



CHAPTER 9: SEWAGE TREATMENT PLANT MONITORING

9.1 Sewage Treatment Plant (STP) Monitoring:

The principal objective of STP 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 STP Monitoring is to be carried out weekly at three locations, one at Kandla, one at Gopalpuri and one STP at Vadinar. The samples from the inlet and outlet of the STP have been collected weekly. The details of the locations of STP to be monitored for Kandla and Vadinar have been mentioned in **Table 23A** as follows:

Frequency of monitoring: weekly

Table 23A: Details of the monitoring locations of STP

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 GPCB were referred for the details of the STP for Kandla and Gopalpuri. The CC&A of Kandla and Gopalpuri entails that the treated domestic sewage should conform to the norms specified in **Table 23B**. 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 22B: Discharge norms (as per CC&A of Kandla STP)

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 3 and 4** as follows:

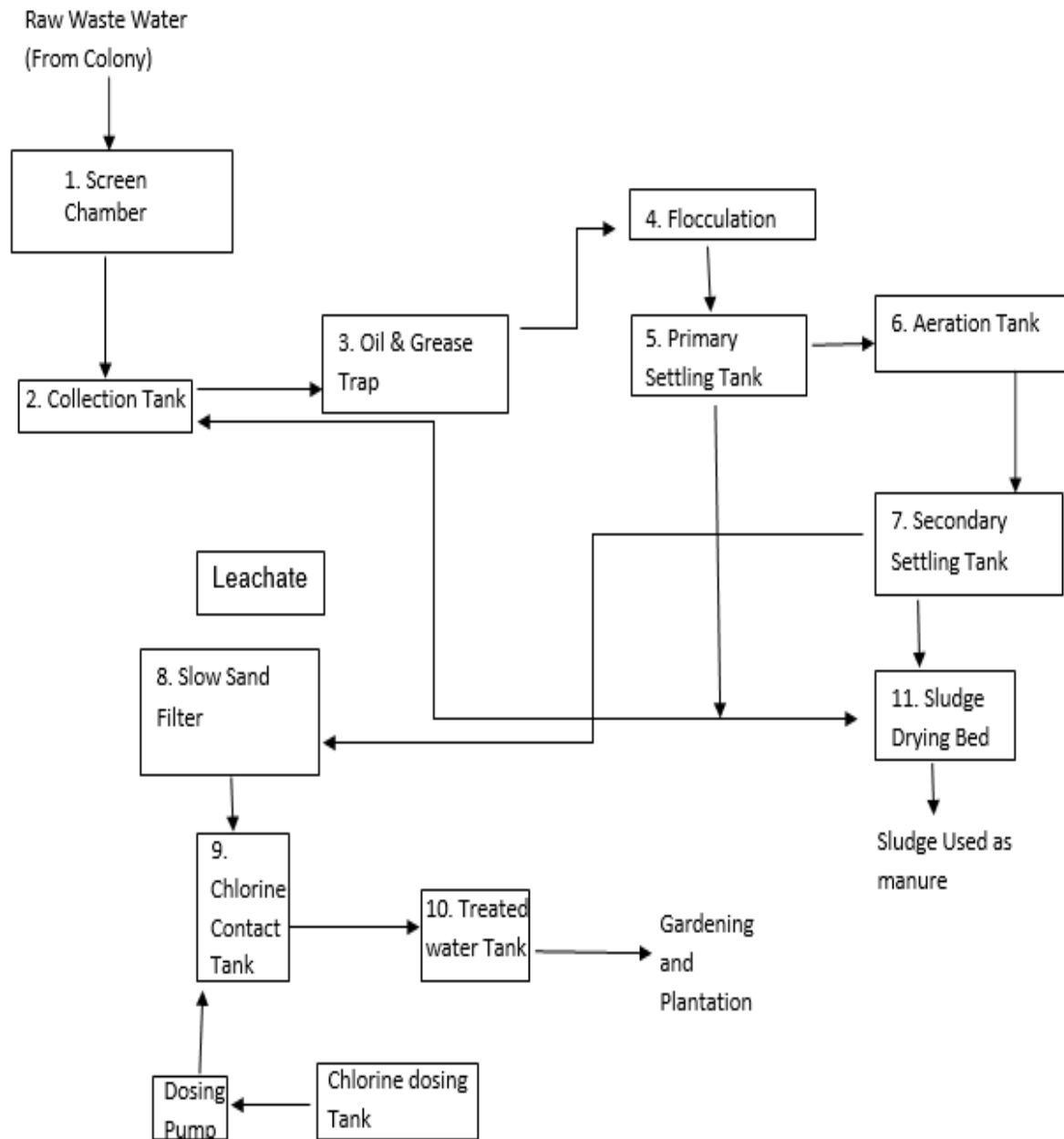


Figure 3: Process flow diagram of STP at Kandla

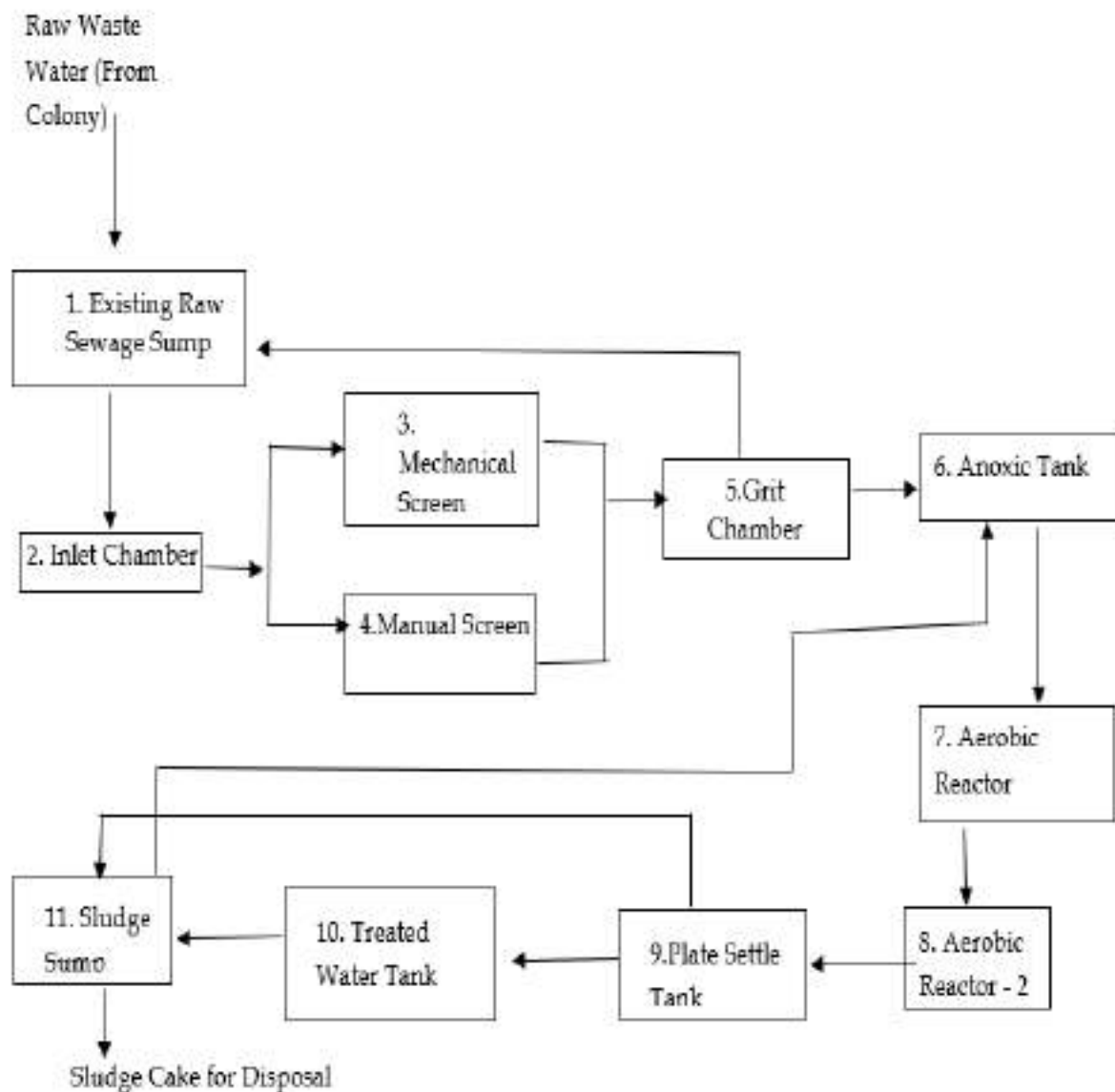


Figure 4: Process flow diagram of STP at Gopalpuri, Kandla

STP at Vadinar

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 GPCB has been referred for the details of the said STP. The CC&A of the Vadinar STP suggests that the domestic effluent generated shall be treated as per the norms specified in **Table 24**. 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 23: Norms of treated effluent as per CC&A of Vadinar STP

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

Sr. No.	Parameters	Prescribed limits
5.	COD	50 mg/L

The detailed process flow diagram of the Vadinar STP have been mentioned in **Figure 5** as follows:

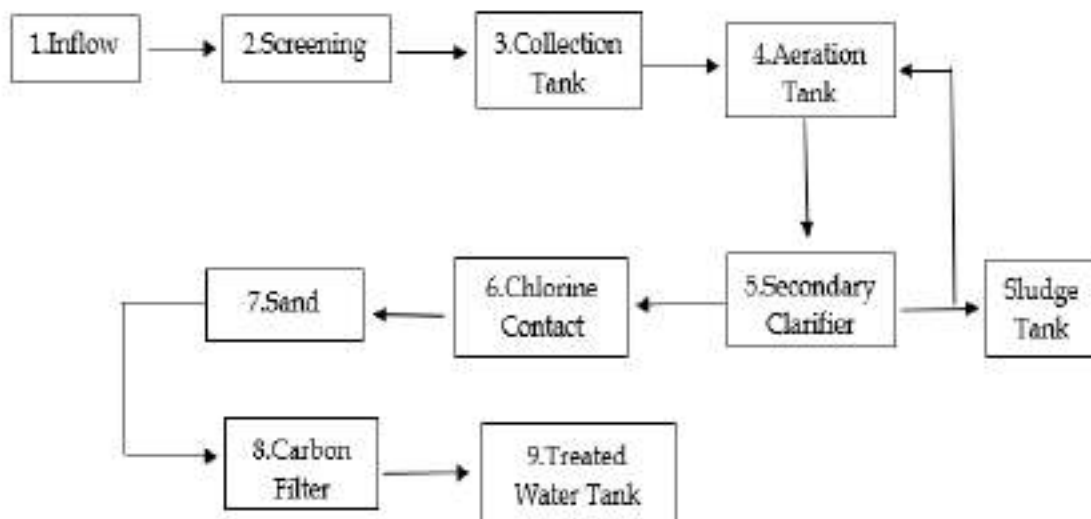


Figure 5: Process flowchart for the STP at Vadinar

The map depicting the locations of STP to be monitored in Kandla and Vadinar have been shown in **Map 14 and 15** as follows:



Map 14: STP Monitoring Locations at Kandla



Methodology

As per the defined scope by DPA, the sampling and analysis of water samples from the inlet and outlet of the STP's 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 26** as follows:

Monitoring Frequency

Monitoring is required to be carried out once a week for monitoring location of Kandla and Vadinar i.e., two STP station at Kandla and one STP station at Vadinar. Sample Collected from this location during the monitoring period April 2023 to March 2024.

Table 24: List of parameters monitored for STP's at Kandla and Vadinar

Sr. No.	Parameters	Units	Reference method	Instruments
1.	pH	-	APHA, 23 rd edition, 4500- H ⁺ B, 2017	pH Meter
2.	TDS	mg/L	APHA, 23 rd Edition, 2540 C: 2017	Vacuum Pump with filtration assembly and Oven
3.	TSS	mg/L		
4.	DO	mg/L	APHA, 23 rd Edition, 4500 C: 2017	Titration Apparatus
5.	COD	mg/L	APHA, 23 rd 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

9.2 Result and Discussion

Analytical results of the STP samples collected from the inlet and the outlet of the STP's of Kandla and Vadinar have been summarized in **Table 26**. Further it was compared with the standard norms specified in the CC&A of the respective STPs.

Table 25: Water Quality of inlet and outlet of STP of Kandla

Sr No.	Parameter	Units	Kandla							Vadinar			
			GPCB Norms (Kandla)	STP-1			STP-2			GPCB Norms (Vadinar)	STP-3		
				Inlet	Outlet		Inlet	Outlet			Inlet	Outlet	
					Avg	Avg		Max	Avg			Avg	Max
1.	pH	-	6.5-8.5	7.17	7.302	7.65	6.99	7.48	8.88	5.5-9	7.19	7.41	8.46
2.	TDS	mg/L	-	3065.7	2069.28	6228	1099.40	1003.3	1814	-	471.61	402.67	482
3.	TSS	mg/L	100	183.4	20.97	88	115.17	16.45	46	20	38.78	8.42	36
4.	COD	mg/L	-	184.7	32.57	133.1	213.54	25.98	88.4	50	138.27	16.18	40.2
5.	DO	mg/L	-	145.91	37.780	277.09	162.29	21.98	76.92	-	115.12	18.69	54.5
6.	BOD	mg/L	30	56.82	11.937	52.4	61.75	8.40	18.45	10	44.62	6.053	11
7.	SAR	meq/L	-	12.06	9.318	21.04	5.75	5.43	13.1	-	2.71	2.12	3.2
8.	Total Coliforms	MPN/100ml	<1000	1565.95	1530.66	1600	1537.02	1500.51	1600	100-230	1551	1492.3	1600

BQL: Below Quantification limit; Total Suspended Solids (QL=2), Dissolved Oxygen (QL=0.5), Biochemical Oxygen Demand (QL=3 mg/L)

9.3 Data Interpretation and Conclusion

For physicochemical analysis, the treated sewage water was gathered from the Kandla STP, Gopalpuri STP, and Vadinar STP and the analytical results were compared with the standards mentioned in the Consolidated Consent and Authorization (CC&A) by GPCB.

- The average pH at the inlet of STP-1, STP-2, and STP-3 is, respectively, **7.17, 6.99, and 7.19**. After treatment, the treated effluent from STPs at Kandla (STP-1 and STP-2) and Vadinar (STP-3) had a maximum pH of **7.65, 8.88, and 8.46** and an average pH of **7.302, 7.48, and 7.41**, respectively. Which conform to their respective stipulated norms of 6.5–8.5 at Kandla and 5.5–9 at Vadinar, respectively.
- The average TDS concentrations at the inlet of STP-1, STP-2, and STP-3 are, respectively, **3065.8, 1099.4, and 471.33** mg/L. After treatment, the treated effluent from STPs at Kandla (STP-1 and STP-2) and Vadinar (STP-3) had a maximum TDS concentration of **6228, 1814, and 482** mg/L, and an average TDS concentration of **2069.3, 1003.3, and 402.67** mg/L, respectively.
- The average TSS at the inlet of STP-1, STP-2, and STP-3 is respectively **183.43, 115.17, and 38.78** mg/L. After treatment, the treated effluent from STPs at Kandla (STP-1 and STP-2) and Vadinar (STP-3) had a maximum TSS of **88, 46, and 36** mg/L, and an average TSS of **20.974, 16.452, and 8.41** mg/L, respectively. Which conform to their respective stipulated norms of 100 mg/L at Kandla and 20 mg/L at Vadinar, respectively, as mentioned in their respective CCA, except in STP-3 at Vadinar, which exceeds norms in the 3rd and 4th weeks of April 2023.
- The average COD at the inlet of STP-1, STP-2, and STP-3 is respectively **184.7, 213.54, and 138.27** mg/L. After treatment, the treated effluent from STPs at Kandla (STP-1 and STP-2) and Vadinar (STP-3) had maximum COD concentrations of **133.1, 88.4, and 40.2** mg/L, and average COD concentrations of **32.576, 25.97, and 16.18** mg/L, respectively. There are no discharge norms for the COD parameter in STP-1 and STP-2 at Kandla, and they conform to their respective stipulated norms of 50 mg/L at Vadinar as mentioned in their respective CCA.
- The average DO concentrations at the inlet of STP-1, STP-2, and STP-3 are, respectively, **145.91, 162.29, and 115.12** mg/L. After treatment, the treated effluent from STPs at Kandla (STP-1 and STP-2) and Vadinar (STP-3) had a maximum DO concentration of **277.09, 76.92, and 54.5** mg/L, and an average DO concentration of **37.78, 21.98, and 18.68** mg/L respectively.
- The average BOD at the inlet of STP-1, STP-2, and STP-3 is respectively **56.82, 61.76, and 44.62** mg/L. After treatment, the treated effluent from STPs at Kandla (STP-1 and STP-2) and Vadinar (STP-3) had a maximum BOD of **52.4, 18.45, and 11** mg/L, and an average BOD of **11.93, 8.40, and 6.05** mg/L, respectively. Which conform to their respective stipulated norms of 30 mg/L at Kandla and 10 mg/L at Vadinar, respectively, as mentioned in their respective CCA, except in STP-3 at Vadinar, which exceeds norms in the 3rd and 4th weeks of April 2023.
- The average SAR concentrations at the inlet of STP-1, STP-2 and STP-3 are respectively **12.068, 5.75 and 2.71** meq/L. After treatment, the treated effluent from

STPs at Kandla (STP-1 and STP-2) and Vadinar (STP-3) having maximum SAR concentration **21.04**, **13.1** and **3.2** meq/L, and having Average SAR concentration **9.31**, **5.46** and **2.12** meq/L respectively.

- The **Total Coliforms** was observed to exceed the norms at the locations of the STP-1 & STP-2 for the treated effluent at Kandla and STP-3 at Vadinar.

During the monitoring period, only Total Coliforms were observed to be exceeding the limits at STPs of Kandla and Vadinar while rest of the treated sewage parameters for STP outlet were within norms as specified under the CCA at both the monitoring sites. Regular monitoring of the STP performance should be conducted on regular basis to ensure adequate treatment as per the norms.

9.4 Remedial Measures:

- The quantum of raw sewage (influent) entering the STP should be monitored by installation of the 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 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.

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 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 has been 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. Details of the locations to be monitored have been mentioned in **Table 27**:

Table 26: Details of the sampling locations for Marine water

Sr. No.	Location Code	Location Name	Latitude Longitude
1.	Kandla	MW-1	Near Passenger Jetty One
2.		MW-2	Kandla Creek (nr KPT Colony)
3.		MW-3	Near Coal Berth
4.		MW-4	Khori Creek
5.		MW-5	Nakti Creek (nr Tuna Port)
6.		MW-6	Nakti Creek (nr NH-8A)
7.	Vadinar	MW-7	Near SPM
8.		MW-8	Near Vadinar Jetty

The map depicting the locations of Marine Water to be sampled and analysed for Kandla and Vadinar have been mentioned in **Map 16 and 17** as follows:



Map 16: Marine Water Monitoring Locations at Kandla



Map 17: Marine Water Monitoring Locations at Vadinar

Methodology

The methodology adopted for the sampling and monitoring of Marine Water was carried out as per the '**Sampling Protocol for Water & Wastewater**' developed by GEMI. The water samples collected through the Niskin Sampler are collected in a clean bucket to reduce the heterogeneity. The list of parameters to be monitored under the project for the Marine Water quality have been mentioned in **Table 28** along with the analysis method and instrument.

Monitoring Frequency

As defined in the scope by DPA, the sampling and analysis of Marine Water has to be carried out once in a month at the eight locations (i.e., six at Kandla and two at Vadinar). For the period April 2023 to March 2024.

Table 27: List of parameters monitored for Marine Water

Sr. No	Parameters	Units	Reference method	Instrument
1.	Electrical Conductivity	μS/cm	APHA, 23 rd Edition (Section-2510 B):2017	Conductivity Meter
2.	Dissolved Oxygen (DO)	mg/L	APHA, 23 rd Edition, 4500 O C, 2017	Titration Apparatus
3.	pH	-	APHA, 23 rd Edition (Section-4500-H+B):2017	pH meter
4.	Color	Hazen	APHA, 23 rd 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, 23 rd Edition (Section-2540 C):2017	Vaccum Pump with Filtration Assembly and Oven
8.	Total Suspended Solids (TSS)	mg/L	APHA, 23 rd Edition, 2540 D: 2017	
9.	Particulate Organic Carbon	mg/L	APHA, 23 rd 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, 23 rd Edition, 4500 C, 2017	UV- Visible Spectrophotometer
13.	Phosphate	mg/L	APHA, 23 rd Edition, 4500 P-D: 2017	
14.	Sulphate	mg/L	APHA, 23 rd Edition, 4500 SO4-2 E: 2017	
15.	Nitrate	mg/L	APHA, 23 rd Edition, 4500 NO3-B: 2017	
16.	Nitrite	mg/L	APHA, 23 rd Edition, 4500 NO2- B: 2017	Flame photometer
17.	Sodium	mg/L	APHA, 23 rd Edition, 3500 Na-B: 2017	

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

10.2 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 29**. The said water quality has been represented in comparison with the standard values as stipulated by CPCB for Class SW-IV Waters.



Table 28: Results of Analysis of Marine Water Sample for the sampling period

Parameters	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		
		Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Density (kg/m ³)	-	1.02	1.03	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.021	1.02	1.02	1.02	1.02	1.02	1.02
pH	6.5-9.0	6.12	8.32	7.89	7.04	8.36	7.99	7.83	8.33	8.11	7.69	8.31	8.05	7.19	8.48	8.03	6.01	8.31	7.94	7.98	8.2	8.11	7.07	8.22	8.06
Colour (Hazen)	No Noticeable	1	10	5.41	1	20	7.83	1	15	7.16	5	20	9	5	15	7.41	5	20	8.27	1	10	5.66	1	10	5.08
EC (µS/cm)	-	49700	63600	54282.5	49800	61700	54490.91	50200	60600	53767.75	50400	75300	55689.91	50100	65100	55115.58	15950	61528	50873.17	52200	56900	54239.2	52.119	57500	50312.6
Turbidity (NTU)	-	56.4	310	188.26	33.9	314	206.76	61.8	317	203.81	69	300	216.66	94.5	379	202.5	70.1	346	209.23	3.15	12.5	5.36	3.42	13.8	6.39
TDS (mg/L)	-	24800	44466	36356.3	24900	41922	36679.5	25100	41624	35690.92	25200	64721	38189.5	25000	47159	36938.58	9970	41436	32927.91	25784	38620	35400.16	26882	41790	35965.75
TSS (mg/L)	-	44	436	342.42	26	563	374.58	52	478	340.75	58	924	402.33	80	682	427.66	58	852	387.72	78	341	255.08	151	346	282.33
COD (mg/L)	-	29.2	79.37	49.62	11.98	79.37	47.81	25.41	81	47.68	22.65	81	52.12	31.56	79.37	53.76	22.97	88.8	49.34	21.28	75	50.98	17.92	75	47.63
DO (mg/L)	3.0 mg/L	4.7	6.4	5.76	5.3	6.4	6.07	4.5	6.7	5.87	3.4	6.5	5.85	5	6.6	6.07	5.6	8.4	6.49	4.3	7.6	6.25	4.4	7.9	6.48
BOD (mg/L)	5.0 mg/L	5.24	8.54	7.56	8.4	8.9	8.57	3.74	8.45	6.81	5	8.78	7.755	9.32	9.87	9.57	3.6	11.1	8.64	3.91	7.5	6.51	4.2	7.16	6.16
Oil & Grease (mg/L)	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulphate (mg/L)	-	2056	2937.5	2529.7	2156.32	2897.7	2544.18	2083.7	2925.2	2530.85	2239	3704.9	2879.88	2334.9	2916.8	2652.42	632.62	3612.8	2561.07	1846.3	3225.8	2472.195	2039.9	3236.8	2664.27
Nitrate (mg/L)	-	1.89	5.40	4.28	1.12	5.16	3.75	3.21	5.68	4.17	3.41	5.85	4.64	3.17	6.92	4.21	3.06	6.84	4.06	2.225	5.17	3.56	1.759	5.1	3.39
Nitrite (mg/L)	-	0.12	0.12	0.12	0	0	0	0	0	0	0	0	0	0.11	0.11	0.11	0.13	0.16	0.14	0	0	0	0	0	0!
Phosphate (mg/L)	-	0.25	1.59	0.82	0.09	1.34	0.69	0.57	1.46	0.96	0.61	2.01	0.92	0.29	1.34	0.76	0.54	1.61	0.81	0.64	0.94	0.79	1.43	1.43	1.43
Silica (mg/L)	-	0.29	3.24	2.12	0.22	4.04	2.24	0.2	3.73	2.19	1.12	3.69	2.54	1.26	4	2.64	0.33	3.74	1.92	0.11	0.96	0.56	0.09	1.86	0.76
Sodium (mg/L)	-	7686	10625	9475.57	7811	10341	9242.42	7763	10308	9347.33	9101	10323	9724.14	8789	10278	9403.67	2086	10722	8042.71	2149.6	9485	6743.97	2349.4	9542	7244.66
Potassium (mg/L)	-	68.35	451.9	318.57	69.27	446.5	303.94	68.57	421	290.60	71.73	543.96	342.71	69.63	423.34	324.92	68.34	442.63	272.9	10.86	421.7	259.6	76.31	518	327.43
Hexavalent Chromium (mg/L)	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	321	321	321	333	333	333
Odour	-	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Arsenic (mg/L)	-	5.13	5.13	5.13	5.25	5.25	5.25	5.4	5.4	5.4	0	0	0	0	0	0	9.44	12.94	11.19	0.11	1	0.41	0.08	1	0.38
Cadmium (mg/L)	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper (mg/L)	-	5.1	6.99	5.8175	0.006	10.9	5.79	0.005	7.7	3.85	5.34	12.01	8.224	0.0067	7.6	5.13	8.07	10.2	9.49	3.4	3.4	3.4	0	0	0
Iron (mg/L)	-	0.69	4.11	1.38	0.21	4.07	1.76	0.37	3.92	1.79	1.02	7.93	2.49	0.98	5.45	2.09	0.43	5.3	2.005	0.01	0.25	0.145	0.08	0.66	0.21
Lead (mg/L)	-	0.002	3.44	2.067	0.0029	3.44	2.29	0.0026	3.06	1.98	0.002	9.68	4.32	0.002	4.65	2.39	0.0029	3.65	2.47	0.0023	2.26	1.035	0.002	2.75	0.96
Manganese (mg/L)	-	0.082	129.91	71.47	0.12	159.78	83.88	0.1085	125.66	74.0	0.096	294.91	93.56	0.074	213.14	74.7	0.11	156.41	80.27	2.39	113.93	39.62	1.97	98.8	34.64
Total Chromium (mg/L)	-	0	0	0	5.62	7.8	6.71	5.67	5.67	5.67	5.14	15.99	12.28	5.11	9.65	7.207	0	0	0	0	0	0	45.75	45.75	45.75
Zinc (mg/L)	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mercury (mg/L)	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Particulate Organic	-	0.51	900	76.22	0.51	35	3.98	0.42	10	1.94	0.58	55	6.03	0.92	30	3.89	0.85	44	5.01	0.47	4.67	1.62	0.32	4.76	1.51

Parameters	Primary	Kandla																		Vadinar					
Carbon (mg/L)																									
Total Coliform* (MPN/ 100ml)	500/100 ml	0.32	1600	159.61	0.16	120	29.76	0.56	108	31.55	0.25	47	14.02	0.35	170	37.19	0.29	50	21.86	0.36	240	39.76	0.39	240	35.28
Floating Material (Oil grease scum, petroleum products) (mg/L)	10 mg/L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	23	23

10.3 Data Interpretation and Conclusion

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 monitoring 2023 at high tide. The detailed interpretation of the parameters in comparison to the Class SW-IV for Harbour Waters is as follows:

- **Density** at Kandla was observed in the range of **1.02 to 1.03 kg/m³**, with the average of **1.022 kg/m³**. Whereas for the location of Vadinar, it was observed in the range of **1.021 to 1.026 kg/m³**, with the average of **1.022 kg/m³**.
- **pH** at Kandla was observed in the range of **6.01 to 8.48**, with the average pH as **7.78**. Whereas for the locations of Vadinar, it was observed in the range of **7.07 to 8.22**, with the average pH as **7.94**. For the monitoring location of both the study areas, pH was found to comply with the norms of 6.5-8.5.
- **Color** range varied from **1 to 20 Hazen** at all the monitoring locations in Kandla, and for Vadinar, it varied from **1 to 10 Hazen**.
- **Electrical conductivity (EC)** was observed in the range of **15,950 to 75,300 µS/cm**, with the average EC as **54,344.32 µS/cm** for the locations of Kandla, whereas for the locations of Vadinar, it was observed in the range of **52,199 to 57,500 µS/cm**, with the average EC as **45,200.67 µS/cm**.
- For all monitoring locations of Kandla the value of **Turbidity** was observed in the range of **33.9 to 379 NTU**, with average value of **198.83 NTU**. For Vadinar it ranges from **3.15 to 13.8 NTU**, with average of **7.43 NTU**. Materials that cause water to be turbid include clay, silt, finely divided organic and inorganic matter, soluble coloured organic compounds, plankton and microscopic organisms. Turbidity affects the amount of light penetrating to the plants for photosynthesis.
- For the monitoring locations at Kandla the value of **Total Dissolved Solids (TDS)** ranged from **9,970 to 64,721 mg/L**, with an average value of **35,171 mg/L**. Similarly, at Vadinar, the TDS values ranged from **25,784 to 41,790 mg/L**, with an average value of **34,073 mg/L**.

- TSS values in the studied area varied between **26 to 924 mg/L** at Kandla and **78 to 346 mg/L** at Vadinar, with the average value of **362.69 mg/L** and **242.23 mg/L** respectively for Kandla and Vadinar.
- COD varied between **11.98 to 88.8 mg/L** at Kandla and **17.92 to 75 mg/L** at Vadinar, with the average value as **51.83 mg/L** and **47.86 mg/L** respectively for Kandla and Vadinar.
- DO level in the studied area varied between **3.4 to 8.4 mg/L** at Kandla and **4.3 to 7.9 mg/L** at Vadinar, with the average value of **5.86 mg/L** and **6.15 mg/L** respectively for Kandla and Vadinar. Which represents that the marine water is suitable for marine life.
- BOD observed was observed in the range of **3.6 to 11.1 mg/L**, with average of **7.76 mg/L** for the location of Kandla and for the locations of Vadinar, it was observed in the range of **3.91 to 7.5 mg/L**, with an average value of **5.9 mg/L**.
- Sulphate concentration in the studied area varied between **632.92 to 3704.9 mg/L** at Kandla and **1846.3 to 3236.8 mg/L** at Vadinar. The average value observed at Kandla was **2566.45 mg/L**, whereas **2580.87 mg/L** was the average value of Vadinar. Sulphate is naturally formed in inland waters by mineral weathering or the decomposition and combustion of organic matter.
- Nitrate in the study area was observed in the range of **1.12 to 6.92 mg/L**, with the average of **4.26 mg/L**. Whereas for the Vadinar the concentration of Nitrate was observed in the range of **1.759 to 5.17 mg/L**, with the average **3.53 mg/L**.
- Nitrite in the study area was observed in the range of **0 to 0.16 mg/L**, with the average of **0.625 mg/L**. Whereas for the Vadinar the concentration of Nitrite was observed Below Quantification Limit During whole monitoring period.
- Phosphate in the study area was observed in the range of **0.09 to 2.01 mg/L**, with the average of **0.92 mg/L**. Whereas for the Vadinar the concentration of Phosphate was observed in the range of **0.64 to 1.43 mg/L**, with the average **1.11 mg/L**.
- Silica in the study area was observed in the range of **0.2 to 4.04 mg/L**, with the average of **2.19 mg/L**. Whereas for the Vadinar the concentration of silica was observed in the range of **0.09 to 1.86 mg/L**, with the average **0.724 mg/L**.
- In the study area of Kandla the concentration of Potassium varied between **68.34 to 543.68 mg/L** and **10.86 to 518 mg/L** at Vadinar, with the average value as **277.71 mg/L** and **268.99 mg/L** respectively for Kandla and Vadinar.
- Sodium in the study area varied between **2,086 to 10,722 mg/L**, with average of **8948.26 mg/L**, at Kandla whereas at Vadinar its value recorded within range of **2149.6 to 9542 mg/L**, with the average of **6252.43 mg/L**.
- Odour was observed 1 for all locations of Kandla and Vadinar.
- Arsenic concentration observed to be BQL for majority of location for Kandla and Vadinar except locations MW-1, MW-2, MW-3, MW-6, MA-7 and MW-8 for some instant of time during whole monitoring period.
- Copper in the study area varied between **0.005 to 12.01 mg/L**, with average of **6.23 mg/L**, at Kandla whereas at Vadinar its value recorded within range of **0 to 3.4 mg/L**,

with the average of **2.04 mg/L**, on both project sites during monitoring majority of time Copper found Below Quantification Limit.

- **Iron** in the studied area varied between **0.21 to 7.93 mg/L**, with the average of **2.55 mg/L**, at Kandla, and for Vadinar value were recorded within range of **0.01 to 0.66 mg/L**, with average value of **0.22 mg/L**.
- **Lead** concentration varied **0.002 to 9.68 mg/L**, with an average of **2.41 mg/L** at Kandla. At Vadinar location within range of **0.002 to 2.753 mg/L** with an average **1.17 mg/L**
- **Manganese** in the studied area varied between **0.0748 to 294.91 mg/L**, with the average of **86.57 mg/L**, at Kandla and for Vadinar, recorded value were observed within the range of **1.97 to 113.93 mg/L**, with the average of **48.56 mg/L**.
- **Total Chromium** in the study area varied between **0 to 15.99 mg/L**, with average of **5.13 mg/L**, at Kandla whereas at Vadinar its value recorded **45.76 mg/L** at MW-8 in the monitoring period of January to February 2024, While on both project sites during monitoring majority of time Total Chromium found Below Quantification Limit
- **Particulate Organic Carbon** in the study area was observed in the range of **0.42 to 900**, with the average value of **65.27**. the maximum spike of 900 is only observed once in the period of April to May 2023 during whole monitoring period. Whereas for the Vadinar, the value observed was Within the range of **0.32 to 4.76**, with the average of **2.22**.
- **Oil & Grease, Nitrite, Phosphate, Hexavalent Chromium, Arsenic, Cadmium, Total Chromium, Zinc, Mercury and Floating Material (Oil grease scum, petroleum products)** were observed to have concentrations “**Below the Quantification Limits (BQL)**” for most of the locations of Kandla and Vadinar, majority of time during whole monitoring period.
- **Total Coliforms** were detected complying with the specified norm of 500 MPN/100ml for all the locations of Kandla and Vadinar, except on location MW-1 in the month of May to June 2023.

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).

However, as a safeguard towards marine water pollution prevention, 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 are 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.

Methodology

As defined in the scope by 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 (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 locations of Marine Sediment to be monitored under the study are mentioned in **Table 30** as follows:

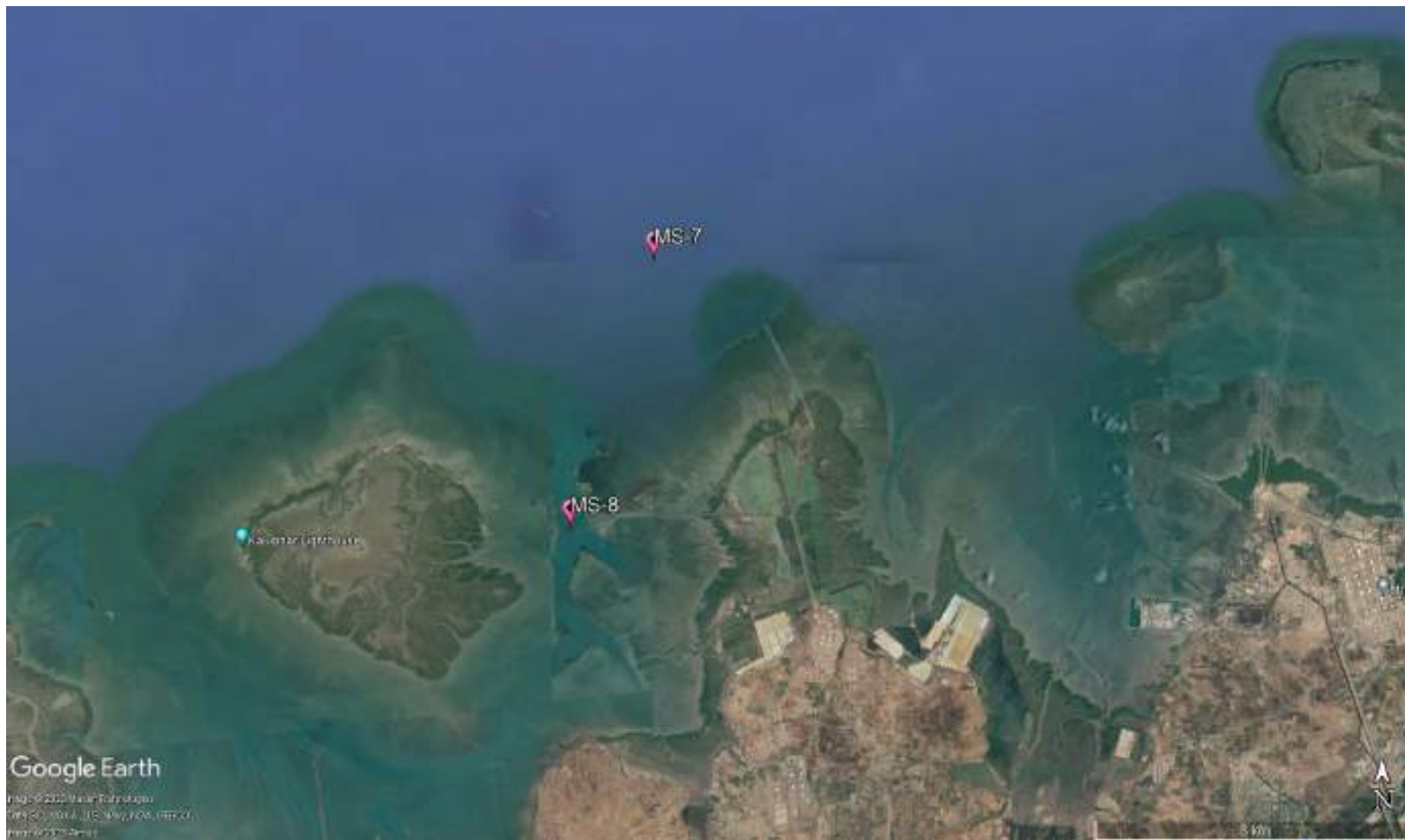
Table 29: Details of the sampling locations for Marine Sediment

Sr. No	Location Code	Location Name	Latitude Longitude
1.	Kandla	MS-1	Near Passenger Jetty One
2.		MS-2	Kandla Creek
3.		MS-3	Near Coal Berth
4.		MS-4	Khori Creek
5.		MS-5	Nakti Creek (near Tuna Port)
6.		MS-6	Nakti Creek (near NH-8A)
7.	Vadinar	MS-7	Near SPM
8.		MS-8	Near Vadinar Jetty

The map depicting the locations of Marine Sediment sampling at Kandla and Vadinar have been mentioned in **Map 18 and 19** as follows:



Map 18: Marine Sediment Monitoring Location at Kandla



Map 19: Marine Sediment Monitoring Locations at Vadinar

The list of parameters to be monitored under the projects for the Marine Sediment sampling been mentioned in **Table 31** as follows:

Table 30: 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 SO ⁴⁻	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	
12.	Potassium	mg/Kg	Methods Manual Soil Testing in India January, 2011	Flame Photometer
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 during the monitoring period of April 2023 to March 2024 has been summarized in the **Table 32**.



Table 31: Summarized result of Marine Sediment Quality

Parameters	Kandla																		Vadinar					
	MS-1			MS-2			MS-3			MS-4			MS-5			MS-6			MS-7			MS-8		
	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
Inorganic Phosphate (kg/ha)	16.85	0.86	6.6042	14.37	0.67	8.81	41.2	0.8	16.98	19.44	0.81	9.532	45.1	0.72	14.48	34.6	0.66	15.24	14.5	1.24	5.65	18.51	0.82	5.7325
Phosphate (mg/Kg)	3247.8	290.8	1280.63	2514.7	258.3	1304	3736	226.6	1515	3871	353.7	1287	3741	306.8	1442	14076	578.3	2793.9	3002	152.5	770.24	3477.29	167.93	940.70
Organic Matter (%)	1.42	0.21	0.7875	2.17	0.29	1.13	1.01	0.17	0.593	2.1	0.33	0.975	1.24	0.67	0.911	2.06	0.21	0.915	2.29	0.15	1.04	1.65	0.17	0.89
Sulphate as SO ⁴⁻ (mg/Kg)	905.25	110.2	366.8	1022.25	98.2	370.03	571.64	95.33	275.09	650.25	97.45	268.51	768	87.28	294.27	732	96.38	249.1	296	74.07	126.31	213.4	80.06	132.03
Calcium as Ca (mg/Kg)	13800	1612	3464.3	5800	1259	2836	4200	962	2163	4200	1102	2669	10500	1089	3102	3800	1047	2274.6	3700	2200	2930.9	3974.2	2100	2805.45
Magnesium as Mg (mg/Kg)	1952	1225	1538.53	3050	826.46	1810.84	2136	764	1592.59	3172	866.94	1810.6	2440	1032	1622.80	2745	906.98	1581.95	1952	854	1385.18	14640	1167	2920.83
Silica (g/Kg)	671.25	261.3	479.11	612.51	289.4	481.7	571.5	329.1	444.8	555.2	245.7	392.1	597.1	179.2	418.6	580.4	245.3	436.12	529.8	220.9	377.71	546.08	264.92	426.66
Nitrite (mg/Kg)	0.75	0.12	0.41	0.92	0.13	0.50	0.81	0.08	0.41	0.91	0.01	0.43	0.71	0.11	0.375	0.89	0.07	0.489	0.22	0.07	0.159	0.37	0.04	0.23
Nitrate (mg/Kg)	22.34	5.86	16.58	37.12	7.59	18.29	36.47	4.51	15.50	25.94	4.31	13.99	10.34	5.24	13.17	20.38	6.34	14.52	25.33	9.54	15.36	25.21	4.75	10.52
Sodium (mg/Kg)	7860	3194	4512.43	14688	2453	5318	8612	2072	4550	18308	2612	6435	10520	2063	4665	14076	2072	5639.6	11944	3971	7904.6	13660	2719.42	9536.63
Potassium (mg/Kg)	2610.7	241	1525.98	11580	276	2320	3479	260.7	2126	4208	294	2424	3152	205	1790	3479	236.9	2233.4	3372	699	1876.1	4377	1028	2025.66
Aluminium (mg/Kg)	8371.7	2116	3827.74	10641	1237.1	4465.9	10363.1	1278.5	4370.2	12008.4	1971.2	5025.2	10361.1	1264.58	3891.23	12314.1	1273.22	4384.20	14179.7	358.3	4028.56	19356.55	479.16	4883.52
Mercury (mg/Kg)	4.71	4.71	4.71	10.74	10.74	10.74	41.29	41.29	41.29	6.44	6.44	6.44	15.21	15.21	15.21	34.69	34.69	34.69	0	0	0	0	0	0
Texture	Sandy loam	Sandy loam	Silt loam	Sandy loam	Silt loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Loam	Loam	Loam

11.3 Data Interpretation and Conclusion

The Marine sediment quality at Kandla and Vadinar has been monitored for various physico-chemical parameters during the monitoring April 2023 to March 2024. The detailed interpretation of the parameters is given below:

- **Inorganic Phosphate** for the sampling period was observed in range of **0.66 to 45.12** Kg/ha for Kandla. Whereas for Vadinar the value observed Within range of **0.82 to 18.51** Kg/ha. For Kandla and Vadinar the average value of Inorganic Phosphate was observed **13.77** and **7.74** Kg/ha respectively.
- The concentration of **Phosphate** was observed in range of **226.6 to 3871.15 mg/Kg** for Kandla and for Vadinar the value observed within the range of **152.53 to 3477.29** mg/Kg. For Kandla and Vadinar the average concentration of Phosphate was observed **1616.78** and **1418.5** mg/Kg respectively.
- The **Organic Matter** for the sampling period was observed in the range of **0.17 to 2.17** % for Kandla with the average value of **0.95%** and for Vadinar the value recorded Within range of **0.15 to 2.29%**, with average concentration as **1.03** %.
- The concentration of **Sulphate** was observed in the range of **87.28 to 1022 mg/Kg** for Kandla and for Vadinar the value observed Within range of **74.07 to 296** mg/Kg. For Kandla and Vadinar the average value of Sulphate was observed **392.10** and **153.64** mg/Kg respectively.
- The value of **Calcium** was observed in the range of **962 to 13800 mg/Kg** for Kandla and for Vadinar the value observed within the range of **2100 to 3974.5** mg/Kg. The average value of Calcium for the monitoring period was observed **3660.21** mg/Kg and **2951.76** mg/Kg at Kandla and Vadinar, respectively.
- The value of **Magnesium** for the sampling period was observed in the range of **764 to 3172 mg/Kg** for Kandla and for Vadinar the value observed Within the range of **854 to 1952** mg/Kg. For Kandla and Vadinar the average value of Magnesium was observed **1726.35** mg/Kg and **1440.69** mg/Kg respectively.
- For the sampling period **Silica** was observed in the range of **179.25 to 671.25 mg/Kg** for Kandla with average value **432.83** mg/Kg and for Vadinar the value observed within the range of **220.98** and **546.5** mg/Kg with average **394.35** mg/Kg.
- The value of **Nitrate** was observed in the range of **4.31 to 37.12 mg/Kg** for Kandla with average value **15.47** mg/Kg and for Vadinar the value observed within the range of **4.75 to 25.33** mg/Kg. with average **15.12** mg/Kg.
- The value of **Nitrite** was observed in the range of **0.01 to 0.92 mg/Kg** for Kandla with average value **0.45** mg/Kg and for Vadinar the value observed to be within the range of **0.04 to 0.37** mg/Kg, with average **0.1828** mg/Kg.
- The value of **Sodium** was observed in the range of **2063.3 to 18308 mg/Kg** for Kandla with average value **6647.43** mg/Kg and for Vadinar the value observed within the range of **2719.42** and **13660** mg/Kg, with average **8289** mg/Kg.
- The value of **Potassium** was observed in the range of **205.08 to 11580 mg/Kg** for Kandla with average value **2357.95** mg/Kg and for Vadinar the value observed within range of **699.09 to 4377** mg/Kg, with average **2229.65** mg/Kg.

- The value of **Aluminium**, was observed in the range of **1237.13 to 12314.13 mg/Kg** for Kandla with average value **5509.23 mg/Kg** and for Vadinar the value observed within the range of **358.3 to 19356 mg/Kg**, with average **7214.30 mg/Kg**.
- The value of **Mercury**, was observed in the range of **4.71 to 41.29 mg/Kg** for Kandla with average value **18.84 mg/Kg** and for Vadinar the value of **Mercury** was observed “Below the Quantification Limit” at both two locations. During monitoring period majority of time Mercury was observed Below Quantification limit.
- Texture was observed to be “**Sandy Loam**” at location MS-1, MS-2, MS-4 and MS-6 “**Silt loam**” at location MS-3 & MS-5 in Kandla. “**Sandy Loam**” at location MS-7 & “**Silt loam**” at location MS-8 in Vadinar during sampling period.

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 33**.

Table 32: 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)

Table 33: Comparison of Heavy metals with Standard value in Marine Sediment

Parameters	Kandla																		Vadinar					
	MS-1			MS-2			MS-3			MS-4			MS-5			MS-6			MS-7			MS-8		
	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
Arsenic (mg/Kg)	5.13	1.09	3.527	4.43	2.11	3.264	6.17	2.06	3.92	5.86	1.28	3.75	5.2	1.75	3.458	5.78	1.98	3.67	5.36	2.04	2.84	5.17	2.5	3.69
Copper (mg/Kg)	5.6	2.13	3.282	11.4	2.14	5.013	8.1	2.08	4.49	9.8	3.48	5.71	12	2.14	5.97	8.9	2.98	4.97	6.13	2.19	4.567	412	2.1	39.05
Chromium (mg/Kg)	64.1	42.12	53.94	67.45	32.74	47.04	73.02	32.41	48.31	83.23	41.08	55.17	59.95	41.87	51.50	104.2	36.71	59.71	59.27	23.18	44.01	104.1	29.7	61.12
Nickel (mg/Kg)	51.4	16.8	31.76	38.9	10.21	23.87	36.41	4.54	22.77	40.87	7.61	27.45	31.86	21.72	25.881	50.78	4.54	25.058	36.21	12.23	22.84	43.66	12.47	29.282
Lead (mg/Kg)	7.05	1.25	5.3	7.45	4.21	5.76	28.73	2.36	6.683	8.25	3.46	5.9	14.22	1.21	6.055	5.01	2.81	7.88	7.94	2.85	4.90	10.58	2.97	5.65
Zinc (mg/Kg)	63.2	35.88	54.63	65.69	32.11	50.455	301.32	23.63	69.545	82.9	18.15	50.86	159.42	19.54	60.65	157.82	23.63	57.7	52.13	11.47	34.6	104.87	13.65	53.8595
Cadmium (mg/Kg)	1.08	0.88	0.98	0.6	0.6	0.6	1.25	0.87	1.1	1.12	0.78	1.022	1.08	0.91	0.995	7.53	0.15	2.302	0	0	0	0	0	0

- **Arsenic** was observed in the range of **1.09 to 6.17 mg/Kg** for Kandla with average value **3.58 mg/Kg** and for Vadinar the value observed within range of **2.04 to 5.36 mg/Kg**, with average of **3.6 mg/Kg**. during monitoring period majority of time arsenic concentration found within moderately polluted class on both study area.
- **Copper** was observed in the range of **2.08 to 12 mg/Kg** for Kandla with average value **5.6 mg/Kg** and for Vadinar the value observed within the range of be **2.1 to 8.33 mg/Kg**, with average **4.72 mg/Kg**. With reference to the guidelines mentioned in table 35, the sediment quality with respect to copper falls in non-polluted class.
- **Chromium** was observed in the range of **32.41 to 104.24 mg/Kg** for Kandla with average value **55.25 mg/Kg** and for Vadinar the value observed within the range of **23.18 to 104.16 mg/Kg**, with average **53.57 mg/Kg**. With reference to the guidelines mentioned in table 35, the sediment quality with respect to chromium falls majority of time in moderately polluted and for some instance it location MS-4, MS-6, and MS-8 fall in Heavily polluted class.
- **Nickel** was observed in the range of **4.54 to 51.47 mg/Kg** for Kandla with average value **26.25 mg/Kg** and for Vadinar the value observed within range of **12.23 to 43.66 mg/Kg**, with average **26.115 mg/Kg**. With reference to the guidelines mentioned in table 35, the sediment quality with respect to nickel falls in moderately polluted class and for some instance it location MS-1, and MS-6 fall in heavily polluted class.

- **Lead** was observed in the range of **1.21 to 28.73 mg/Kg** for Kandla with average value **5.63 mg/Kg** and for Vadinar the value observed within the range of **2.85 and 10.58 mg/Kg**, with average **5.81 mg/Kg**. With reference to the guidelines mentioned in table 35, the sediment quality with respect to lead falls in not polluted class.
- **Zinc** was observed in the range of **18.15 to 301.32 mg/Kg** for Kandla with average value **73.73 mg/Kg** and for Vadinar the value observed within the range of **11.47 to 104.87 mg/Kg**, with average **46.997 mg/Kg**. With reference to the guidelines mentioned in table 35, the sediment quality with respect to zinc falls in non-polluted class and for some instance its location MS-1, MS-3, MS-6 and MS-8 fall in Moderately polluted class.
- **Cadmium** was observed in the range of **0.15 to 7.53 mg/Kg** for Kandla with average value **1.325 mg/Kg**. During the monitoring period majority of time **Cadmium** found BQL, which falls in non-polluted. While exception on one location MS-6 fall within moderately polluted for the duration of July to August 2023. **Cadmium** was observed BQL for all locations at Vadinar during sampling period. With reference to the guidelines mentioned in table 35, the sediment quality with respect to cadmium falls in non-polluted class.

Analysis of the sediments indicates moderate 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.

The presence of anthropic activity in the coastal areas has an effect upon the marine water and sediment. One of the primary risks associated with contaminated sediments is bioaccumulation in benthic organisms, which is a route of entry into the food chain. Generally adopted sediment remediation approaches include dredging, capping of contaminated areas, and monitored natural recovery (MNR). Dredging can remove contaminated sediments, but it requires large areas of land for sediment disposal. It is expensive and may cause secondary contamination of the water column during re-suspension. MNR relies on ongoing naturally occurring processes to decrease the bioavailability or toxicity of contaminants in sediment. These processes may include physical, biological, and chemical mechanisms that act together to reduce the environmental risks posed by contaminated sediments. MNR require longer monitoring time and can be even more expensive than for dredging and capping. Capping consists of in situ covering of clean or suitable isolating material over contaminated sediments layer to limit leaching of contaminants, and to minimize their re-suspension and transport. Hence appropriate remedial measures for the polluted sediment sites may be implemented, to reduce the concentration of the heavy metals.

CHAPTER 12: MARINE ECOLOGY MONITORING

12.1 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 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 35** as follows:

Table 34: Details of the sampling locations for Marine Ecological

Sr. No.	Location Code	Location Name	Latitude Longitude
1.	Kandla	ME-1	Near Passenger Jetty One
2.		ME-2	Kandla Creek (near KPT Colony)
3.		ME-3	Near Coal Berth
4.		ME-4	Khori Creek
5.		ME-5	Nakti Creek (near Tuna Port)
6.		ME-6	Nakti Creek (near NH - 8A)
7.	Vadinar	ME-7	Near SPM
8.		ME-8	Near Vadinar Jetty

The map depicting the locations of Marine Ecological monitoring in Kandla and Vadinar have been mentioned in **Map 20 and 21** as follows:



Map 20 Marine Ecological Monitoring: Locations at Kandla



Map 21: Marine Ecological Monitoring Locations at Vadinar

The various parameters to be monitored under the study for Marine Ecological Monitoring are mentioned in **Table 36** as follows:

Table 35: 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

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 Estimation**

Phytoplankton 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 Estimation**

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.

1. **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, \sum = Summation symbol,

p_i = 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.

2. 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:

$$D = 1 - \sum (p_i^2)$$

Where, \sum = Summation symbol, p_i = Relative abundance of the species

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:

$$D_{Mg} = \frac{S-1}{\ln N}$$

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:

$$d = \frac{N_{max}}{N_i}$$

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. 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

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.

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

The basic idea of 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.

Monitoring Frequency:

Monitoring is required to be carried out once a month for both the locations of Kandla and Vadinar. Sample Collected from this location during the monitoring period April 2023 to March 2024.

12.2 Result and Discussion

The details of Marine Ecological Monitoring conducted for the locations of Kandla and Vadinar during the monitoring period has been summarized in the **Table 37**.

Table 36: Values of Biomass, Net Primary Productivity (NPP), Gross Primary Productivity (GPP), Pheophytin and Chlorophyll for Kandla and Vadinar

Sr. No.	Parameters	Kandla						Vadinar	
		ME-1 (Near Passenger Jetty One)	ME-2 (Kandla Creek)	ME-3 (Near Coal Berth)	ME-4 (Khor Creek)	ME-5 (Nakti Creek-near Tuna Port)	ME-6 (Nakti Creek near NH - 8A)	ME-7 (Near SPM)	ME-8 (Near Vadinar Jetty)
		Avg.	Avg.	Avg.	Avg.	Avg.	Avg.	Avg.	Avg.
1.	Biomass	115	115	96	142	102	121	78	111
2.	Net Primary Productivity	2.91	3.77	3.08	2.99	5.47	2.49	4.16	2.64
3.	Gross Primary Productivity	2.95	3.04	3.73	3.26	2.44	2.85	3.67	3.09
4.	Pheophytin	1.10	1.28	0.80	1.35	0.82	5.81	2.66	2.43
5.	Chlorophyll-a	2.40	1.61	1.72	1.72	2.04	12.43	2.37	3.24
6.	Particulate Oxidisable Organic Carbon	1.34	1.12	1.18	1.51	1.45	1.40	1.26	1.20
7.	Secchi Depth	0.61	0.63	0.56	0.60	0.56	0.62	3.93	2.61

- Biomass:**

With reference to **Table 37**, the average concentration of biomass during the monitoring period, for locations ME-1 to ME-6 was reported within the range of **96-142 mg/L**, with the lowest biomass present in **ME-3 (near coal berth)** and the highest biomass present in **ME-4 (Khor Creek)** during the sampling period. In Vadinar, the value of biomass was observed at **78 mg/L** at ME-7 (near SPM) and **111 mg/L** at ME-8 (near Vadinar Jetty) monitoring station.

- 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. During the Monitoring Period, the monitoring location of Kandla reported GPP value in range between **2.44 to 3.73 mg/L/48 Hr** where the highest value recorded

for ME-3 (Near Coal Bearth) and lowest recorded at ME-5 (Nakti creek-near tuna port). In Vadinar, the value of **GPP** was observed **3.67** at ME-7 (Near SPM) and **3.09** mg/L/48 Hr at ME-8 (Near Vadinar Jetty) monitoring station.

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. During the monitoring period of 2023 to 2024 the Net primary productivity of the monitoring location at Kandla from (ME-1 to ME-6) has been estimated to be between **2.49 to 5.47 mg/L/48 Hr**. While in Vadinar, the value of **NPP** was observed **4.16** at ME-7 (Near SPM) and **2.64** mg/L/48 Hr at ME-8 (Near Vadinar Jetty) monitoring station.

- **Pheophytin**

The level of Pheophytin was detected in the range from **0.8 to 5.81 mg/m³** where the highest value observed at ME-6 (Nakti Creek (Near NH-8A)) and the lowest value observed at ME-3(Near Coral Breth), While in Vadinar, the value of Pheophytin was observed **2.66** mg/m³ at ME-7 and **2.43** mg/m³ at ME-8 monitoring station.

- **Chlorophyll-a**

In the sub surface water, the value of Chlorophyll-a reported in range from **1.61 to 12.43 mg/m³**. The highest value observed at ME-6 (Nakti Creek (Near NH-8A)), while the lowest value observed at ME-2 (Kandla Creek). In Vadinar, the value of chlorophyll-a was observed **2.37** mg/m³ at ME-7 (Near SPM) and **3.24** mg/m³ in ME-8 (Near Vadinar Jetty) monitoring station.

- **Particulate Oxidisable Organic Carbon**

During the sampling period, the particulate oxidisable organic carbon falls within the range of **1.12 to 1.51 mg/L** from monitoring location ME-1 to ME-6 at Kandla, whereas for Vadinar, the value of POC observed **1.26** mg/L at ME-7 (Near SPM) and **1.20** mg/L in ME-8 (Near Vadinar Jetty) monitoring station.

- **Secchi Depth**

In monitoring station of Kandla (ME-1 to ME-6) the level of Secchi Depth was observed between **0.56 to 0.63 ft** whereas at Vadinar, the value recorded at ME-7 i.e. Near SPM is **3.93** ft and in Near Vadinar Jetty is **2.61** ft.

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 during the study period. Total 8 sampling locations were studied i.e. sampling locations (6 from Kandla and two from Vadinar).

The details of variation in abundance and diversity in phytoplankton communities is mentioned in **Table 38**.

Table 37: Phytoplankton variations in abundance and diversity in sub surface sampling stations

Genera	ME-1 (Near Passenger Jetty One)	ME-2 (Kandla Creek)	ME-3 (Near Coal Berth)	ME-4 (Khorī Creek)	ME-5 (Nakti Creek- near Tuna Port)	ME-6 (Nakti Creek near NH - 8A)	ME-7 (Near SPM)	ME-8 (Near Vadinar Jetty)
	Avg	Avg	Avg	Avg	Avg	Avg	Avg	Avg
<i>Bacillaria sp.</i>	360	391	271	404	374	521	390	347
<i>Biddulphia sp.</i>	492	340	73	542	315	434	402	274
<i>Chaetoceros sp.</i>	279	379	316	258	627	322	462	394
<i>Chlamydomonas sp.</i>	286	312	147	329	478	456	325	503
<i>Cyclotella sp.</i>	367	443	284	418	454	609	303	378
<i>Coscinodiscus sp.</i>	455	412	290	206	330	376	370	244
<i>Ditylum sp</i>	342	322	124	241	225	205	227	294
<i>Fragilaria sp.</i>	395	381	336	300	355	0	350	360
<i>Bacteriastrum sp.</i>	178	96	52	166	111	252	162	252
<i>Pleurosigma sp.</i>	236	236	129	565	276	675	352	219
<i>Navicula sp.</i>	366	488	472	393	420	332	375	856
<i>Nitzschia sp.</i>	309	272	249	295	366	284	418	435
<i>Synedra sp.</i>	479	328	82	322	144	541	192	327
<i>Skeletonema sp.</i>	270	566	130	0	488	536	521	495
<i>Oscillatoria sp.</i>	341	351	176	251	493	423.5	144	306
<i>Thalassiosira</i>	147	134	64	132	170	224	235	161
<i>Gomphonema sp.</i>	550	495	128	360	600	310	564	500
<i>Planktothrix sp.</i>	140	302	123	411	393	495	272	353
<i>Gyrosigma sp.</i>	410	560	130	750	0	685	400	667
<i>Actinestrum sp.</i>	0	0	0	0	0	500	0	0
<i>Cymbella</i>	500	500	0	550	0	685	700	500
<i>Limnithrix sp.</i>	0	700	0	650	0	800	750	0
<i>Scendesmus sp.</i>	0	0	0	485	0	630	0	0
<i>Mougeotia sp.</i>	0	0	0	8	0	20	0	4
<i>Chlorella sp.</i>	0	0	0	0	0	850	0	0
Density-Units/L	3107.1	3525	3177.3	2918	3073	3704	3357	3576
No. of genera	20	21	19	22	18	24	21	21

The phytoplankton community of the sub surface water in the Kandla and Vadinar was represented by, Diatoms, green algae and filamentous Cynobacteria. Diatoms were

represented by 15 genera; green algae were represented by 1 genera and filamentous Cynobacteria were represented by 1 genera during the sampling period.

The density of phytoplankton of the sampling stations from ME-1 to ME-6 (Kandla) varying from **2918** to **3704** units/L, while for Vadinar its density of phytoplankton observed **3357** units/L at ME-7 and **3576** units/L at ME-8. During the sampling, all communities were contributing in phytoplankton on both location of Kandla & Vadinar except *Gyrosigma sp*, *Actinestrum sp*, *cymbella*, *Limnothrix sp*, *Scendesmus sp*, *Mougeotia sp* and *cholera sp*.

The details of Species richness Index and Diversity Index in Phytoplankton is mentioned in **Table 39**.

Table 38: Species richness Index and Diversity Index in Phytoplankton

Indices	ME-1 (Near Passenger Jetty One)	ME-2 (Kandla Creek)	ME-3 (Near Coal Berth)	ME-4 (Khor Creek)	ME-5 (Nakti Creek- near Tuna Port)	ME-6 (Nakti Creek near NH - 8A)	ME-7 (Near SPM)	ME-8 (Near Vadinar Jetty)
	Avg	Avg	Avg	Avg	Avg	Avg	Avg	Avg
Taxa S	13	14	13	14	13	15	14	13
Individuals	3099	3408	3202	2926	3094	3768	3357	3597
Shannon diversity	2.09	2.12	2.05	1.97	1.94	2.02	2.10	1.95
Simpson 1-D	0.86	0.86	0.85	0.83	0.83	0.84	0.86	0.80
Species Evenness	0.92	0.91	0.90	0.89	0.90	0.87	0.90	0.85
Margalef richness	1.03	1.09	1.02	1.00	0.93	1.01	1.07	1.01
Berger-Parker	0.20	0.21	0.22	0.24	0.25	0.24	0.22	0.28
Relative abundance	0.41	0.44	0.38	0.44	0.38	0.41	0.40	0.41

- **Shannon- Wiener's Index (H):** During monitoring period 2023 to 2024, Average Shanon- Wiener's index of phytoplankton communities was in the range of **1.94 to 2.12** between selected sampling stations from ME-1 to ME-6. While for Vadinar, Average Shannon Wiener's index of phytoplankton communities recorded to be **2.10** at ME-7 and **1.95** at ME-8. The apportionment of the numbers of individuals among the species observed higher stability at all monitoring location of Kandla and Vadinar.
- **Simpson diversity index (1-D):** During the monitoring period **2023 to 2024**, average Simpson diversity index (1-D) of phytoplankton communities was ranged between **0.83 to 0.86** at all sampling stations in the Kandla creek and nearby creeks. Similarly, for Vadinar average Simpson diversity index (1-D) of phytoplankton communities was **0.86** at ME-7 and **0.80** at ME-8.
- **Margalef's diversity index (Species Richness):** During the monitoring period **2023 to 2024**, average margalef's diversity index of phytoplankton communities in Kandla and nearby creeks sampling stations was varying from **0.93 to 1.09**. While for Vadinar, average Margalef's diversity index (Species Richness) of phytoplankton communities observed **1.07** at ME-7 and **1.01** at ME-8.
- **Berger-Parker Index (d):** During the monitoring period **2023 to 2024**, average Berger-Parker Index (d) of phytoplankton communities was in the range of **0.20 to 0.25** between selected sampling stations from ME-1 to ME-6. at Kandla creek and nearby creeks.

Average Berger-Parker Index (d) of phytoplankton communities in the sampling stations of Vadinar, was in the range of **0.22 to 0.28**. All the monitoring station signifies a low diversity with an even distribution among the different species.

- The Average **Species Evenness** is observed in the range of **0.87 to 0.92** for all the six-monitoring station of Kandla and for the Vadinar the average species evenness is observed in the range of **0.85 to 0.90**.
- During the sampling period, average **Relative Abundance** of phytoplankton communities was in range of **0.38 to 0.44** between selected sampling stations from ME-1 to ME-6 at Kandla creek and nearby creeks. Whereas for Vadinar the Average relative Abundance value **0.40** at ME-7 and **0.41** at ME-8. thus, it is concluded that the studied species can be stated as neither highly dominant nor rare.

The details of variation in abundance and diversity in zooplankton communities is mentioned in **Table 40**.

Table 39: Zooplankton variations in abundance and diversity in sub surface sampling stations

Genera	ME-1 (Near Passenger Jetty One)	ME-2 (Kandla Creek)	ME-3 (Near Coal Berth)	ME-4 (Khorī Creek)	ME-5 (Nakti Creek- near Tuna Port)	ME-6 (Nakti Creek near NH - 8A)	ME-7 (Near SPM)	ME-8 (Near Vadinar Jetty)
	Avg	Avg	Avg	Avg	Avg	Avg	Avg	Avg
<i>Acartia sp.</i>	2	2	2	2	2	2	3	2
<i>Acrocalanus</i>	2	2	2	2	2	2	2	4
<i>Amoeba</i>	3	2	3	3	4	2	3	2
<i>Brachionus sp.</i>	3	2	2	2	2	3	4	2
<i>Calanus sp.</i>	2	3	3	2	2	3	2	3
<i>Cladocera sp.</i>	2	3	5	2	3	2	3	3
<i>Cyclopoid sp.</i>	5	4	4	4	2	2	4	2
<i>Copepod larvae</i>	2	3	2	3	2	4	2	2
<i>Diaptomus sp.</i>	5	2	4	2	3	2	3	3
<i>Eucalanus sp.</i>	3	2	2	4	3	6	3	4
<i>Mysis sp.</i>	3	9	7	5	1	6	6	8
<i>Oithona sp.</i>	1	2	4	2	1	4	4	9
<i>Paracalanus sp.</i>	8	7	4	8	11	8	9	10
Density Unit/L	24.45	24.91	25.82	26.00	22.91	26.45	27.64	27.36
No. of genera	13	13	13	13	13	13	13	13

A total of 13 groups/taxa of zooplankton were recorded in Kandla and Vadinar during the study period which mainly constituted by *diaptomus*, *copepods*, *brachionus*, *cladocera*, fish and shrimp larval forms. *Amoeba* and *Cyclopoida* had the largest representation at all stations from (ME-1 to ME-8). The average density of Zooplankton of the sampling stations from ME-1 to ME-6 (Kandla) varying from **22.91 to 26.45** units/L, while for Vadinar its average density of zooplankton observed **27.64** units/L at ME-7 and **27.36** units/L at ME-8. During

the sampling, all communities were contributing in zooplankton except *Oithana sp.* in Kandla and Vadinar.

The details of Species richness Index and Diversity Index in Zooplankton communities is mentioned in **Table 41**.

Table 40: Species richness Index and Diversity Index in Zooplankton

Indices	ME-1 (Near Passenger Jetty One)	ME-2 (Kandla Creek)	ME-3 (Near Coal Berth)	ME-4 (Khor Creek)	ME-5 (Nakti Creek-near Tuna Port)	ME-6 (Nakti Creek near NH - 8A)	ME-7 (Near SPM)	ME-8 (Near Vadinar Jetty)
	Avg	Avg	Avg	Avg	Avg	Avg	Avg	Avg
Taxa S	11	13	10	13	10	12	13	10
Individuals	24	57	26	26	23	26	28	27
Shannon diversity	1.77	1.74	1.76	1.79	1.67	1.76	1.79	1.72
Simpson (1-D)	0.79	0.75	0.79	0.79	0.76	0.77	0.79	0.77
Species Evenness	0.78	0.61	0.78	0.79	0.79	0.73	0.82	0.76
Margalef	2.15	2.21	2.07	2.21	2.06	2.34	2.22	2.16
Berger-Parker	0.34	0.42	0.32	0.34	0.35	0.37	0.31	0.35
Relative abundance	34.93	40.08	31.95	37.76	39.98	38.18	39.18	37.27

- Shannon- Wiener's Index (H):** During monitoring period 2023 to 2024, Average Shanon- Wiener's index of zooplankton communities was in the range of **1.67 to 1.79** between selected sampling stations from ME-1 to ME-6, at Kandla creek and its nearby creeks. While for Vadinar, average Shannon Wiener's index of zooplankton communities recorded to be **1.79** at ME-7 and **1.72** at ME-8. The apportionment of the numbers of individuals among the species observed higher stability at all monitoring location of Kandla and Near SPM (Vadinar).
- Simpson diversity index (1-D):** During the monitoring period **2023 to 2024**, average Simpson diversity index (1-D) of zooplankton communities was ranged between **0.75 to 0.79** at all sampling stations in the Kandla creek and nearby creeks, for Vadinar average Simpson diversity index (1-D) of zooplankton communities was **0.79** at ME-7 and **0.77** at ME-8.
- Margalef's diversity index (Species Richness):** During the monitoring period **2023 to 2024**, average margalef's diversity index of zooplankton communities in Kandla and nearby creeks sampling stations was varying from **2.06 to 2.34**, during the sampling period. While for Vadinar, average Margalef's diversity index (Species Richness) of zooplankton communities observed **2.2** at ME-7 and **2.16** at ME-8.
- Berger-Parker Index (d):** During the monitoring period **2023 to 2024**, average Berger-Parker Index (d) of zooplankton communities was in the range of **0.32 to 0.42** between selected sampling stations from ME-1 to ME-6, at Kandla creek and nearby creeks. Average Berger-Parker Index (d) of zooplankton communities in the sampling stations of Vadinar, was in the range of **0.31 to 0.35**. All the monitoring station signifies a low diversity with an even distribution among the different species.

- The average **Species Evenness** is observed in the range of **0.61 to 0.79** for all the six-monitoring station of Kandla whereas, for the Vadinar the average species evenness was observed in the range of **0.76 to 0.82**, during the monitoring period.
- During the sampling period, **average Relative Abundance** of zooplankton communities was in range of **31.95 to 40.08** between selected sampling stations from ME-1 to ME-6. at Kandla creek and nearby creeks. Whereas for Vadinar the average relative abundance value **39.18** at ME-7 and **37.27** at ME-8, thus it can be concluded that the studied species is stated as neither highly dominant nor rare.

The details of variation in abundance and diversity in **Benthic organism** is mentioned in **Table 42**.

Table 41: Benthic Fauna variations in abundance and diversity in sub surface sampling

Genera	ME-1 (Near Passenger Jetty One)	ME-2 (Kandla Creek)	ME-3 (Near Coal Berth)	ME-4 (Khor Creek)	ME-5 (Nakti Creek- near Tuna Port)	ME-6 (Nakti Creek near NH - 8A)	ME-7 (Near SPM)	ME-8 (Near Vadinar Jetty)
	Avg	Avg	Avg	Avg	Avg	Avg	Avg	Avg
<i>Thiaridae</i>	2	1	2	2	2	2	1	3
<i>Mollusca sp.</i>	2	1	2	2	3	2	2	3
<i>Odonata sp.</i>	2	1	2	3	2	2	2	3
<i>Lymnidae</i>	2	1	5	2	2	2	3	2
<i>Planorbidae</i>	1	1	2	1	2	2	2	1
<i>Atyidae</i>	2	1	2	2	1	2	2	2
<i>Gammaridae</i>	2	1	1	2	1	2	2	3
<i>Portunidae</i>	1	1	1	1	0	1	1	1
<i>Turbinidae</i>	2	1	3	1	1	2	2	2
<i>Palaemonidae</i>	1	1	2	3	3	1	2	2
<i>Diapatra sp.</i>	2	1	3	4	2	4	2	3
<i>Coleoptera sp.</i>	2	1	3	3	0	1	3	2
<i>Crustacea sp.</i>	3	1	3	3	3	3	2	1
<i>Hemiptera sp.</i>	2	1	0	2	2	2	3	2
<i>Tricoptera sp.</i>	2	1	3	4	3	5	2	1
<i>Hydrobidae</i>	1	1	1	2	1	3	0	3
<i>Viviparidae</i>	3	1	0	1	2	2	3	3
<i>Neridae</i>	2	1	2	0	4	2	1	2
Density-m³	10.18	8.82	9.64	10.09	8.5	9.73	9.73	9.55
No of genera	18	18	16	5.00	16	18	17	18

Few Benthic organisms were observed in the collected sample by using the Van-Veen grabs during the sampling conducted for DPA Kandla and Vadinar. Majority of the species were found under the Macro-benthic organisms during the sampling period were represented by *Atyde*, *Palaemonidae*, *Mollusca sp.*, etc. The average density of benthic fauna was varying from **8.55 to 10.18 m³**.

The details of Species richness Index and Diversity Index in Benthic Organisms is mentioned in **Table 43**.

Table 42: Species richness Index and Diversity Index in Benthic Organisms

Indices	ME-1 (Near Passenger Jetty One)	ME-2 (Kandla Creek)	ME-3 (Near Coal Berth)	ME-4 (Khor Creek)	ME-5 (Nakti Creek- near Tuna Port)	ME-6 (Nakti Creek near NH - 8A)	ME-7 (Near SPM)	ME-8 (Near Vadinar Jetty)
	Avg.	Avg	Avg	Avg	Avg	Avg	Avg	Avg
Taxa S	6	7	6	6	7	6	6	6
Individuals	10	9	10	10	9	10	9	10
Shannon diversity	1.55	1.42	1.47	1.50	1.43	1.48	1.43	1.43
Simpson 1-D	0.76	0.73	0.75	0.75	0.73	0.75	0.73	0.74
Species Evenness	0.89	0.89	0.92	0.92	0.90	0.91	0.90	0.89
Margalef	1.92	1.77	1.73	1.81	1.83	1.79	1.76	1.68
Berger-Parker	0.33	0.37	0.33	0.34	0.37	0.34	0.38	0.36
Relative abundance	55.92	57.66	53.67	56.55	60.63	56.18	57.46	51.58

- Shannon- Wiener's Index (H):** During monitoring period 2023 to 2024, Average Shanon- Wiener's index of benthic organism was in the range of **1.42 to 1.55** between selected sampling stations from ME-1 to ME-6, at Kandla creek and its nearby creeks. While for Vadinar, average Shannon Wiener's index of benthic organism recorded to be **1.43** at ME-7 and ME-8. The apportionment of the numbers of individuals among the species observed higher stability at all monitoring location of Kandla and Vadinar.
- Simpson diversity index (1-D):** During the monitoring period **2023 to 2024**, average Simpson diversity index (1-D) of benthic organism was ranged between **0.73 to 0.76** at all sampling stations in the Kandla creek and nearby creeks, Similarly, for Vadinar average Simpson diversity index (1-D) of benthic organism was **0.73** at ME-7 and **0.74** at ME-8.
- Margalef's diversity index (Species Richness):** During the monitoring period **2023 to 2024**, average margalef's diversity index of benthic organism in Kandla and nearby creeks sampling stations was varying from **1.73 to 1.92**. While for Vadinar, average Margalef's diversity index (Species Richness) of benthic organism observed to be **1.76** at ME-7 and **1.68** at ME-8.
- Berger-Parker Index (d):** During the monitoring period **2023 to 2024**, average Berger-Parker Index (d) of benthic organism was in the range of **0.33 to 0.37** between selected sampling stations from ME-1 to ME-6, at Kandla creek and nearby creeks. average Berger-Parker Index (d) of benthic organism in the sampling stations of Vadinar, was in the range of **0.36 to 0.38**. All the monitoring station signifies a low diversity with an even distribution among the different species.

- The average **Species Evenness** is observed in the range of **0.89 to 0.92** for all the six-monitoring station of Kandla and for the Vadinar the species evenness is observed in the range of **0.89 to 0.90**.
- During the sampling period, **average Relative Abundance** of Benthic organisms was in range of **53.67 to 60.63** between selected sampling stations from ME-1 to ME-6 at Kandla creek and nearby creeks. Whereas for Vadinar the Average relative abundance value **57.46** at ME-7 and **51.58** at ME-8, thus it is concluded that the studied species can be stated as neither highly dominant nor rare.

CHAPTER 13: SUMMARY AND CONCLUSION

13.1 Summary and Conclusion

The report, prepared by the Gujarat Environment Management Institute (GEMI), details the environmental monitoring and management plan for the Deendayal Port Authority (DPA) at Kandla and Vadinar. The monitoring covers the period from April 2023 to March 2024.

The primary objective is to systematically assess and monitor environmental parameters including ambient air, water (drinking and surface), soil, sediment, noise, and ecology to ensure compliance with environmental standards and statutory norms.

Methodology

Environmental monitoring was conducted using standard operating procedures, protocols, and guidelines to ensure accurate data collection. Various parameters were measured, including air quality, water quality, soil characteristics, noise levels, and meteorological data.

Based on the results obtained for both study areas, Kandla and Vadinar, during the monitoring period from April 2023 to March 2024, the following observations are concluded.

- **Ambient Air Quality Monitoring**

Particulate matter (PM₁₀ and PM_{2.5}) levels exceeded the national ambient air quality standards (NAAQS) at most monitoring locations, especially at the coal storage area. The high particulate matter levels were attributed to heavy vehicular traffic, loading/unloading of cargo, and dust from unpaved roads. For Gaseous monitoring, sulfur dioxide (SO₂), nitrogen oxides (NO_x), volatile organic compounds (VOCs), and carbon monoxide (CO) were generally within the NAAQS limits.

The noise level was within the permissible limits for the industrial, commercial, and residential zones for daytime and nighttime.

- **DG Stack Monitoring**

Monitoring of the diesel generator (DG) stacks was conducted at one location each in Kandla and Vadinar. Parameters like suspended particulate matter, SO₂, NO_x, CO, and CO₂ were measured and found to be within the prescribed emission limits.

- **Soil Monitoring**

The pH in Kandla varies from slightly alkaline to strongly alkaline, while the soil at Vadinar was found to be moderately alkaline. The soil texture was observed as “sandy loam” to “loamy sand” at all the monitoring locations in Kandla, and the soil texture of Vadinar varies from “loam” to “slit loam. Kandla displays higher salinity and nutrient levels, while Vadinar exhibits lower nutrient levels. Vadinar generally shows moderate conditions with higher water holding capacity and more consistent soil composition. The presence of heavy metals such as aluminium, chromium, nickel, copper, zinc, lead, arsenic, and cadmium vary considerably at both study area.

- **STP Monitoring**

After the effluent treatment in both the study areas, the treated water followed the GPCB discharge norms except for total coliform.

- **Drinking Water Quality Monitoring**

Drinking water samples were collected from 20 locations across Kandla and Vadinar. Most water quality parameters like pH, color, turbidity, chloride, and total hardness were within the drinking water standards (IS 10500:2012). A few locations showed slightly elevated levels of electrical conductivity, salinity, and total dissolved solids, likely due to the coastal location.

- **Marine Water and Sediment Quality Monitoring**

Marine water and sediment samples were collected from 6 locations in Kandla and 2 locations in Vadinar. The water quality parameters like pH, salinity, dissolved oxygen, and nutrients were within the acceptable limits for coastal waters. The sediment quality in terms of heavy metals and organic contaminants was also found to be within the prescribed standards.

- **Marine Ecology Monitoring**

Monitoring of marine ecology was conducted at 6 locations in Kandla and 2 locations in Vadinar. The analysis indicates that both regions exhibit low diversity with an even distribution among species, as evidenced by the Berger-Parker Index and Simpson Diversity Index values. These indices suggest a stable ecosystem where no single species overwhelmingly dominates, nor are any species exceedingly rare. The even distribution of species, coupled with moderate levels of biomass and primary productivity, highlights the resilience of these ecosystems.

Overall, the report concludes that the environmental monitoring conducted by the DPA during the period of April 2023 to March 2024 indicates compliance with the applicable environmental regulations, with some exceptions related to particulate matter levels in the ambient air.

Annexure 1: Photographs of the Environmental Monitoring conducted at Kandla

STP Monitoring



Noise Monitoring



Soil Monitoring



Marine Monitoring



Air Monitoring



Drinking Water Monitoring



Annexure 2: Photographs of the Environmental Monitoring conducted at Vadinar

Air Monitoring



Noise Monitoring



STP Monitoring



Drinking water Monitoring



Marine Monitoring



Soil Monitoring



Source: GEMI

CHAPTER 14: REFERENCES

References:

- (1) National ambient air quality standards central pollution control board, 2009
- (2) Ambient Air Quality Standards in respect of Noise, 2000.
- (3) American Public Health Association 23rd Addition, Standard Methods for Water and Waste water analysis, 2017.s
- (4) Indian Standard DRINKING WATER – SPECIFICATION (Second Revision), 2012.



Gujarat Environment Management Institute (GEMI)

(An Autonomous Institute of Government of Gujarat)

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

Head Office

Plot No. B 246 & 247, G.I.D.C. Electronic Estate,
Sector-25, Gandhinagar-382024

Laboratory

Plot No. B-64, G.I.D.C. Electronic Estate,
Opp. I.P.R., Sector-25, Gandhinagar-382025

Tel: (+91) 79-23240964 (O), T: (+91) 79-23287758 (Lab), F: (+91) 79-23240965

E-mail: info-gemi@gujarat.gov.in | Website: www.gemi.gujarat.gov.in

"We Provide Environmental Solutions"

MARINE DEPARTMENT
(ACCOUT SECTION)

Annexure C

Sub :- Annual return statement showing the collection and disposal of Hazardous and Non Hazardous Wastes carried out by various parties for the year 04/2023 to 03/2024.

With reference to the above subject, the annual return showing the collection and Disposal of Hazardous and Non Hazardous Wastes carried out by various parties for the period 01.04.2023 to 31.03.2024 of Marine department is enclosed herewith.

Encl : AS above



Dy. Conservator
Deendayal Port Authority

✓ EMC (I/C)

NO: MR/WK/1316/282

Dt. 21.06.2024




**Deendayal Port Authority
Marine Department**

**Statement of Hazardous and Non hazardous Waste disposal from the Vessels
at Kandla Port for the Period April 2023 to March 2024 – For the Whole Port
Area**

(PCB ID 28494)

Sr.No.	Month	Year	Hazardous Waste Generation in MT			Solid Waste Generated in MT
			Total Quantity	Used Oil	Waste Residue Containing Oil	
1.	April	2023	484.45	121.11	363.34	169.57
2.	May	2023	1065.92	266.48	799.44	307.83
3.	June	2023	671.82	167.96	503.87	155.03
4.	July	2023	743.45	185.86	557.59	207.71
5.	August	2023	814.63	203.66	610.97	221.78
6.	September	2023	758.07	189.52	568.55	318.76
7.	October	2023	1002.51	250.63	751.89	144.20
8.	November	2023	982.88	245.72	737.16	198.54
9.	December	2023	802.58	200.65	601.94	254.75
10.	January	2024	825.89	206.47	619.41	207.61
11.	February	2024	549.50	137.38	412.13	200.38
12.	March	2024	1023.87	255.97	767.90	186.79
Total			9725.56	2431.39	7294.17	2572.94


Deputy Conservator
Deendayal Port Authority

Marine Department

Statement showing the Collection and disposal of Hazardous and Non-Hazardous Wastes carried out by

Name of Party	Type of Licence	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23	Jan-24	Feb-24	Mar-24	Total
1 Acid Organic Industries Limited	Hazardous	-	-	-	-	-	-	-	-	36.76	-	-	-	36.76
2 Amar Hydrocarbon Pvt Ltd	Hazardous	-	-	-	-	-	-	-	18.42	-	-	-	41.48	59.90
3 Atlas Organics Pvt Ltd	Hazardous	-	-	-	19.24	7.00	-	-	-	-	-	-	-	26.24
4 Aviation Corporation	Hazardous	9.60	18.45	23.97	-	-	-	-	-	-	-	-	-	52.02
5 Mahalaxmi Asphalt Pvt Ltd	Hazardous	102.96	-	-	138.88	-	25.21	67.34	-	73.93	50.49	14.85	43.97	517.65
6 Pnyansi Corporation	Hazardous	16.25	91.36	87.35	-	-	29.89	-	35.57	67.03	-	-	-	327.45
7 Revolution Petrochem LLP	Hazardous	379.86	591.26	594.09	622.50	534.20	453.78	589.26	681.93	423.16	383.95	442.62	648.60	6,345.21
8 Shana Oil Process	Hazardous	-	-	-	-	-	-	-	-	-	-	-	-	-
9 United Shipping Company	Hazardous	-	418.14	-	-	314.16	287.07	396.04	296.10	241.83	432.74	119.51	341.01	2,846.60
10 Chitrekut Trading & Industries	Non-Hazardous	7.24	26.39	14.70	14.98	10.70	6.35	4.78	-	-	0.83	-	-	87.97
11 Golden Shipping Services	Non-Hazardous	1.03	61.82	-	56.87	43.26	77.20	36.10	23.64	75.26	42.55	37.33	49.00	504.06
12 Green Earth Manne Solutions	Non-Hazardous	18.50	37.68	4.42	18.50	27.60	5.00	-	20.34	-	3.71	6.71	-	142.46
13 Harsh A. Pandya	Non-Hazardous	12.00	7.18	1.95	-	5.02	-	6.42	-	12.59	7.29	-	-	52.45
14 K M Enterprise	Non-Hazardous	62.00	99.18	74.30	64.40	64.00	48.37	36.34	56.74	70.28	64.32	67.04	113.62	820.79
15 Naaz Shipping Services Ent	Non-Hazardous	-	-	-	7.56	-	12.40	6.35	5.47	6.35	6.36	-	-	44.49
16 New India Manne Works	Non-Hazardous	4.00	-	-	10.50	23.70	45.15	7.00	11.00	17.80	9.00	-	-	128.15
17 Omega Manne Services	Non-Hazardous	23.81	31.42	30.66	-	-	68.44	19.51	47.35	46.10	30.31	58.85	-	356.45
18 V K Enterprise	Non-Hazardous	24.00	30.00	-	15.00	18.00	18.00	18.00	15.00	15.00	15.00	9.00	-	177.00
19 Vishwa Trade-link Inc.	Non-Hazardous	16.99	12.16	29.00	19.90	29.50	37.85	9.70	19.00	11.37	29.14	21.45	24.17	259.13
Hazardous - Total		508.67	1,119.21	705.41	780.62	866.36	796.97	1,052.64	1,032.02	842.71	867.18	576.98	1,075.06	10,211.83
Non-Hazardous - Total		169.57	307.83	155.03	207.71	221.78	318.76	144.20	198.54	254.75	207.61	200.38	186.79	2,572.94

Copy to : GPCB, Gandhidham / Harbour Master

Annexure D

Statement Showing the quantity of Domestic Waste Water Generation
(STP – Kandla) for the period from April 2023 to March 2024

Sr. No.	Month	Average Quantity of Domestic Waste Water Generation (KLD)
1.	April 2023	225
2.	May 2023	200
3.	June 2023	210
4.	July 2023	220
5.	August 2023	230
6.	September 2023	225
7.	October 2023	230
8.	November 2023	210
9.	December 2023	235
10.	January 2024	255
11.	February 2024	230
12.	March 2024	220
Average		224.16

XEN (Road)

DEENDAYAL PORT AUTHORITY

Annexure -II

Annexure 2

Monitoring the Implementation of Environmental Safeguards
Ministry of Environment Forest & Climate Change
Integrated Regional Office (WZ), Gandhinagar
Monitoring Report
(Period October 2024 to March 2025)

DATA SHEET

1.	Project type: River-valley/ Mining / Industry / Thermal / Nuclear / Other (specify)	:	Infrastructure & miscellaneous projects + CRZ
2.	Name of the project	:	Development of 3 Remaining Integrated Facilities (stage I) within the existing Deendayal Port Trust (Erstwhile: Kandla Port Trust) at Gandhidham, Kutch, Gujarat.
3.	Clearance letter (s) / OM No. and Date	:	Environment and CRZ clearance accorded by the MoEF&CC, GoI vide file no. 10-9/2017-IA-III dated 18/2/2020.
4.	Location	:	
	a. District (S)	:	Kachchh
	b. State (s)	:	Gujarat
	c. Latitude/ Longitude	:	23°01' N, 70°13' E
5.	Address for correspondence	:	
	a. Address of Concerned Project Chief Engineer (with pin code & Telephone/telex/fax numbers)	:	Chief Engineer, Deendayal Port Authority, A.O. Building, Gandhidham- 370 201. P.O. Box no. 50. Phone: 02836 233192 02836 220050
	b. Address of Project: Engineer/Manager (with pin code/ Fax numbers)	:	Same as above
6.	Salient features	:	
	a. of the project	:	1. Development of Container Terminal at Tuna off-Tekra on BOT Basis: (Jetty: T-shape 1100m X 54m, Capacity: 2.19 million TEUs/Annum, Capital Dredging: 13,56,000 M3, Maintenance Dredging 271200 M3/year, Land Area req.: 84 ha, Breakwater: Length of 1400 m, with 20 m of height, Estimated

				Cost: 3097 cr.). 2. Construction of Port Craft Jetty & Shifting of SNA Section. (Dredging: 27357.00 m3, Estimated Cost: 23.17 cr.). 3. Providing Railway Line from NH 8A to Tuna Port. (Length – 11 km, Estimated cost: 94 cr.).
	b.	of the environmental management plans	:	The salient feature of the EMP has already been submitted with last compliance report submitted
7.		Production details during the compliance period and (or) during the previous financial year		Project at Sr. No. 1 – Container terminal at Tuna Tekra – For handling Container Cargo. Project at Sr. no 2 – For Parking of port Crafts. Project at Sr. no. 3 – Railway Line from NH 8 A to tuna.
8.	The breakup of the project area		:	~95 Ha
	a.	submergence area forest & non-forest	:	NIL
	b.	Others	:	NIL
9.	Breakup of the project affected Population with enumeration of Those losing houses / dwelling units Only agricultural land only, both Dwelling units & agricultural Land & landless labourers/artisan		:	NIL
	a.	SC, ST/Adivasis	:	NIL
	b.	Others (Please indicate whether these Figures are based on any scientific And systematic survey carried out Or only provisional figures, it a Survey is carried out give details And years of survey)	:	NIL
10.	Financial details		:	
	a.	Project cost as originally planned and subsequently revised estimates and the year of price reference :		
	1.	Estimated Cost of the Project	:	Total Rs. 4657.01 Crore 1. Development of Container Terminal at Tuna off-Tekra on a BOT Basis (Estimated Cost: Investment on part of concessionaire: Rs. 4243.64

				<p>Cr. Investment on part of concessioning authority: Rs. 296.20 Cr.)</p> <p>2. Construction of Port Craft Jetty & Shifting of SNA Section (Estimated Cost: 23.17 cr.)</p> <p>3. Providing Railway Line from NH 8A to Tuna Port. (Estimated cost: 94 cr.)</p>
	b.	Allocation made for environmental management plans with item wise and year wise Break-up.	:	The allocation made under the "Environmental Services & Clearance of other related Expenditure" scheme during RBE 2024-2025 is Rs. 585 Lakhs.
	c.	Benefit cost ratio / Internal rate of Return and the year of assessment	:	<p>1. Development of Container Terminal at Tuna off-Tekra on a BOT Basis. (Project IRR 22.86 %, Economic IRR 31.71 %).</p> <p>2. Provide a railway line from NH 8A to Tuna Port. (Project IRR is 14.4 % and EIRR is 15.47%).</p> <p>3. Construction of the Port Craft jetty and shifting of the SNA Section is essential, looking towards the safety aspect and smooth operation of the entire Port (essential urgent requirement).</p>
	d.	Whether (c) includes the cost of environmental management as shown above.	:	Yes
	e.	Actual expenditure incurred on the project so far	:	<p>The projects viz. Construction of the Port Craft jetty and shifting of the SNA Section (Actual Cost: Rs. 22 crores) and Railway line NH 8 A to Tuna (Rs. 94 crores deposited by DPA to Indian Railways) have already been completed.</p> <p>The Project at Sr. No. 1 of the EC & CRZ Clearance dated 18/02/2020 i.e. Development of Container Terminal at Tuna off</p>

			<p>Tekra on BOT Basis - Cost incurred by the concessioning authority: Rs. 45 Lakhs + GST.</p> <p>The expenditure incurred by the Concessionaire: Rs. 233.21 Cr (up to March 2025).</p>
	f.	Actual expenditure incurred on the environmental management plans so far	<p>The allocation made by DPA under the scheme of "Environmental Services & Clearance of other related Expenditure" scheme during RBE 2024-2025 is Rs. 585 Lakhs and the expenditure made under the scheme of "Environmental Services & Clearance thereof other related Expenditure" is Rs. 522 Lakhs from October 2024 to March 2025.</p>
11.	Forest land requirement		:
	a.	The status of approval for diversion of forest land for non-forestry use	: NIL
	b.	The status of clearing felling	: NIL
	c.	The status of compensatory afforestation, if any	: NIL
	d.	Comments on the viability & sustainability of compensatory afforestation program in the light of actual field experience so far	: NIL
12.	The status of clear felling in Non-forest areas (such as submergence area of reservoir, approach roads), if any with quantitative information		: NIL
13.	Status of construction		:
	a.	Date of commencement (Actual and/or planned)	<p>1. Development of Container Terminal at Tuna off - Tekra on BOT Basis – 14.03.2024.</p> <p>2. Construction of Port Craft Jetty & Shifting of SNA Section – Work Completed.</p> <p>3. Provide a railway line from NH 8A to Tuna Port – Work completed.</p>
	b.	Date of completion (Actual and/or planned)	<p>1. Development of Container Terminal at Tuna off-Tekra on BOT Basis – Planned Construction End Date: 13/03/2027.</p> <p>2. Construction of Port Craft Jetty & Shifting of SNA Section –</p>

				Work Completed. 3. Provide a railway line from NH 8A to Tuna Port. – Work completed.
14.	Reasons for the delay if the Project is yet to start	:	<p>The projects viz. Construction of the Port Craft jetty and shifting of the SNA Section and Railway line NH 8 A to Tuna have already been completed.</p> <p>The Project at Sr. No. 1 of the EC & CRZ Clearance dated 18/02/2020 i.e. Development of Container Terminal at Tuna off Tekra on BOT Basis – No Delay. The Concession Agreement was signed on 25.08.2023. Both the parties i.e., DPA and M/s. Hindustan Gateway Container Terminal Kandla Private Limited (M/s. HGCTKPL-the Concessionaire of the Project) have fulfilled their respective Conditions Precedent (CPs). The Concession of the Project was awarded to M/s. HGCTKPL on 14.03.2024.</p> <p>As per the Monthly Project Progress Report of Independent Engineer M/s. RITES Ltd, the work at Site started on 10.05.2024.</p> <p>Tender for main civil work divided into two parts, viz. marine work and non-marine work. Tender for Marine Work closed on 15.09.2024 and five bids are under evaluation. Tender for Non Marine work expected to close on 31.10.2024.</p>	
15	<p>Details of site visit:</p> <p>a) The dates on which the project was monitored by the MoEF&CC Regional Office on previous occasions (if applicable).</p> <p>b) Date of site visit for this monitoring report.</p>	:	<p>-----</p> <p>-----</p>	
16	Details of correspondence with project authorities for obtaining action plans/information on the status of	:	-----	

	<p>compliance to safeguards other than the routine letters for logistic support for site visits.</p> <p>(The first monitoring report may contain the details of all the letters issued so far, but the later reports may cover only the letters issued subsequently)</p>		
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