DEENDAYAL PORT AUTHORITY
(Erstwhile: DEENDAYAL PORT TRUST)

दीनदयाल पत्तन प्राधिकरण
DEENDAYAL PORT AUTHORITY

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

www.deendayalport.gov.in

EG/WK/4751 (CCA Renewal)/50

Date: 23/07/2025

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 2024-25 reg.

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
13) DPA letter no. EG/WK/EMC/CCA/Part III/91 dated 19/07/2024

Sir,

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

In this connection, it is to state that, the GPCB has renewed the consolidated consent & Authorization granted to Deendayal Port Authority (Erstwhile Deendayal Port Trust) and issued CCA order no. AWH-110594 vide PC/CA-KUTCH-812 (5)/GPCB ID 28494/581914 dated 21/01/2021 valid upto 21/07/2025 area and correction to consent order done dated 09/04/2021 and its further amendment dated 11/01/2024. Further, Renewal of the consent order issued by the GPCB to the DPA vide consent order no. AWH – 143399 letter no. PC/CCA-KUTCH-812(6)/GPCB ID 28494/864889 dated 16/06/2025 valid upto 21/07/2030.

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 2024-25

This is for kind information and record please.

Encl : As above

Yours faithfully

XEN (EMC)
Deendayal Port Authority

GPCB

GUJARAT POLLUTION CONTROL BOARD

PARYAVARAN BHAVAN, SECTOR 10-A,
GANDHINAGAR - 382010,
(T) 079-23232152

Annexure I

By R.P.A.D

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 6(2) of the Hazardous and Other Waste (Management and Transboundary) Rules, 2016 framed under the Environmental (Protection) Act-1986.

And whereas Board has received consolidated consent application **inward No.331753** dated **24/04/2025** for the **Renewal of Consolidated Consent and Authorization (CC&A)** of this Board under the provisions / rules of the aforesaid Acts. Consents & Authorization are hereby granted as under:

CONSENTS AND AUTHORISATION:
(Under the provisions /rules of the aforesaid environmental acts)

To,
M/s. Kandla Port Trust,
Kandla, A.O. Building Gandhidham,
Tal: Gandhidham,
Dist: Kutch - 370 201.

1. **Consent Order No. AWH-143399 Date of issue: 06/03/2025.**
2. The consents shall be **valid upto 21/07/2030** for the use of outlet for the discharge of trade effluent and emission due to operation of industrial plant for manufacturing of the following items/ products:

Sr. No	Product	Quantity
1.	Dry Cargo Handling	26,54,00,000 MTM
2.	Liquid Cargo Handling	54,34,00,000 MTM
3.	Loading and unloading operation at 13th and 15th Berth	2 MMTPA (each)
4.	Loading and unloading operation at 14th and 16th Berth	4.5 MMTPA (each)

Subject to specific condition:

1. Industry shall strictly comply with all conditions of Environment and CRZ Clearance issued by MoEF vide letter no. F. no. 10-26/2018-IA-III dated 14/06/2018 & 11/06/2020.
2. Applicant shall comply with Manufacture, Storage and Import of Hazardous Chemicals Rules-1989 (MSIHC) as amended time to time.
3. Applicant shall ensure that all storage terminal located within DPT area shall strictly comply with MSIHC Rules including site notification & submit details periodically to board with relevant details.
4. Applicant shall renew Public Liability Insurance time to time & submit a copy to this Board.
5. Unit shall notify site under MSIHC Rule-1989 from competent authority as mentioned in schedule-5 of MSIHC Notifications.

6. Industry shall not withdraw groundwater without prior NOC from CGWA as per Hon. National Green Tribunal order.
7. Industry shall manage Solid Wastes generated from industrial activities as per Solid Waste Management Rules-2016 (solid waste as defined in Rule-3(46)).
8. Applicant shall ensure that there shall be no damage to the existing mangrove patches near site and also ensure the free flow of water to avoid damage to the mangroves.
9. Applicant shall ensure as per EC condition that no creeks or rivers are blocked due to any activities at the site and free flow of water is maintained.
10. Applicant shall provide proper system for collection, storage & treatment & disposal of waste water generated by vessel as per MARPOL& maintain records.
11. Applicant shall install storm drainage catch basin to avoid directly discharge into surface water.
12. Waste effluent accumulated with port activities including storm water & sewage from port operation including sewage ballast water, bilge water &clean waste water from ships shall be as per MARPOL norms.
13. Applicant shall make separate records regarding generation, collection, transportation& disposal of waste generation from ship & maintain its records.
14. Applicant shall made necessary arrangement for the plastic Waste, Solid Waste or other waste generation due to port activities & for facilitation of reception facilities under MARPOL & Environment (Protection) Act-1986 rules etc.
15. Ports shall obtain approval of their oil spill contingency plan (OSCP) as required under national oil spill disaster contingency plan (NOS-DCP) of coast guard, ministry of defence, govt. of India.
16. Best environmental practices by ports maybe uploaded on "Indian ports Association" as well as the same maybe linked to websites of CPCB and respective SPCBs.
17. Manually handling of cargo should be converted into mechanized system, in time bound manner.
18. 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.

3. CONDITIONS UNDER THE WATER ACT:

3.1 Water Source: - GWIL.

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

3.3 The quantity of the fresh water consumption for domestic purpose shall not exceed 3000 KL/Day.

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 (for discharge into Ponds, Lakes)	1.0 mg/L
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. In no case waste water shall be discharged outside 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 in any case.

4. Conditions under the Air Act-1981:

4.1. The following shall be used as a fuel in D.G. Sets;

Sr. No.	Utility	Name of Fuel	Quantity
1.	D G Sets	HSD	500 Lit/Hr

4.2. The applicant shall install & operate air pollution control system efficiently in order to achieve prescribed norms.

4.3. The flue gas emission through stack attached to D.G. Sets shall conform to the following standards;

Sr. No.	Stack attached to	Stack height	APCM	Parameter	Permissible Limit
1.	D. G. Set (2 nos.) (1010 KVA, stand by)	15 mtr each	Adequate Stack Height	PM SO_2 NO_X	150 mg/NM^3 100 ppm 50 ppm

4.4. There shall be no process gas emission from manufacturing process and other ancillary operations.

4.5. 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 Standards issued by MoEF & CC dated 18th November-2009.In addition to following parameters Industry shall also carry out AAQ monitoring of all other applicable parameter as per MoEF notification dated 18/11/2009 and submit the report to the Board.

Sr. No.	Pollutant	Time Weighted Average	Concentration in Ambient air in µg/M^3
1.	Sulphur Dioxide (SO_2)	Annual 24 Hours	50 80
2.	Nitrogen Dioxide (NO_2)	Annual 24 Hours	40 80

3.	Particulate Matter (Size less than 10 µm) or PM_{10}	Annual 24 Hours	60 100
4.	Particulate Matter (Size less than 2.5 µm) or $PM_{2.5}$	Annual 24 Hours	40 60

4.6. The applicant shall provide portholes, ladder, platform etc. at chimney(s) for monitoring the air emissions and the same shall be open for inspection to/and for use of Board's 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.

4.7. The industry shall take adequate measures for control of noise levels from its own sources within the premises so as to maintain ambient air quality standards in respect of noise to less than 75dB(A) during day time and70 dB (A) during night time. Daytime is reckoned in between 6a.m. and10 p.m. and nighttime is reckoned between 10 p.m. and 6 a.m.

4.8. **D.G. Sets Conditions**

The D.G. Set shall have acoustic enclosure and shall comply with the standards specified at Sr. no. 95 of Schedule-I of the rule-3 of E.P. Rules -1986 and Noise pollution level as per the Air Act-1981.

D.G. Sets standards:-

The flue gas emission through stack attached to D.G. Sets shall conform to the following standards.

a) The minimum height of stack to be provided with each of the generator set shall be H=h + 0.2 (KVA) 1/2, where H= Total stack height in meter, h= height of the building in meters where or by the side of which the generator set is installed.

b) Noise from DG set shall be controlled by providing an acoustic enclosure or by treating the room acoustically, at the users end.

c) The acoustic enclosure or acoustic treatment of the room shall be designed for minimum 25 dB (A) insertion loss or for meeting the ambient noise standards, whichever is on the higher side (if the actual ambient noise is on the higher side, it may not be possible to check the performance of the acoustic enclosure/ acoustic treatment. Such circumstances the performance may be checked for noise reduction up to actual ambient noise level, preferably, in the night time). The measurement for insertion loss may be done at different points at 0.5 m from the acoustic enclosure/room, and the averaged.

d) The D.G. Set shall be provided with proper exhaust muffler with insertion loss of minimum 25 dB (A).

e) All efforts shall be made to bring down the noise level due to the D.G. Set, outside the premises, within the ambient noise requirements by proper siting and control measures.

f) Installation of a D.G. Sets must be strictly in compliance with the recommendations of the D.G. Set manufacturer.

g) A proper routine and preventive maintenance procedure for the D.G. Set should be set and followed in consultation with the DG Set manufacture which would help prevent noise levels of the DG Set from deteriorating with use.

5. AUTHORIZATION as per HAZARDOUS AND OTHER WASTE (MANAGEMENT AND TRANSBOUNDARY) RULES, 2016 Form-2 [See rule 6 (2)]

Form for grant of authorization for occupier or operator handling Hazardous waste

5.1 Authorization order no:-**AWH-143399** Date of issue: 03/06/2025.

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
1.	Used Oil	4250 MT	I-5.1	Collection, Storage, Transportation, and send to registered recycler processors.
2.	Waste Residue containing oil	8500 MT	I-5.2	

5.3 The authorization shall be valid up to **21/07/2030.**

5.4 The authorization is subject to the conditions stated below and such other conditions as may be specified in the rules from time to time under the Environment (Protection) Act-1986.

5.5 The authorization is granted to operate a facility for collection, storage within factory premises transportation and ultimate disposal of Hazardous wastes as per condition no 5.2 to the industry having valid CCA of this Board.

5.6 **TERMS AND CONDITIONS OF AUTHORISATION**

1. The applicant shall comply with the provisions of the Environment (Protection) Act-1986 and the rules made there under.
2. The authorization or its renewal shall be produced for inspection at the request of an officer authorized by the Gujarat Pollution Control Board.
3. The persons authorized shall not rent, lend, sell, and transfer or otherwise transport the hazardous wastes without obtaining prior permission of the Gujarat Pollution Control Board.
4. Any unauthorized change in personnel, equipment or working conditions as mentioned in the authorization order by the persons authorized shall constitute a beach of this authorization.
5. The person authorized shall implement Emergency Response Procedure (ERP) for which this authorization is being granted considering all site specific possible scenarios such as spillages, leakages, fire etc. and their possible impacts and also carry out mock drill in this regard at regular interval of time;
6. The person authorized shall comply with the provisions outlined in the Central Pollution Control Board guidelines on "Implementing Liabilities for Environmental Damages due to Handling and Disposal of Hazardous Wastes and Penalty"

7. It is the duty of the authorized person to take prior permission of the Gujarat Pollution Control Board to close down the facility.
8. An application for the renewal of an authorization shall be made as laid down in rules 6(2) under Hazardous and Other Waste Rules, 2016.
9. The imported hazardous and other wastes shall be fully insured for transit as well as for any accidental occurrence and its clean-up operation.
10. The record of consumption and fate of the imported hazardous and other wastes shall be maintained.
11. The hazardous and other wastes which gets generated during recycling or reuse or recovery or pre-processing or utilization of imported hazardous or other wastes shall be treated and disposed of as per specific conditions of authorization.
12. The importer or exporter shall bear the cost of import or export and mitigation of damages if any.
13. Any other conditions for compliance as per the Guidelines issued by the Ministry of Environment, Forest and Climate Change or Central Pollution Control Board from time to time.
14. The waste generator shall be totally responsible for (i.e. collection, storage, transportation and ultimate disposal) the wastes generated.
15. Records of waste generation, its management and annual return shall be submitted to Gujarat Pollution Control Board in Form-4 by 30th day of June of every year for the preceding period April to March.
16. In case of any accident, details of the same shall be submitted on Form-11 to Gujarat Pollution Control Board.
17. As per "Public Liability Insurance Act-91" company shall get Insurance Policy, if applicable.
18. Empty drums and containers of toxic and hazard material shall be treated as per guideline published for "Management & Handling of discarded containers". Records of the same shall be maintained and forwarded to Gujarat Pollution Control Board regularly.
19. In case of transport of hazardous wastes to a facility for (i.e. treatment, storage and disposal) existing in a State other than the State where hazardous wastes are generated, the occupier shall obtain 'No Objection Certificate' from the State Pollution Control Board or Committee of the concerned State of Union Territory Administration where the facility exists.
20. Unit shall take all concrete measures to show tangible results in waste generation, reduction, avoidance, reuse and recycle. Actions taken in this regard shall be submitted within three months and also along with Form-4.
21. Industry shall have to display the relevant information with regards to hazardous waste as indicated in the Hon. Supreme Court's Order in W.P. No.657 of 1995 dated 14th October, 2003.
22. 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 emissions and solid hazardous wastes generated within the factory premises.

6. **SPECIFIC CONDITIONS:-**

6.1 The authorized actual user of hazardous and other wastes shall maintain records of hazardous and other wastes purchased in a passbook issued by the State Pollution Control Board along with the authorization.

6.2 Handling over of the hazardous and other wastes to the authorized actual user shall be only after making the entry in the passbook of the actual user.

6.3 In case of renewal of authorization, a self-certified compliance report in respect of effluent, emission standards and the conditions specified in the authorization for hazardous and other wastes shall be submitted to SPCB.

6.4 The occupier of the facility shall comply Standard operating procedure/guidelines published by MOEF&CC or CPCB or GPCB from time to time.

6.5 Unit shall comply provisions of E-Waste Management Rules-2016.

6.6 The disposal of Hazardous Waste shall be carried out as per the waste Management hierarchy.

6.7 The occupiers of facilities shall not store the hazardous and other wastes for a period not exceeding **ninety days**. Prior permission of the Board shall be obtained for extension of the storage period.

6.8 The occupier shall maintain the records of generation, sale, storage, transport, recycling, co processing and disposal of hazardous waste and make available during the inspection.

6.9 The transportation of the hazardous waste shall be carried out in GPS mounted dedicated vehicles.

7. **GENERAL CONDITIONS: -**

7.1 Any change in personnel, equipment or working conditions as mentioned in the consents form/order should immediately be intimated to this Board.

7.2 Applicant shall also comply with the general conditions given in annexure I.

7.3 Whenever due to accident or other unforeseen act or ever, such emissions occur or is apprehended to occur in excess of standards laid down such information shall be forthwith reported to Board, concerned Police Station Office of Directorate of Health Service, Department of Explosives, Inspectorate of Factories and local body.

7.4 In case of failure of pollution control equipments, the production process connected to it shall be stopped. Remedial actions/measures shall be implemented immediately to bring entire situation normal.

7.5 The Environmental Management Unit/Cell shall be setup to ensure implementation on and monitoring of environmental safeguards and other conditions stipulated by statutory authorities. The Environmental Management Cell/Unit shall directly report to the Chief Executive of the organization and shall work as a focal point for

internalizing environmental issues. These cells/units also coordinate the exercise of environmental audit and preparation of environmental statements.

7.6 The Environmental audit shall be carried out yearly and the environmental statements pertaining to the previous year shall be submitting to this State Board latest by 30th September every year.

7.7 The Board reserves the right to review and/or revoke the consent and/or make variations in the conditions, which the Board deems, fit in accordance with Section 27 of the Act.

7.8 In case of change of ownership/management the name and address of the new owners/ partners/directors/proprietor should immediately be intimated to the Board.

7.9 Industry shall have to display the relevant information with regard to hazardous waste as indicated in the Hon. Supreme order in w.p. no. 657 of 1995 dated 14th October 2003.

For and on behalf of
GUJARAT POLLUTION CONTROL BOARD

(T.C. Patel)
Unit Head

NO: PC/CCA-Kutch-812(6)/GPCB ID-28494/ **Date: - /06/2025**

Issued to:
M/s. Kandla Port Trust,
Kandla, A.O. Building Gandhidham,
Tal: Gandhidham,
Dist: Kutch - 370 201.

Annexure II

Environmental Statement (Form V)
For Deendayal Port Authority, Kandla
For the FY @ 2024-2025

"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, 2025

"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	:	27th June, 2016

"PART-B"

WATER AND RAW MATERIAL CONSUMPTION

Sr.No.	WATER CONSUMPTION	KLD
1.	Process	**1491.5**
2.	Cooling	
3.	Domestic Purpose	
Total water consumption for the period from April 2024 to March 2025 was **544388 KL** hence, average water consumption for per day –1491.5 **KLD**		

I. Water Consumption

Sr. No.	Name of Products	Process Water Consumption per unit of products output	
		During the current financial year 2023-24	**During the current financial year 2024-25**
01.	Dry Cargo Handling	**132.37 MT**	**150.15 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 2024-25 Total Cargo Handled is **150.15** MMTPA However, Details of the Domestic water consumption for the financial year 2024-25 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 2023-24	**During the current financial year 2024-25**
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 • Ambient Air Quality Monitoring • Drinking Water Quality Monitoring • Marine Water Monitoring • Noise Level Monitoring			

"PART-D"

HAZARDOUS WASTE

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

Sr.No.	Hazardous Waste	Total Quantity in MT/Year	
		During the current financial year 2023-24	During the current financial year 2024-25
1.	5.1- Used Spent Oil	2431.39	4498.91
2.	5.2- Waste Residue Containing Oil	7294.17	13496.72
• Details of Hazardous Waste generated during the financial year 2024-25 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 2023-24	**During the current financial year 2024-25**
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	**2572.94**	**3274.60**
Details of Solid Waste (Non-Hazardous Waste) generated during the financial year 2024-25 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 2026-2026 is Rs. 545 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 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
5. 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
6. 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
7. 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.
8. DPA has accorded the work of green belt development in Deendayal port Authority and its Surrounding areas to GUIDE for the plantation of 10000 saplings of suitable species
9. 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.
10. DPA has installed Mist Canon at the Port area to minimize the coal dust.
11. 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.
12. 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.

13. 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.
14. 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**)
15. Deendayal Port Authority had carried out mangrove plantation in an area of 1650 ha. through various government agencies like Gujarat Ecology Commission, State Forest Department, GUIDE, Bhuj etc.
16. DPA is involved in various CER activities like providing the proper sanitation and development of better roads for connectivity
17. 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, DPA 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
18. 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
19. 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)
20. Recently, DPA has entrusted the work to GEMI, Gandhinagar for "Study of CO_2 Emission Estimation and Reduction Strategy under Maritime India Vision 2030.
21. DPA has assigned the work for Installation of Continuous Ambient Air Quality Monitoring System (CAAQMS) for monitoring of Air quality at DPA Kandla to GUIDE, bhuj.

ANNEXURE A

Details of the Domestic water consumption for the financial year 2024-25

Statement showing the quantity of water consumed from GWSSB from April 2024 to March 2025

Sr.	Month	Total Quantity Consumed in KL
1.	April 2024	50069
2.	May 2024	52451
3.	June 2024	41576
4.	July 2024	62994
5.	August 2024	51467
6.	September 2024	51583
7.	October 2024	48200
8.	November 2024	43990
9.	December 2024	50340
10.	January 2025	26970
11.	February 2025	42570
12.	March 2025	22178
Total		**544388**

XEN (PL)

ANNEXURE B

Environmental Monitoring Report

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: March-April 2025)

Document Ref No.: GEMI/DPA/782(2)(5)/2025/006

Submitted to:

Deendayal Port Authority (DPA), Kandla

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 March to 14th April 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

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 (March-April 2025)"* is prepared.

- **Name of the Report:** *Environment Monitoring Report (March-April 2025)*
- **Date of Issue:** 26/05/2025
- **Version:** 1.0
- **Report Ref.:** GEMI/DPA/782(2)(5)/2025/006

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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 EMP

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

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

Hence, for the determination of levels of pollution, identification of pollution sources, control and disposal of waste from various point and non-point sources and for prediction of pollution levels for future, regular monitoring and assessment are required during the entire construction and operation phase of a major port. As per the Ministry of Environment, Forest and Climate Change **(MoEF&CC)**, The Environmental Management Plan (EMP) is required to ensure sustainable development in the area surrounding the project. Hence, it needs to be an all encompasses plan consist of all mitigation measures for each item wise activity to be undertaken during the construction, operation and the entire life cycle to minimize adverse environmental impacts resulting from the activities of the project. for formulation, implementation and monitoring of environmental protection measures during and after commissioning of projects. The plan 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 March-16th April 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

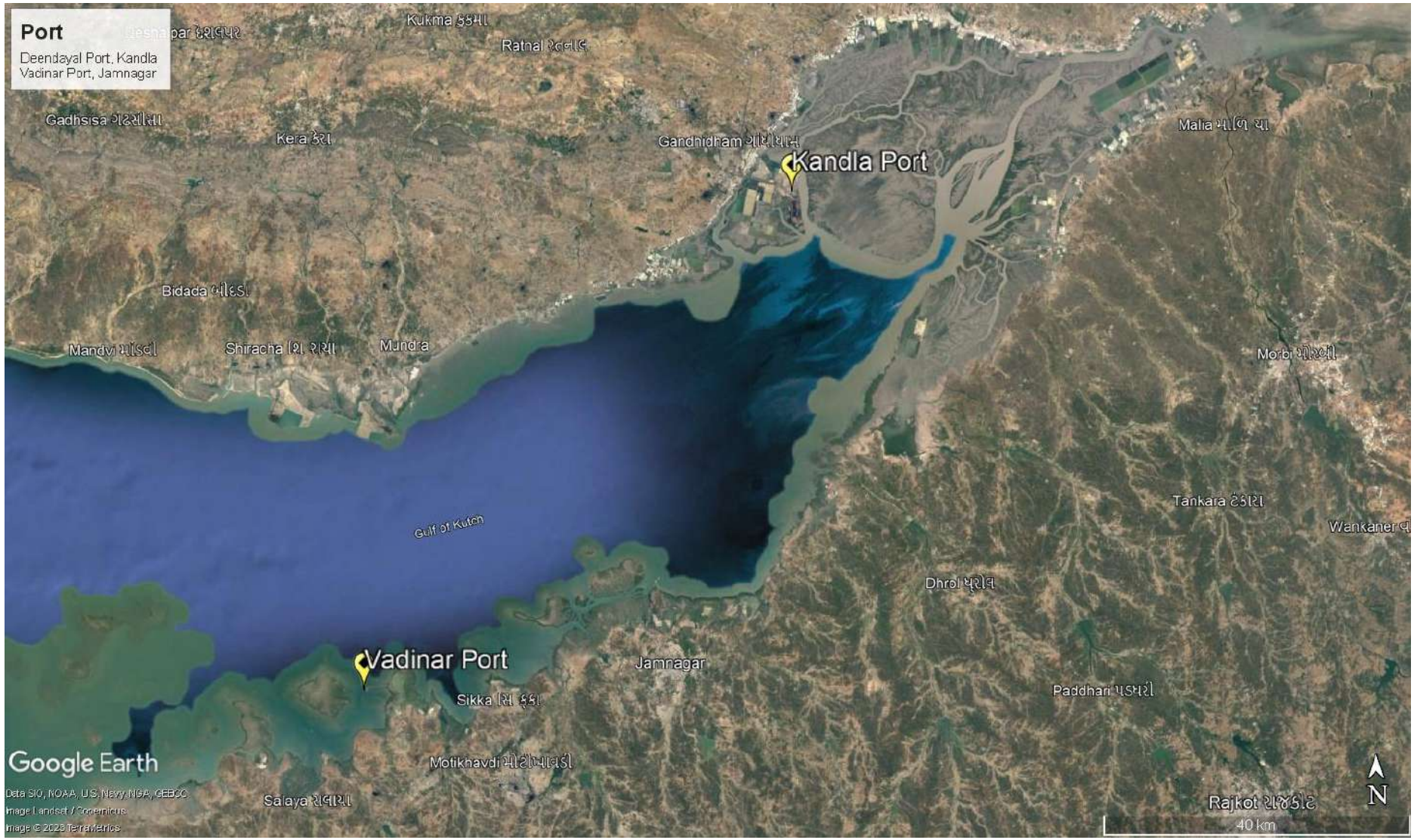
Vadinar is a small coastal town located in Devbhumi Dwarka district of the Gujarat state in India located at coordinates 22° 27' 16.20" N - 069° 40' 30.01". DPA had commissioned the Off Shore Oil Terminal (OOT) facilities at Vadinar in the year 1978, for which M/s. Indian Oil Corporation Limited (IOCL) 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 transhipment), 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:

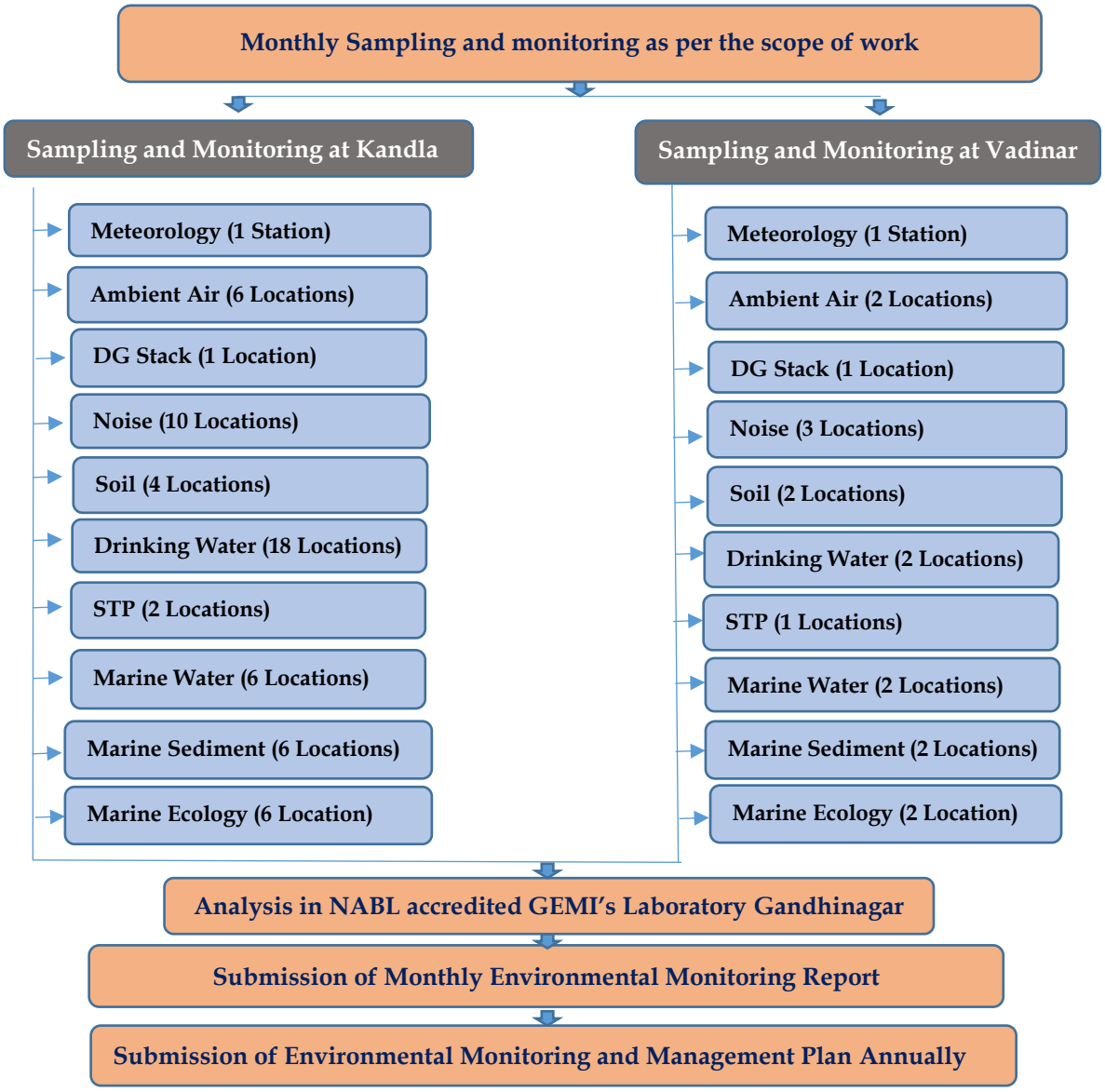


Figure 1: Methodology flow chart

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	^{o}C		
6.	Solar Radiation	W/m^2		

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

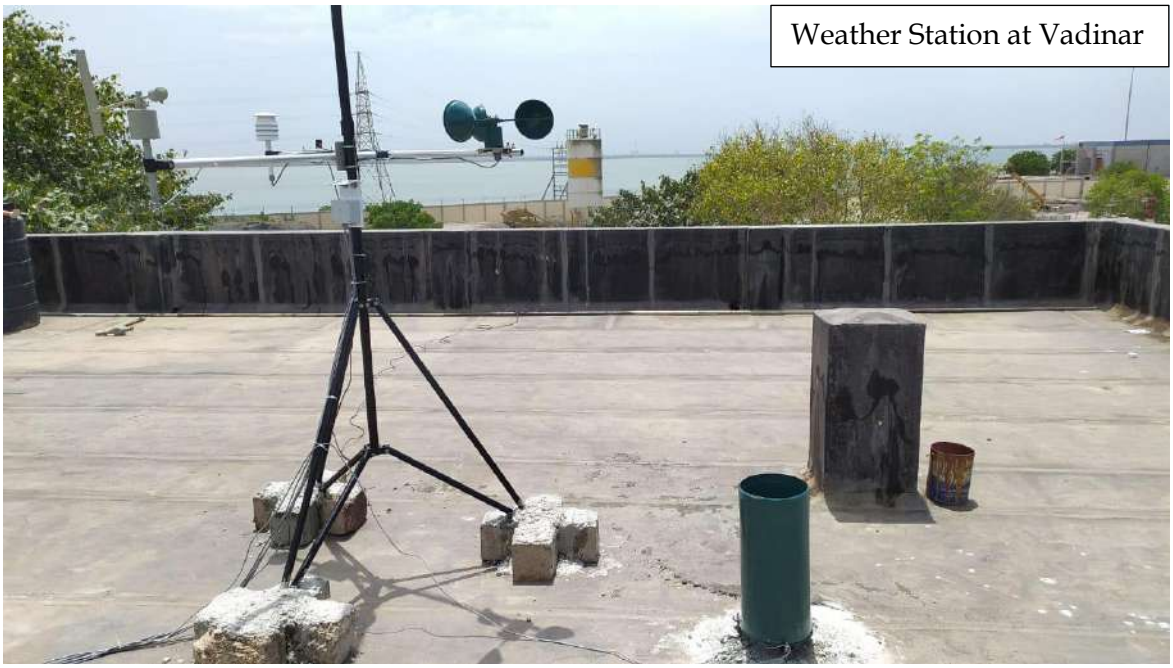


Figure 2: Photographs of Automatic Weather Monitoring Station at Kandla and Vadinar

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/m²)**	**Wind Direction (°)**	**Rainfall (mm)**
Stat.	**Mean**	**Max.**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**			
March-April, 2025	3.38	42.6	0.66	30.53	43	21.9	42.22	85	18.7	92.27	From North	0
Details of Micro-meteorological data at Vadinar Observatory												
Monitoring Period	**Wind Speed (Km/h)**			**Temperature (°C)**			**Relative humidity (%)**			**Solar Radiation (W/m²)**	**Wind Direction (°)**	**Rainfall (mm)**
Stat.	**Mean**	**Max.**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max.**	**Min**			
March-April, 2025	12.18	57.3	3.32	27.56	38.3	21.8	68.26	97.6	19.9	110.30	From West-North-West	0

3.3 Data Interpretation and Conclusion

- **Temperature**

a. **Kandla:** The ambient temperature for the monitoring period varies between the range of 21.9 – 43 °C for Kandla, with average temperature of 30.53 °C.
b. **Vadinar:** The ambient temperature for the monitoring period varies between the range of 21.8 – 38.3 °C for Vadinar, with average temperature of 27.56 °C.

- **Relative Humidity**

a. **Kandla**: The Relative Humidity recorded between the range of 18.7 – 85 %, with average Humidity of 42.22 %.
b. **Vadinar:** During the study period, the Relative Humidity varies between 19.9 – 97.6 %, with average Humidity of 68.26 %.

- **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 0.66 – 42.6 Km/hr with average wind speed 3.38 m/s.
b. **Vadinar:** During the monitoring period, the Wind speed recorded ranges between 3.32 – 57.3 Km/hr with average wind speed 12.18 m/s.

- **Solar Radiation:**

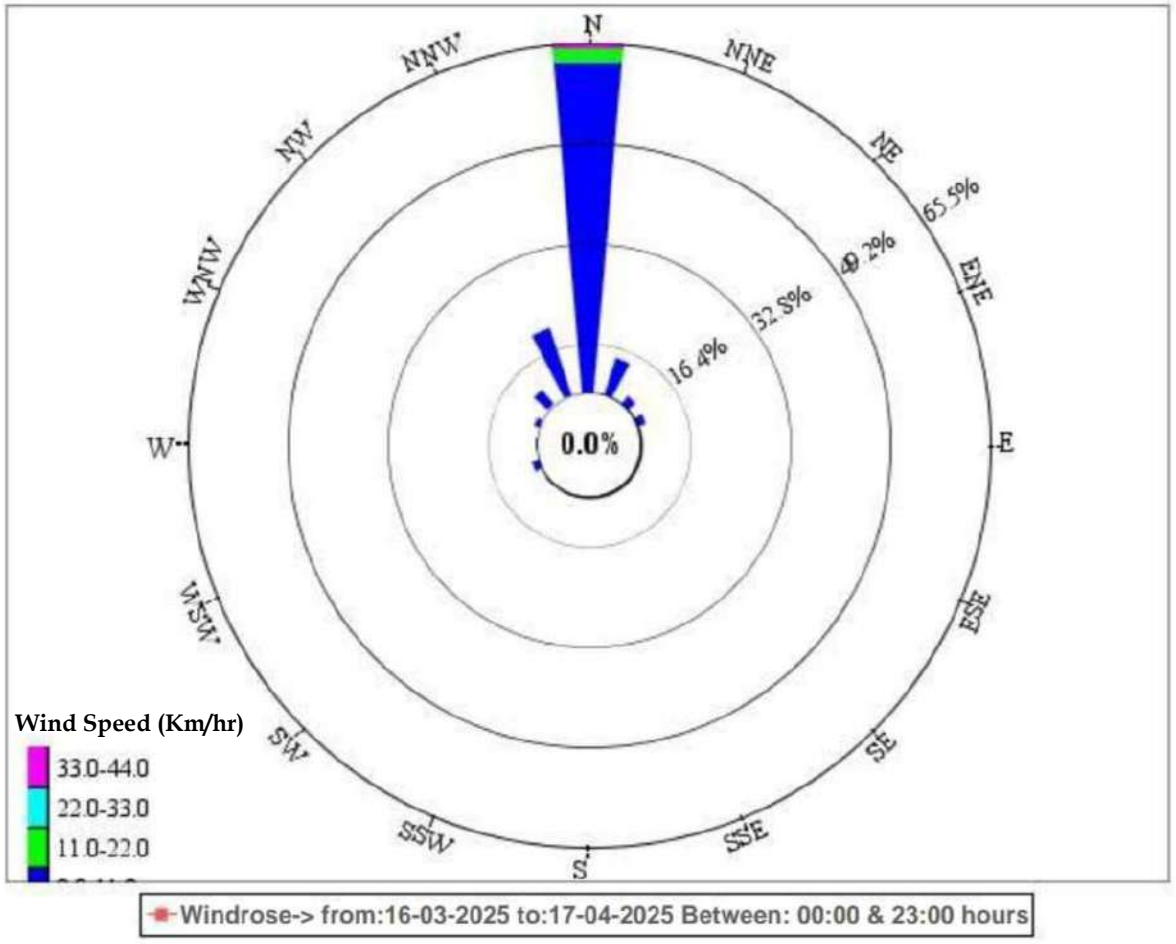
a. **Kandla:** The average Solar Radiation for the monitoring period was recorded as 92.27 W/m^2.
b. **Vadinar:** The average Solar Radiation was recorded as 110.30 W/m^2.

- **Wind rose diagram -**

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

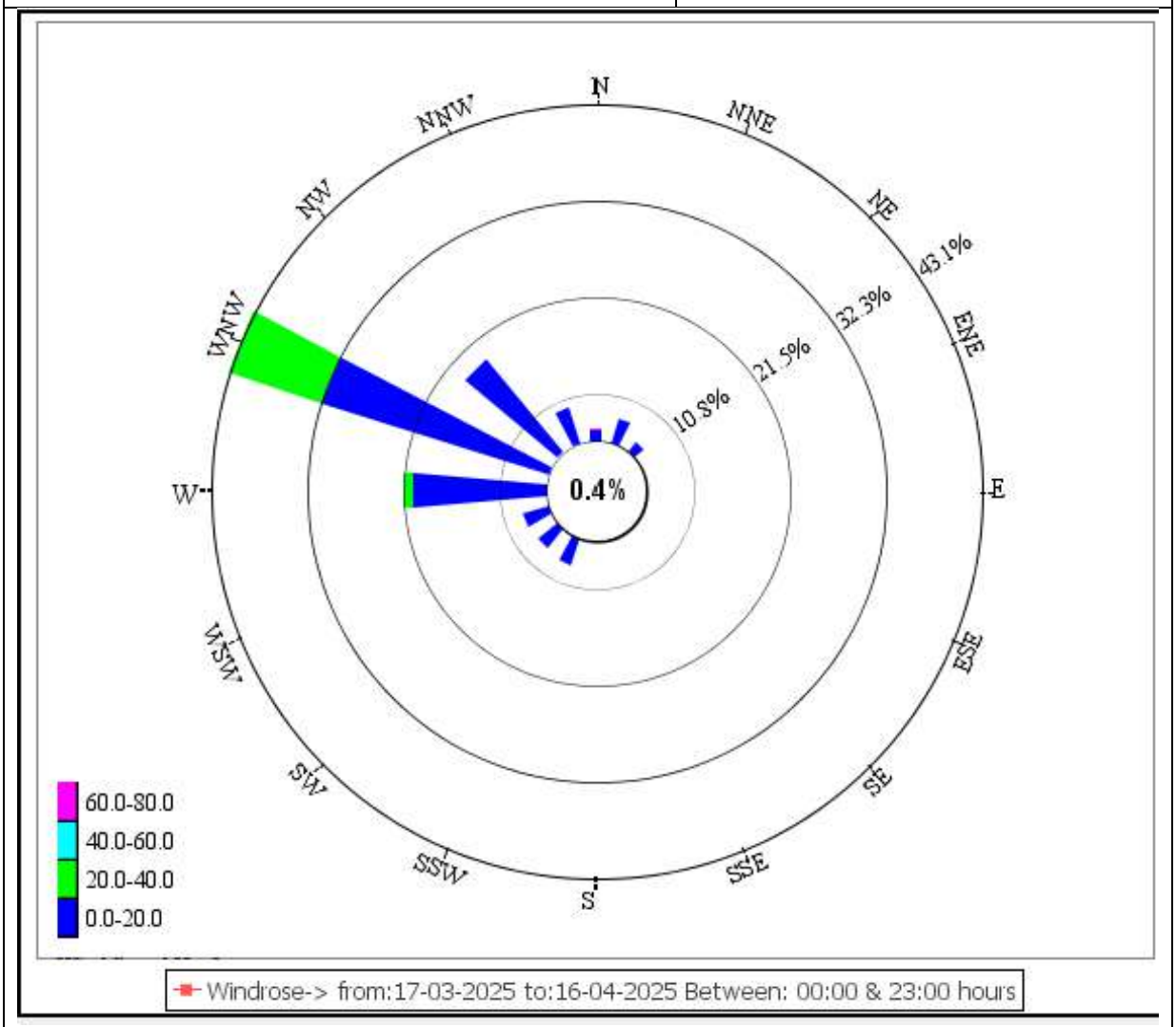
This Wind Rose Diagram reveals that at Kandla and Vadinar, during the monitoring period, the prevailing winds predominantly blow from the North direction at Kandla. whereas, At Vadinar, the winds were observed to blow from West-North-West direction.

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 16th March to 17th April, 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

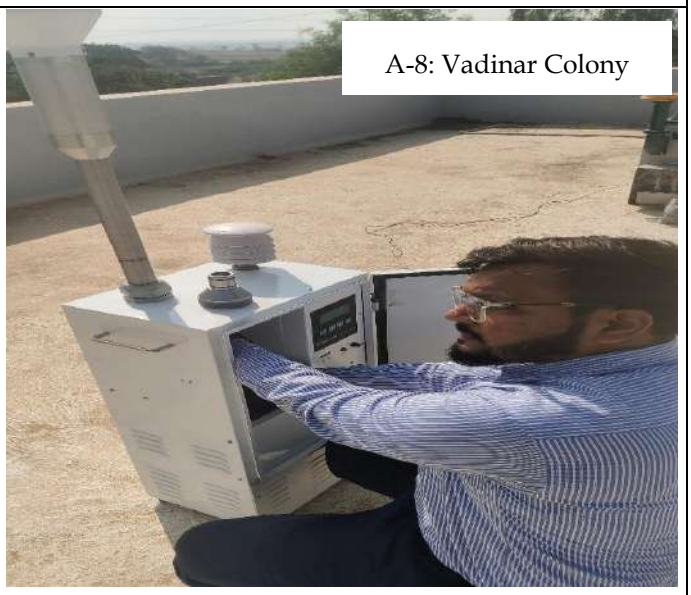
A-2: Oil Jetty No. 7

A-3: Kandla Port Colony

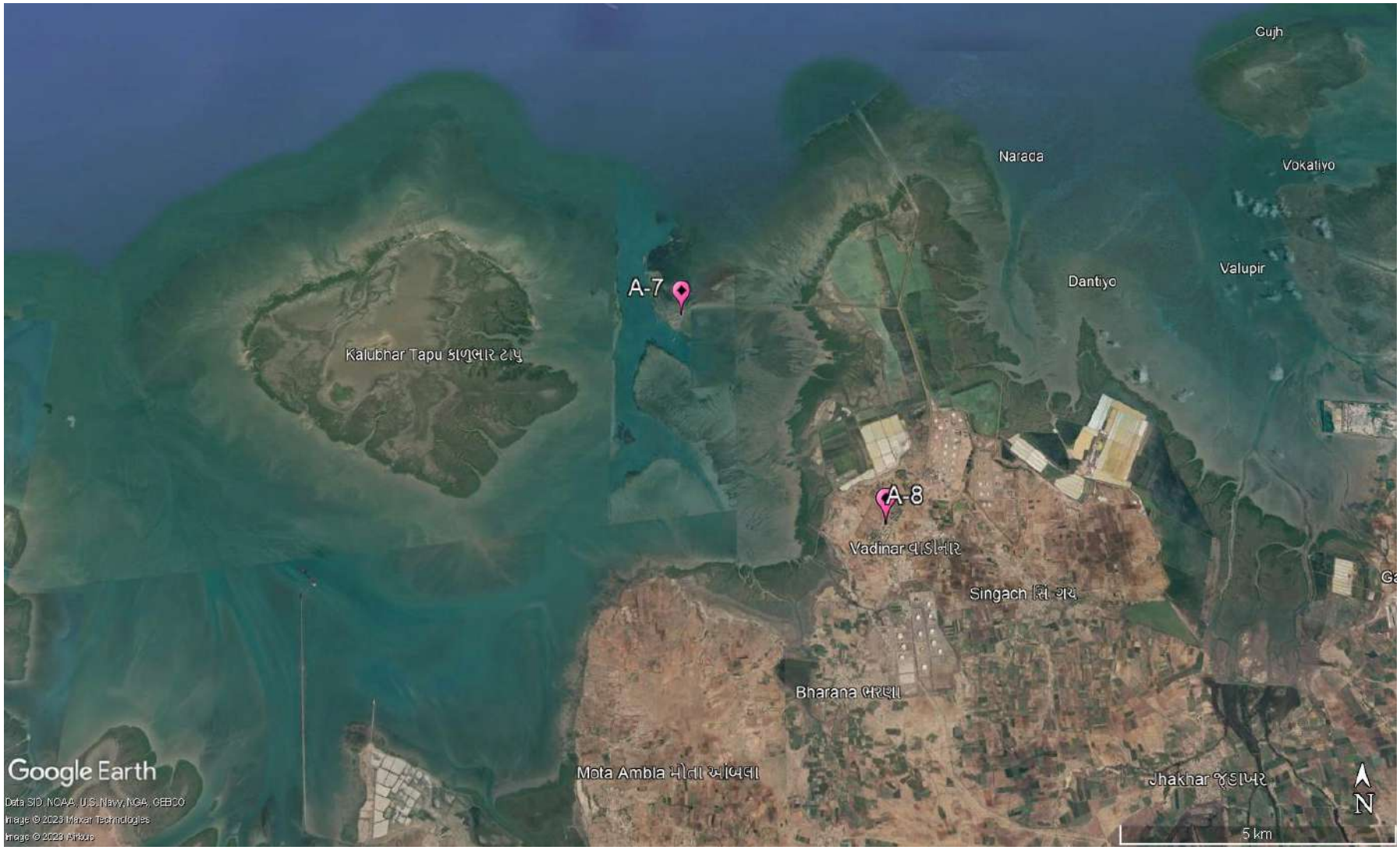
A-4: Marine Bhavan

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. PM_{10} 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 PM_{10}, 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 SO_2 was performed by adopting the 'Improved West and Gaeke Method'. The ambient air, drawn through the draft created by the RDS, is passed through an impinger, containing a known volume of absorbing solution of Sodium tetrachloromercurate, at a pre-determined 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 PM_{10}, $PM_{2.5}$, 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/m³	IS 5182 (Part 23): 2006	Respirable Dust Sampler (RDS) conforming to IS:5182 (Part-23): 2006	Twice in a week
2.	$PM_{2.5}$	µg/m³	IS:5182 (Part:24):2019	Fine Particulate Sampler (FPS) conforming to IS:5182 (Part-24): 2019	
3.	Sulphur Dioxide (SO_x)	µg/m³	IS 5182 (Part:2): 2001	Gaseous Attachment conforming to IS:5182 Part-2	
4.	Oxides of Nitrogen (NO_x)	µg/m³	IS:5182 (Part-6): 2006	Gaseous Attachment conforming to IS:5182 Part-6	
5.	Carbon Monoxide (CO)	mg/m³	GEMI/SOP/AAQM/11 ; Issue no 01, Date 17.01.2019: 2019	Sensor based Instrument	
6.	VOC	µg/m³	IS 5182 (Part 17): 2004	Low Flow Air Sampler	
8.	PAH	µg/m³	IS: 5182 (Part 12): 2004	Respirable Dust Sampler (RDS) conforming to IS:5182 (Part-12): 2004	Monthly
7.	Benzene	µg/m³	IS 5182 (Part 11): 2006 RA: 2017	Low Flow Air Sampler	
9.	Non-methane VOC	µg/m³	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 PM_{10}, $PM_{2.5}$, SO_2, NO_x, VOC and CO for Ambient Air quality monitoring

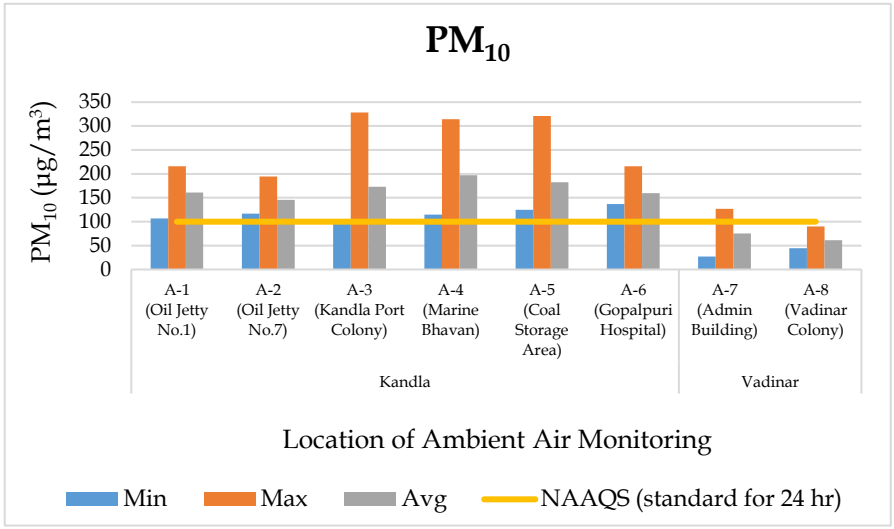
Station Code & Name	Unit of Average Concentration	Average Pollutant Concentration					
	Pollutants	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)	SO_2 (µg/m³)	NO_X (µg/m³)	VOC (µg/m³)	CO (mg/m³)
	Duration	(24 hr)				(2 hr)	(1 hr)
	NAAQS by CPCB / Monitoring Days	100	60	80	80	-	2
A-1: Oil Jetty No.1, Kandla	17/03/2025	199.46	24.32	5.63	6.93	0.04	0.85
	19/03/2025	215.97	22.11	5.8	16.54	0.05	0.82
	24/03/2025	169.28	19.23	8.38	21.87	0.13	0.82
	26/03/2025	183.32	22.62	13.21	7.86	0.16	0.81
	01/04/2025	147.65	25.32	12.53	9.65	0.12	0.86
	03/04/2025	135.26	15.84	11.28	13.54	0.11	0.81

Station Code & Name	Unit of Average Concentration	Average Pollutant Concentration					
	Pollutants	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)	SO_2 (µg/m³)	NO_X (µg/m³)	VOC (µg/m³)	CO (mg/m³)
	Duration	(24 hr)				(2 hr)	(1 hr)
	NAAQS by CPCB / Monitoring Days	100	60	80	80	-	2
A-2: Oil Jetty No.7, Kandla	07/04/2025	128.42	19.65	6.75	14.75	0.25	0.83
	09/04/2025	106.84	24.54	10.22	9.02	0.24	0.82
	Minimum	**106.84**	**15.84**	**5.63**	**6.93**	**0.04**	**0.81**
	Maximum	**215.97**	**25.32**	**13.21**	**21.87**	**0.25**	**0.86**
	Average	**160.78**	**21.70**	**9.23**	**12.52**	**0.14**	**0.83**
	Std. Deviation	**37.61**	**3.24**	**3.01**	**5.11**	**0.08**	**0.02**
	17/03/2025	194.47	22.20	<5	8.67	0.15	0.84
	19/03/2025	158.93	23.00	<5	22.97	0.21	0.83
	24/03/2025	151.19	15.70	8.38	9.17	0.12	0.81
	26/03/2025	126.89	9.31	11.12	10.11	0.19	0.80
	01/04/2025	124.59	16.58	9.86	16.38	0.09	0.79
	03/04/2025	148.25	11.23	12.35	15.03	0.15	0.82
	07/04/2025	143.26	23.57	11.36	18.42	0.14	0.83
	09/04/2025	116.87	20.01	8.62	21.56	0.11	0.80
	Minimum	**116.87**	**9.31**	**8.38**	**8.67**	**0.09**	**0.79**
	Maximum	**194.47**	**23.57**	**12.35**	**22.97**	**0.21**	**0.84**
	Average	**145.56**	**17.70**	**10.28**	**15.29**	**0.15**	**0.82**
	Std. Deviation	**24.57**	**5.42**	**1.59**	**5.57**	**0.04**	**0.02**
A-3: Kandla Port Colony, Kandla	17/03/2025	103.67	25.60	12.1	26.57	0.27	0.75
	19/03/2025	210.65	21.23	5.24	31.91	0.17	0.72
	24/03/2025	143.12	21.41	27.65	10.23	0.10	0.77
	26/03/2025	138.33	22.46	16.23	17.25	0.13	0.84
	01/04/2025	117.46	24.59	8.15	16.53	0.16	0.69
	03/04/2025	128.40	21.53	12.45	21.58	0.23	0.72
	07/04/2025	216.34	21.38	16.87	19.34	0.23	0.75
	09/04/2025	328.58	38.87	20.14	<6	0.21	0.74
	Minimum	**103.67**	**21.23**	**5.24**	**10.23**	**0.10**	**0.69**
	Maximum	**328.58**	**38.87**	**27.65**	**31.91**	**0.27**	**0.84**
	Average	**173.32**	**24.63**	**14.85**	**20.49**	**0.19**	**0.75**
	Std. Deviation	**75.10**	**5.98**	**7.05**	**7.09**	**0.06**	**0.04**
A-4: Marine Bhavan, Kandla	17/03/2025	114.52	28.07	9.48	7.86	0.12	0.80
	19/03/2025	314.47	28.18	8.95	25.33	0.23	0.85
	24/03/2025	127.69	23.54	14.32	10.73	0.17	0.87
	26/03/2025	143.32	19.56	28.19	15.11	0.08	0.74
	01/04/2025	208.85	27.33	6.16	15.48	0.07	0.79
	03/04/2025	137.49	11.42	5.26	9.27	0.09	0.76
	07/04/2025	240.19	35.29	6.53	30.69	0.15	0.82
	09/04/2025	290.83	48.03	5.25	18.45	0.14	0.78
	Minimum	**114.52**	**11.42**	**5.25**	**7.86**	**0.07**	**0.74**
	Maximum	**314.47**	**48.03**	**28.19**	**30.69**	**0.23**	**0.87**
	Average	**197.17**	**27.68**	**10.52**	**16.62**	**0.13**	**0.80**
	Std. Deviation	**78.05**	**10.82**	**7.75**	**7.98**	**0.05**	**0.04**
	17/03/2025	164.59	38.36	25.68	8.48	0.23	0.90
	19/03/2025	124.56	28.69	16.47	9.87	0.11	0.95

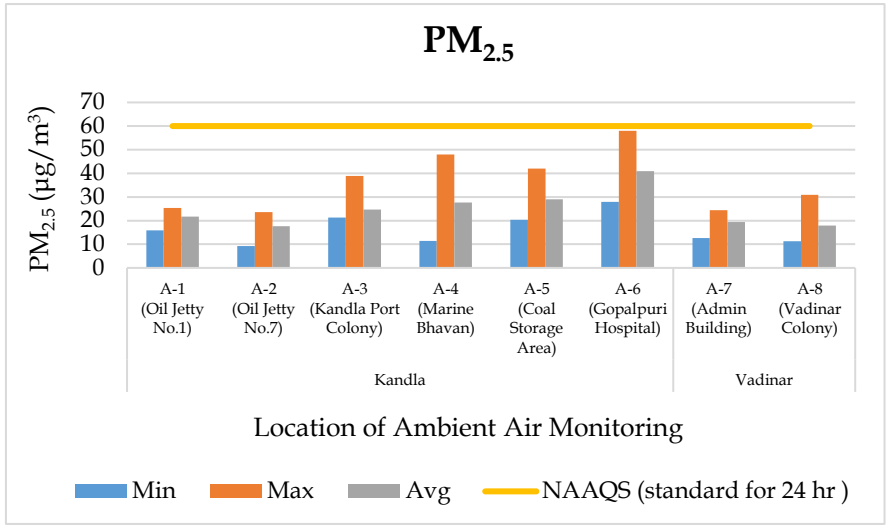
Station Code & Name	Unit of Average Concentration	Average Pollutant Concentration					
	Pollutants	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)	SO_2 (µg/m³)	NO_X (µg/m³)	VOC (µg/m³)	CO (mg/m³)
	Duration	(24 hr)				(2 hr)	(1 hr)
	NAAQS by CPCB / Monitoring Days	100	60	80	80	-	2
A-5: Coal Storage Area, Kandla	24/03/2025	172.84	42.08	15.32	32.62	0.25	0.98
	26/03/2025	321.23	23.21	16.94	14.11	0.14	0.95
	01/04/2025	227.16	26.84	12.59	15.26	0.15	0.96
	03/04/2025	127.95	24..12	24.37	18.42	0.17	0.93
	07/04/2025	168.47	20.38	22.58	20.56	0.14	0.91
	09/04/2025	153.29	23.63	16.75	26.81	0.12	0.95
	Minimum	**124.56**	**20.38**	**12.59**	**8.48**	**0.11**	**0.90**
	Maximum	**321.23**	**42.08**	**25.68**	**32.62**	**0.25**	**0.98**
	Average	**182.51**	**29.03**	**18.84**	**18.27**	**0.16**	**0.94**
	Std. Deviation	**64.41**	**8.17**	**4.73**	**8.25**	**0.05**	**0.03**
A-6: Gopalpuri Hospital, Kandla	17/03/2025	146.35	36.67	<5	7.69	0.08	0.61
	19/03/2025	143.61	57.93	6.67	35.66	0.06	0.65
	24/03/2025	160.99	53.25	9.74	10.99	0.13	0.60
	26/03/2025	148.03	27.95	8.23	<6	0.07	0.63
	01/04/2025	160.53	33.79	6.1	<6	0.11	0.6
	03/04/2025	137.05	32.50	12.08	20.46	0.08	0.63
	07/04/2025	216.23	31.27	6.38	7.01	0.09	0.61
	09/04/2025	166.19	54.42	6.25	10.63	0.16	0.64
	Minimum	**137.05**	**27.95**	**6.10**	**7.01**	**0.06**	**0.60**
	Maximum	**216.23**	**57.93**	**12.08**	**35.66**	**0.16**	**0.65**
	Average	**159.87**	**40.97**	**7.92**	**15.41**	**0.10**	**0.62**
	Std. Deviation	**24.86**	**12.10**	**2.26**	**11.03**	**0.03**	**0.02**
A-7: Admin Building, Vadinar	17/03/2025	85.55	18.55	<5	12.25	0.04	0.59
	19/03/2025	126.66	24.39	5.1	<6	0.19	0.65
	24/03/2025	111.81	17.83	6.17	<6	0.14	0.67
	26/03/2025	88.41	17.39	8.34	<6	0.18	0.62
	01/04/2025	81.78	23.85	5.29	<6	0.16	0.61
	03/04/2025	46.14	20.36	6.02	10.01	0.18	0.69
	07/04/2025	27.31	12.68	5.35	<6	0.13	0.63
	09/04/2025	32.96	20.54	<5	<6	0.15	0.59
	Minimum	**27.31**	**12.68**	**5.10**	**10.01**	**0.04**	**0.59**
	Maximum	**126.66**	**24.39**	**8.34**	**12.25**	**0.19**	**0.69**
	Average	**75.08**	**19.45**	**6.05**	**11.13**	**0.15**	**0.63**
	Std. Deviation	**36.32**	**3.77**	**1.20**	**1.58**	**0.05**	**0.04**
A-8: Vadinar Colony, Vadinar	17/03/2025	54.61	18.95	<5	7.39	0.12	0.62
	19/03/2025	62.61	19.39	5.2	<6	0.16	0.55
	24/03/2025	84.71	20.26	6.11	<6	0.18	0.52
	26/03/2025	44.35	11.96	8.34	<6	0.17	0.53
	01/04/2025	89.94	11.25	33.79	11.82	0.15	0.63
	03/04/2025	45.04	30.95	5.18	7.17	0.14	0.53
	07/04/2025	61.76	18.43	5.35	<6	0.15	0.70
	09/04/2025	48.13	11.69	<5	<6	0.11	0.55
	Minimum	**44.35**	**11.25**	**5.18**	**7.17**	**0.11**	**0.52**
	Maximum	**89.94**	**30.95**	**33.79**	**11.82**	**0.18**	**0.70**

Station Code & Name	Unit of Average Concentration	Average Pollutant Concentration					
	Pollutants	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	SO_2 ($\mu g/m^3$)	NO_X ($\mu g/m^3$)	VOC ($\mu g/m^3$)	CO (mg/m^3)
	Duration	(24 hr)				(2 hr)	(1 hr)
	NAAQS by CPCB / Monitoring Days	100	60	80	80	-	2
	Average	61.39	17.86	10.66	8.79	0.15	0.58
	Std. Deviation	17.48	6.52	11.39	2.62	0.02	0.06

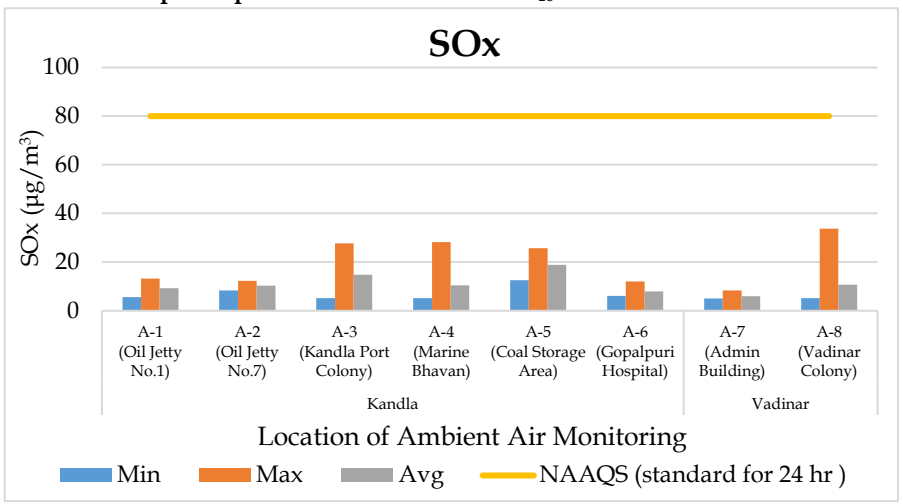
Graphs 1-6 shows spatial trend of ambient air parameter at all the eight-monitoring location (six at Kandla and 2 at Vadinar)



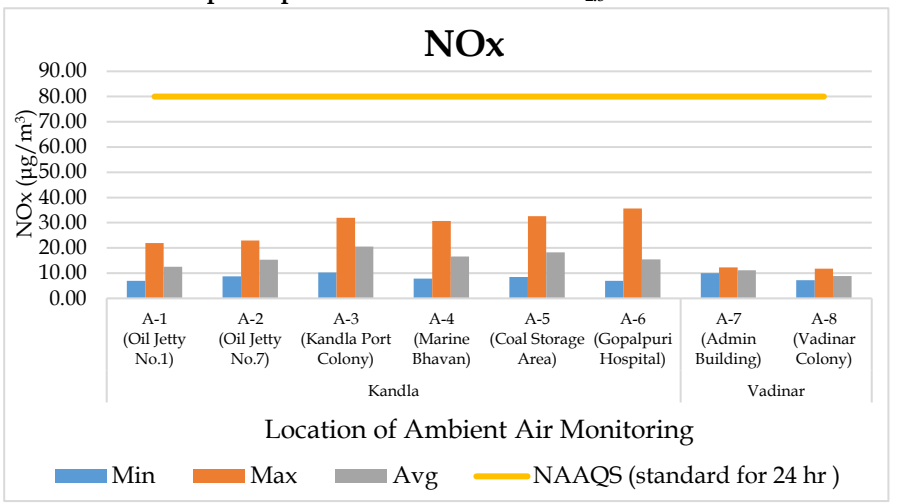
Graph 1: Spatial trend in Ambient PM_{10} Concentration



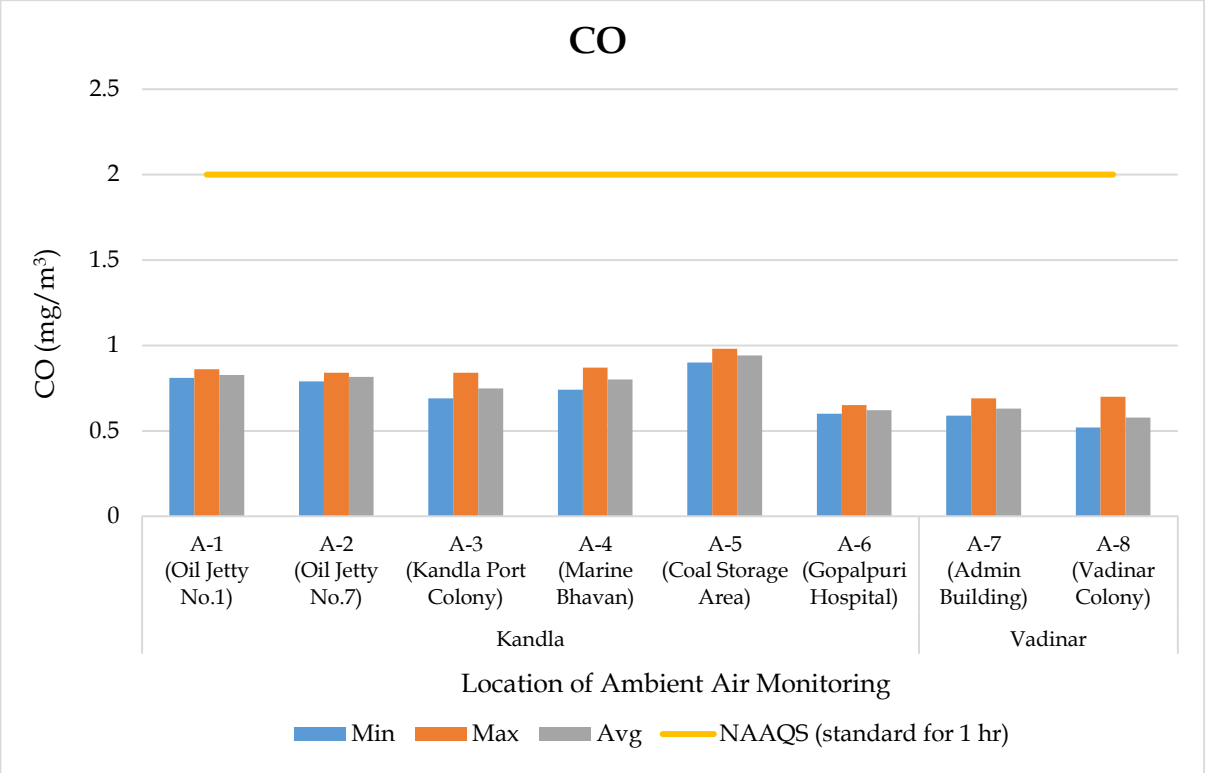
Graph 2: Spatial trend in Ambient $PM_{2.5}$ Concentration



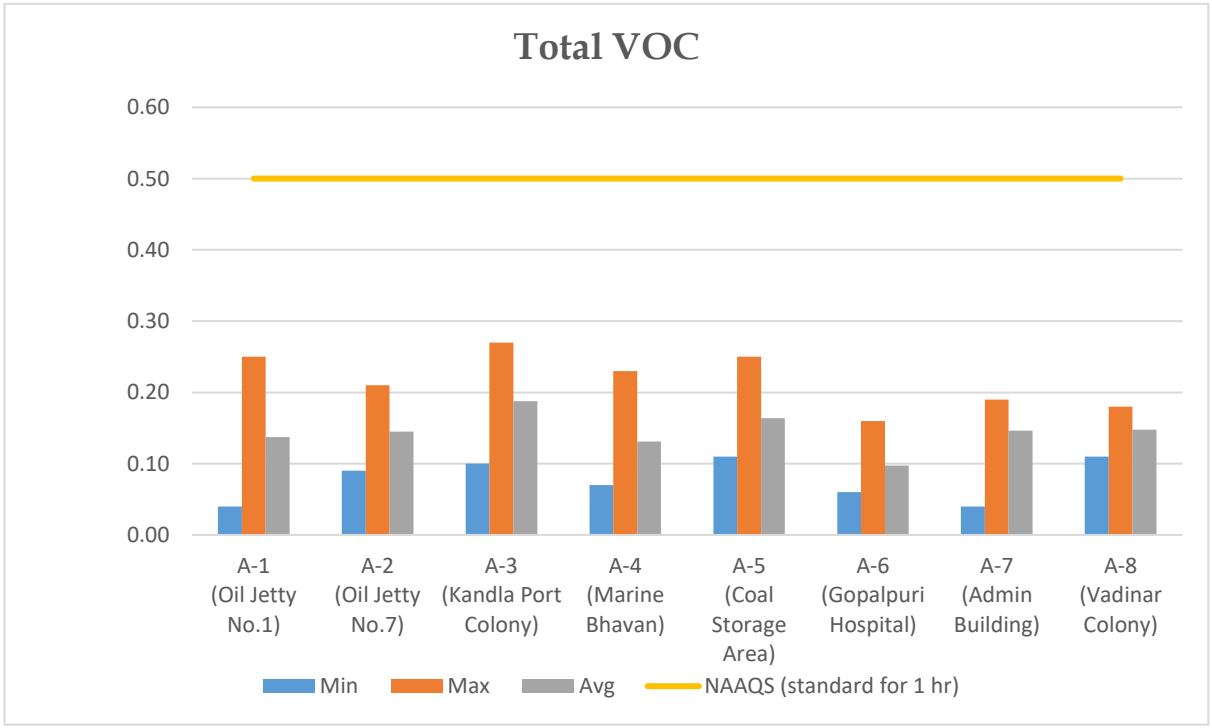
Graph 3: Spatial trend in Ambient SOx Concentration



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 (µg/m³)									
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	0	0	0	0	0	0	0	5 µg/m³

Table 8: Summarized results of Polycyclic Aromatic Hydrocarbons

Sr. No.	Components in ng/m³	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
s7	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	0.56	0.51	0.82	0.59	1.21	0.32	0.00	0.00

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 **103.67** to **328.58** µg/m³ with an average value of **169.87** µg/m³. PM_{10} exceeded NAAQS of all of the monitoring locations in Kandla. Whereas, at Vadinar, the concentration varies from **27.31** to **126.66** µg/m³, with an average value of **68.24** µg/m³, and complies with the stipulated norm (100 µg/m³).

- The highest concentration of PM_{10} at locations **A-3 i.e. Kandla Port Colony** Area could be attributed to the presence of heavy vehicular traffic in upwind areas which bring higher impact causing the dispersion of emitted particulate matter in the ambient air. The unloading of coal directly in the truck, using grabs causes the coal 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/dumpers during its transit from vessel to yard or storage site. This might increase the PM_{10} in and around the Coal storage area and Marine bhavan.
- The **$PM_{2.5}$** concentrations at Kandla varies from **9.31** to **57.93** µg/m³ with average **26.95** µg/m³. The **$PM_{2.5}$** concentration falls within the NAAQS limit for all locations of Kandla. Whereas, at Vadinar its concentration varies from **11.25** to **30.95** µg/m³ with average **18.65** µg/m³ which falls within the limit of NAAQS of 60 µg/m³.
- The concentration of **SO_x** varies from **5.24** to **28.19** µg/m³ with average concentration as **11.94** µg/m³ at Kandla and **5.10** to 33.79 µg/m³ with average as **8.35** µg/m³ at Vadinar. The average concentration of SO_x complies with the prescribed limit of NAAQS (80 µg/m³) for both the monitoring site.
- The concentration of **NO_x** varies from **6.93** to 35.66 µg/m³ with average **16.43** µg/m³ at Kandla and **7.17** to **12.25** µg/m³ with average **9.96** µg/m³ at Vadinar. The concentration of **NO_x** falls within the prescribed limit of NAAQS i.e. 80 µg/m³ at both the monitoring site of Kandla and Vadinar.
- The concentration of **CO** varies from **0.60** to **0.98** µg/m³ with average **0.79** µg/m³ at Kandla and **0.52** to **0.70** µg/m³ with average 0.61 µg/m³ at Vadinar. The concentration falls within the norm of **2** mg/m³ specified by NAAQS at both the monitoring sites
- The concentration of **Total VOCs** levels was recorded in range of **0.04** to **0.27** µg/m³ and **0.04 to 0.19** µg/m³ at Kandla and 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 not detected at any of locations of Kandla and 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 **0.32** to **1.21** µg/m^3. While at Vadinar, the concentration of NM-VOC not detected.

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 $PM_{2.5}$ complies with the NAAQS at majority of the locations. For both the ambient air monitoring parameters (PM_{10} and $PM_{2.5}$), 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.

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.
- 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.

- 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.

CHAPTER 5: DG STACK MONITORING

5.1 DG Stack Monitoring

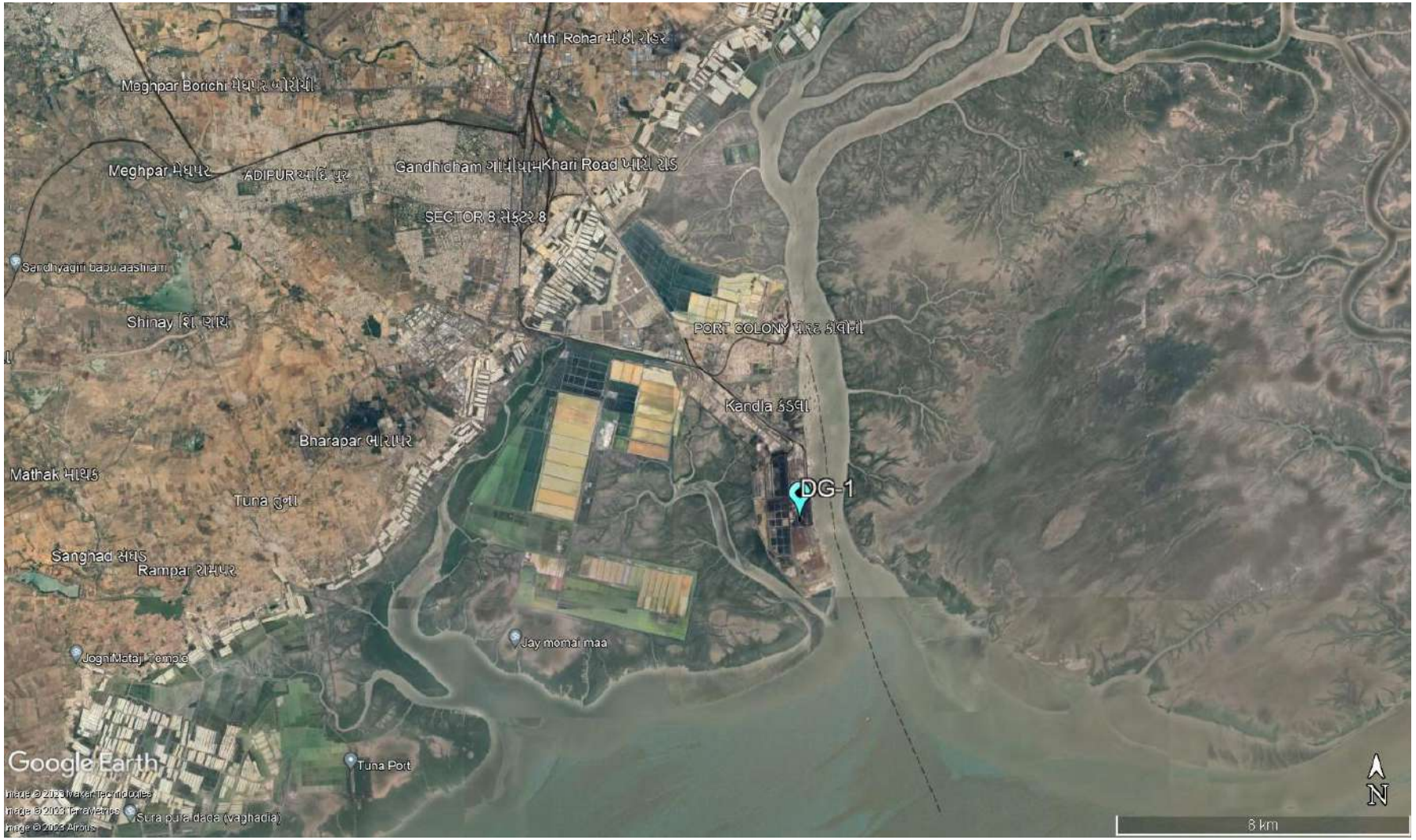
A diesel generator is a mechanical-electrical machine that produces electrical energy (electricity) from diesel fuel. They are used by the residential, commercial, charitable and governmental sectors to provide power in the event of interruption to the main power, or as the main power source. Diesel 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, SO_2, 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:

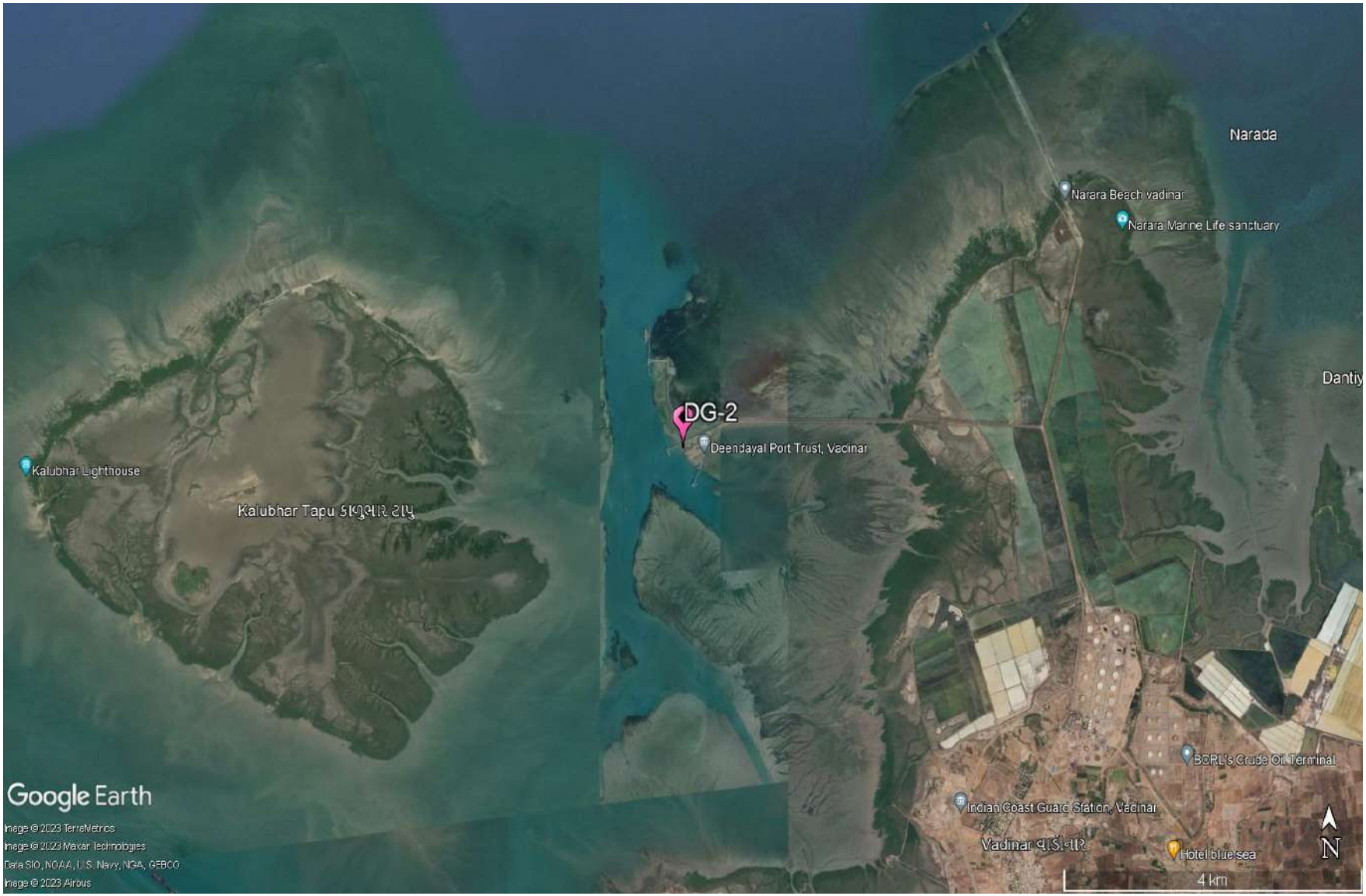
Table 10: Details of DG Stack monitoring locations

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: Locations for DG Stack monitoring at Kandla



Map 7: Locations for DG Stack monitoring 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.

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	79.52	25.04
2.	Sulphur Dioxide (SO_2) (PPM)	100	4.11	3.14
3.	Oxides of Nitrogen (NO_x) (PPM)	50	8.6	6.88
4.	Carbon Monoxide (CO) (%)	1	0.29	0.15
5.	Carbon Dioxide (CO_2) (%)	-	2.27	2.09s

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	58.1	33.8	47	70	58.1	31.6	39.3
2	N-2	West Gate No.1	A	75	67.3	44.2	55.3	70	67.3	36.7	45.6
3	N-3	Canteen Area	B	65	64.8	38	51.9	55	64.8	31.2	40.9
4	N-4	Main Gate	A	75	71.9	37.1	53.3	70	71.9	33.7	43.2
5	N-5	Main Road	A	75	70.5	36.2	52.3	70	70.5	33.6	42.9
6	N-6	Marin Bhavan	B	65	62.6	34.4	51.2	55	62.6	32.6	42.1
7	N-7	Port & Custom Building	B	65	67.3	34.9	50	55	67.3	33.5	41.9
8	N-8	Nirman Building	B	65	66.2	34.8	49.6	55	66.2	32.7	41.8
9	N-9	ATM Building	B	65	77.4	35.9	52.3	55	77.4	32.1	43.7
10	N-10	Wharf Area/ Jetty	A	75	69.2	38.8	54.2	70	69.2	35.4	42.9
11	N-11	Near Main Gate	A	75	71.1	53.1	59.4	70	71.1	44.7	53.5
12	N-12	Near Vadinar Jetty	A	75	73.4	57.2	59.2	70	73.4	49.2	55.2
13	N-13	Port Colony Vadinar	C	55	62.4	35.5	43.7	45	64.8	33.8	41.4

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 77.4** dB(A), while at Vadinar, the noise levels for the three-location ranged from **35.5** dB(A) **to 73.4** dB(A). Whereas, during Night Time the average Noise Level ranged from **31.2** dB(A) **to 77.4** dB(A) at Kandla and **33.8** dB(A) to **73.4** dB(A) at Vadinar, which was within the permissible limits for the industrial and commercial area. Overall, the noise levels at Kandla and Vadinar fall within the prescribed norms for both Day and Night times.

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, 6th 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 (Khori Creek)	S-4 (Nakti Creek)	S-5 (Near SPM)	S-6 (Near Vadinar Jetty)
1	pH	-	8.4	8.73	8.1	8.21	8.37	8.33
2	Conductivity	µS/cm	14970	1000	9120	13860	147.7	257
3	Inorganic Phosphate	Kg/ha	0.9	1.3	1.39	0.99	0.62	1.15
4	Organic Carbon	%	0.56	0.5	0.62	0.44	1.33	0.51
5	Organic Matter	%	0.97	0.86	1.07	0.76	2.3	0.88
6	SAR	meq/L	17.64	0.27	6.71	14.03	0.68	0.73
7	Aluminium	mg/Kg	18845.62	13886.25	9503.7	16874.4	30421.22	44431.53
8	Chromium	mg/Kg	85.69	62.38	53.36	90.14	83.15	106.83
9	Nickel	mg/Kg	31.35	28.26	27.62	29	39.82	49.62
10	Copper	mg/Kg	80.24	34.86	54.71	87.77	85.11	94.12
11	Zinc	mg/Kg	90.75	43.34	53.88	105.23	57.28	54.64
12	Cadmium	mg/Kg	BQL	BQL	BQL	BQL	BQL	BQL
13	Lead	mg/Kg	4.12	2.93	3.75	7	BQL	BQL
14	Arsenic	mg/Kg	BQL	1.94	2.13	BQL	0.55	0.37
15	Mercury	mg/Kg	BQL	BQL	BQL	BQL	BQL	BQL
16	Water Holding Capacity	%	55.98	54	46	50	70	72
17	Sand	%	50.24	64.24	60.24	54.24	72.24	66.24
18	Silt	%	34.16	18.16	32.16	34.16	24.16	26.16
19	Clay	%	15.60	17.60	7.6	11.6	3.6	7.6
20	Texture	-	Loam	Sandy loam	Sandy loam	Sandy loam	Loamy sand	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:

- The value of **pH** ranges from **8.1 to 8.73**, highest at location S-2 (IFFCO Plant) and lowest at S-3 (Khori Creek); while the average pH for Kandla was observed to be **8.36**. Whereas, at Vadinar the pH was observed as **8.37** at S-5 i.e., Near SPM and **8.33** at S-6

i.e., Near Jetty Area. The pH in Kandla varies from the **Slightly alkaline.** Whereas, pH of Soil at Vadinar was found to be **Slightly alkaline**.

- At entire monitoring locations of Kandla the value of **Electrical Conductivity** ranges from **1000 to 14970 µs/cm**, highest at location S-1 (Oil Jeety 7) and lowest at S-2 (IFFCO Plant), with the average as **9737.5** µs/cm. Whereas, at Vadinar the conductivity falls within the range of **147.7 to 257** µs/cm with an average value of **202.35 µs/cm.**

- At Kandla, the concentration of **Inorganic Phosphate** varied from **0.9 to 1.39 Kg/ha**, with average **1.145** Kg/ha. Whereas, at the locations of Vadinar, the Inorganic Phosphate was observed as **0.62** Kg/ha at S-5 (Near SPM) and **1.15** Kg/ha at S-6 (near Jetty Area), with the average **0.885** 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 **0.44** % to **0.62** % while the average TOC at Kandla was detected as **0.53** %. Whereas, at Vadinar the average TOC was found to be **0.92** % where the observed TOC value found at S-5 and S-6 to be **1.33**% and **0.51**% respectively.

- The **Sodium Adsorption Ratio** ranges from **0.27 to 17.64 meq/L** with an average value **9.66** meq/L at Kandla. Whereas, at Vadinar, the average SAR was found to be **0.705** meq/L where the observed SAR value found at S-5 (**0.68 meq/L**) and S-6 (**0.73 meq/L**).

- The **Water Holding Capacity** in the soil samples of Kandla and Vadinar varies from **46** to **55.98** % and **70** to **72** % respectively.

- The Soil Texture was observed as "Sandy loam" at S-2 (IIFCO plant) and S-3 (Khori creek) while "loam" & "Sandy loam" at S-1 (Oil jetty 7) and S-4 (Nakti Creek) respectively in Kandla. Whereas, at Vadinar, the location S-5 and S-6 found "Sandy loam" & "Loamy Sand".

Heavy Metals

- For the sampling period, the concentration of **Aluminium** varied from **9503.7 to 18845.62 mg/kg** at Kandla, and **30421.22 to 44431.53 mg/kg** at Vadinar. Whereas, the average Aluminium concentration was observed to be **14777.49** and **37426.37** mg/kg at Kandla and Vadinar monitoring station respectively.

- The concentration of **Chromium** varied from **53.36 to 90.14 mg/kg** at Kandla and **83.15 to 106.83 mg/kg** at Vadinar and the average value was observed to be **72.89** and **94.99** mg/kg at Kandla and Vadinar monitoring station, respectively.

- The concentration of **Nickel** varied from **27.62 to 31.35 mg/kg** at Kandla and **39.82 to 49.62 mg/kg** at Vadinar and the average value was observed to be **29.05** and **44.72** mg/kg at Kandla and Vadinar monitoring station, respectively.

- The concentration of **Zinc** varied from **43.34 to 105.23 mg/kg** at Kandla and **54.64 to 57.28 mg/kg** at Vadinar and the average value was observed to be **73.3** and **55.96** mg/kg at Kandla and Vadinar monitoring station, respectively.

- The concentration of **copper** varied from **34.86 to 87.77 mg/kg** at Kandla and **85.11 to 94.12 mg/kg** at Vadinar and the average value was observed to be **64.39** and **89.61** mg/kg at Kandla and Vadinar monitoring station, respectively.

- Concentration of **Lead** varied from **2.93 to 7 mg/kg** at Kandla with average value **4.45** mg/Kg, whereas for Vadinar, the values recorded BQL at both S-5 and S-6 location.

- The concentration of **Arsenic** varied from **1.94 to 2.13 mg/kg** at Kandla with average value **2.03** mg/Kg, whereas for Vadinar, the values recorded **0.37 to 0.55** at both S-5 and S-6 location.
- While other heavy metals in the Soil i.e., **Mercury and Cadmium** were observed "Below Quantification Limit" for 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 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.	Kandla	DW-1	Oil Jetty 7	23.043527N 70.218456E
2.		DW-2	Port & Custom Building	23.009033N 70.222047E
3.		DW-3	North Gate	23.007938N 70.222411E
4.		DW-4	Workshop	23.009372N 70.222236E
5.		DW-5	Canteen Area	23.003707N 70.221331E
6.		DW-6	West Gate 1	23.006771N 70.217340E
7.		DW-7	Sewa Sadan -3	23.009779N 70.221838E
8.		DW-8	Nirman Building	23.009642N 70.220623E
9.		DW-9	Custom Building	23.018930N 70.214478E
10.		DW-10	Port Colony Kandla	23.019392N 70.212619E
11.		DW-11	Wharf Area/ Jetty	22.997833N 70.223042E
12.		DW-12	Hospital Kandla	23.018061N 70.212328E
13.		DW-13	A.O. Building	23.061914N 70.144861E
14.		DW-14	School Gopalpuri	23.083619N 70.132061E
15.		DW-15	Guest House	23.078830N 70.131008E
16.		DW-16	E- Type Quarter	23.083306N 70.132422E
17.		DW-17	F- Type Quarter	23.077347N 70.135731E
18.		DW-18	Hospital Gopalpuri	23.081850N 70.135347E
19.	Vadinar	DW-19	Near Vadinar Jetty	22.440759N 69.675210E
20.		DW-20	Near Port Colony	22.401619N 69.716822E

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, 23rd Edition (Section-4500-H+B):2017	pH Meter
2.	Colour	Hazen	APHA, 23rd Edition, 2120 B:2017	Color Comparator
3.	EC	µS/cm	APHA, 23rd Edition (Section-2510 B):2017	Conductivity Meter
4.	Turbidity	NTU	APHA, 23rd Edition (Section -2130 B):2017	Nephlo Turbidity Meter
5.	TDS	mg/L	APHA, 23rd Edition (Section-2540 C):2017	Vaccum Pump with filtration assembly and Oven
6.	TSS	mg/L	APHA, 23rd Edition, 2540 D: 2017	
7.	Chloride	mg/L	APHA, 23rd Edition (Section-4500-Cl-B):2017	Titration Apparatus
8.	Total Hardness	mg/L	APHA, 23rd Edition (Section-2340 C):2017	
9.	Ca Hardness	mg/L	APHA, 23rd Edition (Section-3500-Ca B):2017	
10.	Mg Hardness	mg/L	APHA, 23rd Edition (Section-3500-Mg B):2017	
11.	Free Residual Chlorine	mg/L	APHA 23rd Edition, 4500	
12.	Fluoride	mg/L	APHA, 23rd Edition (Section-4500-F-D):2017	UV- Visible Spectrophotometer
13.	Sulphate	mg/L	APHA, 23rd Edition (Section 4500-SO4-2-E):2017	
14.	Sodium	mg/L	APHA, 23rd Edition (Section-3500-Na-B):2017	Flame Photometer
15.	Potassium	mg/L	APHA,23rd Edition, 3500 K-B: 2017	
16.	Salinity	mg/L	APHA, 23rd Edition (section 2520 B, E.C. Method)	Salinity /TDS Meter
17.	Nitrate	mg/L	APHA, 23rd Edition, 4500 NO3- B: 2017	UV- Visible Spectrophotometer

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

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**	**-**	7.68	7.99	7.63	8.32	8.42	7.57	7.74	7.56	7.52	7.02	6.77	7.06	7.31	7.02	7.41	7.54	7.45	7.17	8.12	8.32
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	**-**	**-**	225	260	24.04	23.4	48.3	142	19.10	22.4	27.5	136	108.6	135.6	121.3	263	89.1	22.8	21.8	54.9	461	55.4
4.	Salinity	PSU	**-**	**-**	0.12	0.13	0.07	0.02	0.05	0.05	0.02	0.02	0.02	0.07	0.07	0.07	0.06	0.13	0.05	0.02	0.02	0.03	0.22	0.03
5.	Turbidity	NTU	**1**	**5**	BQL	BQL	0.65	BQL	0.65	0.63	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
6.	Chloride	mg/L	**250**	**1000**	58.62	53.32	8.77	8.80	13.64	112.63	5.87	7.34	7.34	23.97	107.99	23.97	29.35	53.32	20.06	8.32	7.83	13.21	51.37	11.25
7.	Total Hardness	mg/L	**200**	**600**	2	35	2	BQL	9	12	3	2.5	8	26	56	30	2.5	36	6	3	2.5	4	135	8
8.	Ca Hardness	mg/L	**-**	**-**	1	20	1	1	5	7	2.5	2	6	14	26	16	2	20	3	2	1.5	3	65	4
9.	Mg Hardness	mg/L	**-**	**-**	1	15	1	BQL	4	5	BQL	BQL	2	12	30	14	BQL	16	3	1	1	1	70	4
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**	120	142	16	14	23	332	12	14	16	74	128	74	68	144	48	12	12	30	246	30
12.	TSS	mg/L	**-**	**-**	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	2	BQL	BQL	2	BQL	2	2	BQL	BQL	BQL	BQL
13.	Fluoride	mg/L	**1.0**	**1.5**	BQL	BQL	BQL	BQL	BQL	0.345	BQL	BQL	BQL	BQL	0.439	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
14.	Sulphate	mg/L	**200**	**400**	BQL	BQL	BQL	BQL	BQL	37.82	BQL	BQL	BQL	BQL	12.62	BQL	BQL	BQL	BQL	BQL	BQL	BQL	35.02	BQL
15.	Nitrate	mg/L	**45**	**-**	5.862	2.668	BQL	BQL	1.400	8.551	BQL	BQL	BQL	1.626	5.740	1.512	2.719	2.622	1.029	BQL	BQL	BQL	2.522	BQL
16.	Nitrite	mg/L	**-**	**-**	BQL	BQL	BQL	BQL	BQL	0.23	BQL	BQL	BQL	BQL	0.623	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
17.	Sodium	mg/L	**-**	**-**	42.32	36.56	BQL	6.07	6.27	77.96	4.28	4.90	3.62	14.19	78.19	12.62	19.56	35.59	13.59	BQL	BQL	9.13	32.59	7.56
18.	Potassium	mg/L	**-**	**-**	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	1.49	BQL

Sr. No.	Parameters	Units	Standard values as per IS		Kandla																		Vadinar	
			A	P	DW-1	DW-2	DW-3	DW-4	DW-5	DW-6	DW-7	DW-8	DW-9	DW-10	DW-11	DW-12	DW-13	DW-14	DW-15	DW-16	DW-17	DW-18	DW-19	DW-20
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
21.	Arsenic	mg/L	0.01	0.05	BQL	BQL	BQL	BQL	BQL	0.007	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	0.007	BQL	BQL	0.007	BQL	BQL	BQL	0.006	0.027	BQL	0.24	BQL	0.02	BQL	BQL	BQL	BQL	BQL	0.011
24.	Iron	mg/L	0.3	-	BQL	0.164	BQL	BQL	BQL	BQL	BQL	BQL	BQL	0.104	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	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	BQL	BQL
26.	Manganese	mg/L	0.1	0.3	BQL	0.1	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		BQL	BQL	BQL	BQL	BQL	BQL	40	BQL	285	BQL	BQL	20	BQL	BQL	BQL	BQL	BQL	90	BQL	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 NO_3 (QL=1 mg/L), Nitrite as NO_2 (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 19 locations (17 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 **6.77 to 8.42**, with an average pH of **7.51**. In Vadinar, its values ranged from **8.12 to 8.32**, with an average pH of **8.22**. Notably, the pH levels at both project sites fall within the acceptable range of 6.5 to 8.5 for all the locations of Kandla and Vadinar, as specified under IS:10500:2012.
- **Colour:** The colour varies from 1 to 5 at the monitoring locations of Kandla. Only location DW-11 showed the value of 5 Hazen, whereas, all the other locations showed a value of 1 in Hazen at Kandla. At Vadinar, the color was observed to be 1 Hazen at both the monitoring locations.
- **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 **19.1 to 263 µS/cm**, with an average value of **96.94** µS/cm. In Vadinar, the EC values showed variation from **55.4 to 461 µS/cm**, with an average value of **258.20** µS/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 0.13 PSU** with an average of **0.06** PSU, while at Vadinar, salinity was observed to be **0.22** and **0.03 PSU** for locations DW-19 & DW-20 respectively.
- **Turbidity:** At the drinking water locations of Kandla, most of the locations were found BQL except locations DW-3 (with value **0.65** NTU), DW-5 (with value of **0.65** NTU) & DW-6 (with value of **0.63** NTU). Whereas, at Vadinar the value of turbidity was reported BQL at both the locations.
- **Chlorides:** The chloride concentrations in Kandla varied from **5.87 to 112.63 mg/L**, with an average value of **31.35** mg/L. At Vadinar the locations DW-19 and DW-20, the chloride concentration was observed as **51.37** mg/L and **11.25** mg/L, with an average value of **31.31** mg/L. Thus, the chloride levels at both project sites fall within the acceptable limit of 250 mg/L, as specified under IS:10500:2012.
- **Total Hardness (TH):** The concentration of Total Hardness varies from **2 to 56 mg/L**, with an average concentration of **14.09** mg/L. While at Vadinar, the observed values were **135** & **8** mg/L; at locations DW-19 & D-20, with an average concentration of **71.50** mg/L. which was found to be within the acceptable norm of 200 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 **12** to **332** mg/L, with an average concentration of **71.06** mg/L. While in Vadinar, it ranged from **30** to **246** mg/L, with an average of **138** 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.

- **Fluoride:** The concentration was found BQL, at all of the monitoring location except for locations DW-6 (with value of 0.345 mg/L), DW-11 (with value 0.439 mg/L) at Kandla. While at Vadinar Fluoride concentration was reported BQL at both of the monitoring location.
- **Sulphate:** At the monitoring locations of Kandla, the sulphate concentrations were recorded BQL for majority of the locations except the locations DW-6 (with value of 37.82), DW-11 (12.62 mg/L) and In Vadinar, the sulphate concentration was observed 35.02 at DW-19 & BQL at DW-20. 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:** During the monitoring period, at Kandla & Vadinar variation in the concentration of Nitrate was observed to be in the range of **1.029 to 8.55 mg/L,** with the average concentration of **3.37** mg/L and locations DW-3, DW-4, DW-7, DW-8,DW-9, DW-16, DW-17, DW-18, were recorded as "BQL". While at Vadinar, the concentration recorded **2.522** at location DW-19 and **BQL** at location DW-20.
- **Nitrite:** All monitoring locations showed the Nitrite concentration as BQL at Kandla except DW-6 (with value of 0.23 mg/L) & DW-11 (with value of 0.623 mg/L) While at Vadinar Nitrite concentration was reported BQL at both of the monitoring location.
- **Sodium:** During the monitoring period, at Kandla variation in the concentration of Sodium was observed to be in the range of **3.62 to 78.19 mg/L**, with the average concentration of **24.32** mg/L and Location DW-3, DW-16 and DW-17 showed the BQL concentration for Sodium. While at Vadinar, the concentration recorded **32.59** mg/L at DW-19 and **7.56** mg/L at DW-20.
- **Odour:** Odour values recorded 1 TON at all monitoring locations of Kandla and Vadinar.
- **Arsenic:** The Arsenic concentrations were recorded BQL for all of the locations except DW-6 (with value of **0.006 mg/L**) at Kandla & In Vadinar, the Arsenic concentrations were recorded BQL for both the locations.
- **Copper:** In Kandla & Vadinar, the Copper concentrations were recorded BQL except **DW-2, DW-5, DW-9, DW-10, DW-12, DW-14 and DW-20** (0.007, 0.007, 0.006, 0.027, 0.024, 0.020 respectively).
- **Iron:** Except for locations **DW-2 (0.164 mg/L) and DW-10 (0.104 mg/L)** the other locations were observed to have concentrations Below the detection Limit at Kandla. Whereas, at Vadinar the concentrations were recorded BQL for both locations DW-19 and DW-20 respectively.
- **Lead:** In Kandla & Vadinar, the Lead concentrations were recorded BQL at all locations.
- **Potassium:** All of locations observed to have BQL concentration for both the monitoring locations at Kandla and Vadinar except the location DW-19 (1.49 mg/L).\
- **Total Suspended Solids:** All of locations observed to have BQL concentration for the monitoring locations at kandla except **DW-10 (2 mg/L), DW-13 (2 mg/L), DW-15 (2**

mg/L) and DW-16 (2 mg/L). while both the monitoring locations of Vadinar have recorded BQL.

- **Manganese:** Except for locations **DW-2 (102.603 mg/L)** the other locations were observed to have concentrations Below the detection Limit at Kandla. Whereas, at Vadinar the concentrations were recorded BQL for both locations DW-19 and DW-20 respectively.
- The parameters such as **Free Residual Chlorine, Hexavalent Chromium** and **the metals (Cadmium, Mercury, Total Chromium and Zinc)** were all observed to have concentrations "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 at location DW-7 (40 MPN/100ml), DW-9 (285 MPN/100ml), DW-12 (20 MPN/100ml), and DW-18 (90 MPN/100ml). For the rest of the monitoring locations of Kandla and Vadinar were detected low or "Below the Quantification Limit (BQL)". Reporting such concentration of Coliforms indicates certain external influx may contaminate the source. Hence, water quality should be regularly checked at every distribution point. The presence of total coliforms may be due to insufficient disinfection, as well as inadequate cleaning of drinking water areas and storage containers/jars.

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:

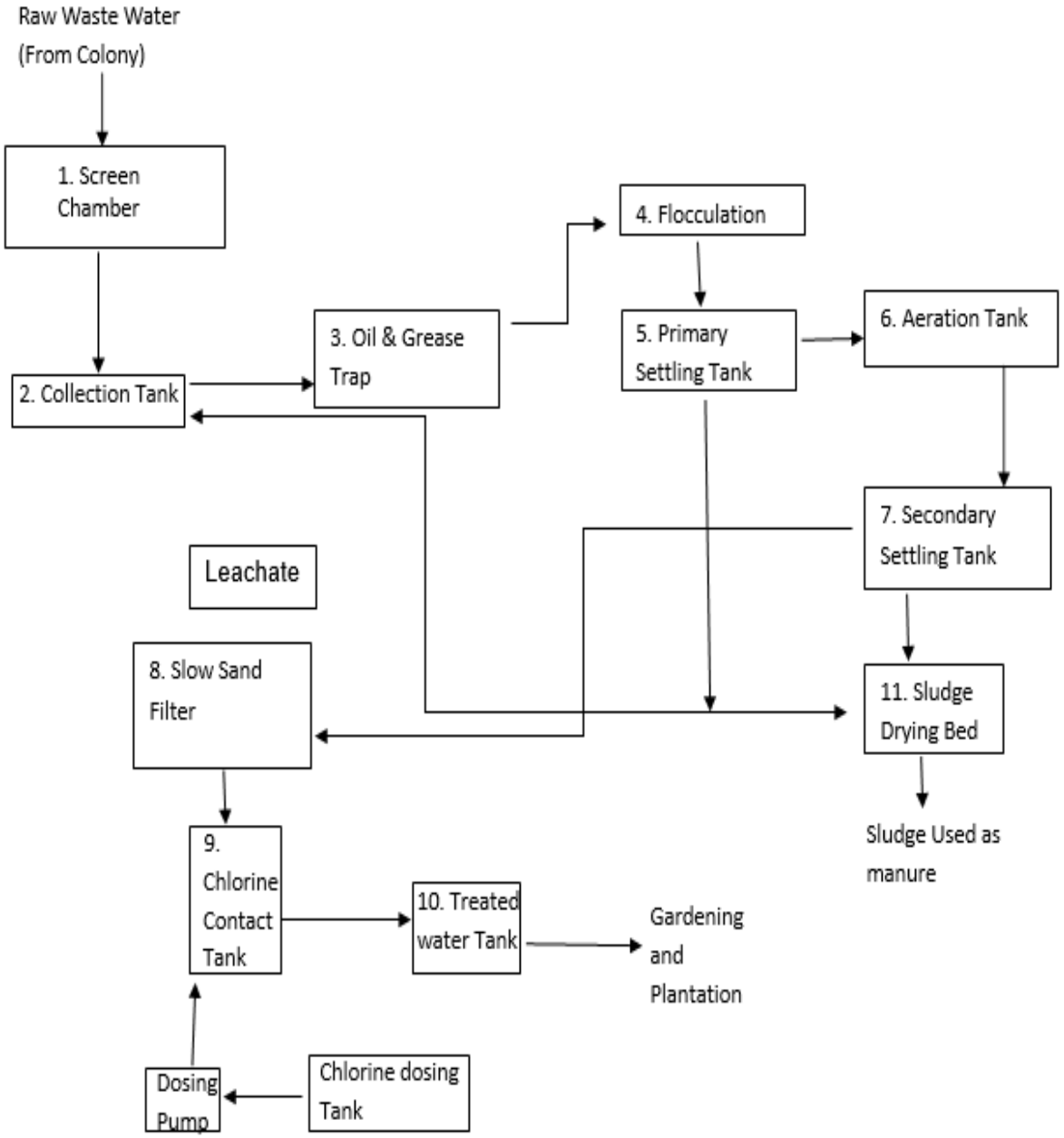


Figure 3: Process flow diagram of STP at Kandla

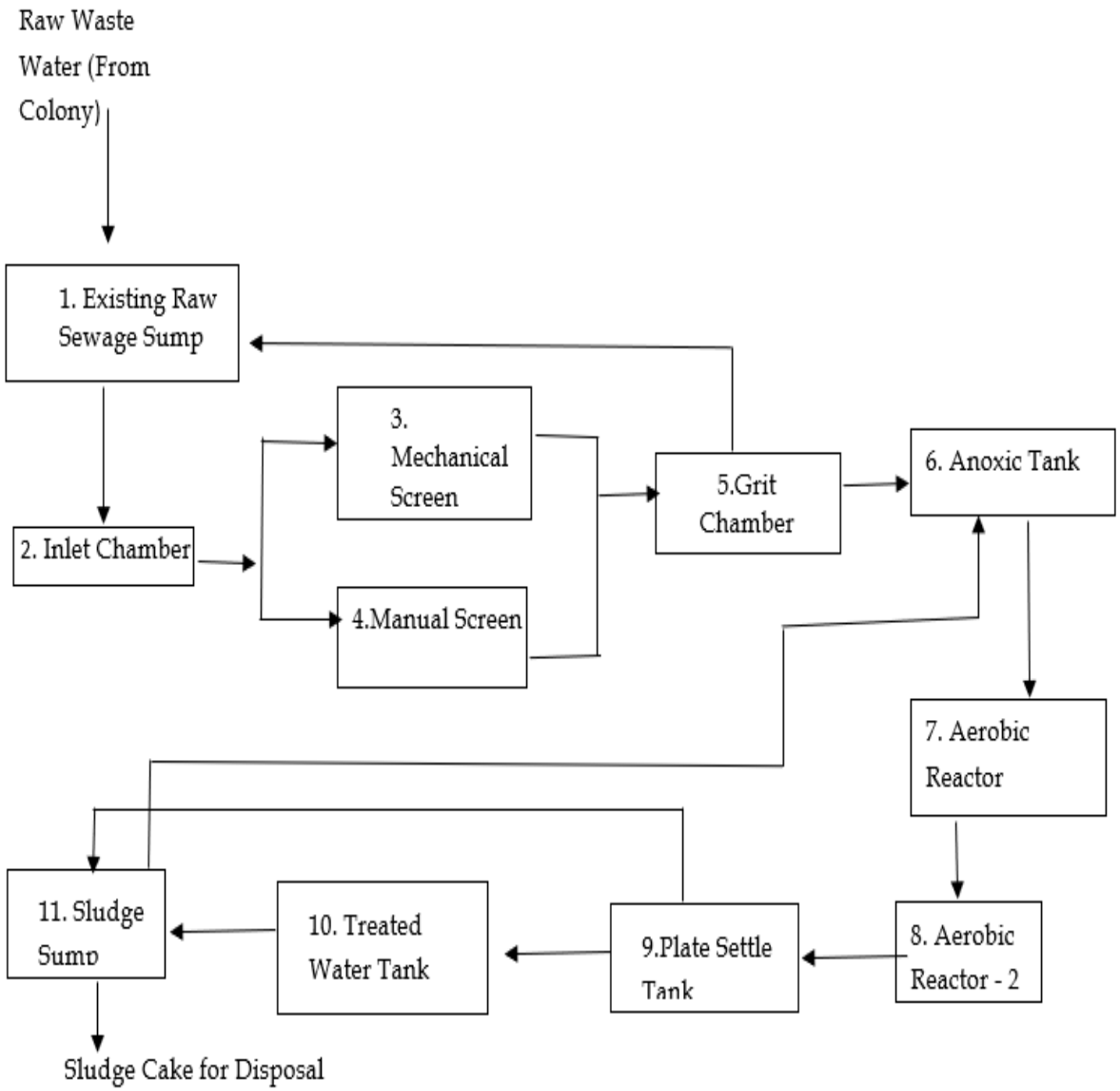


Figure 4: Process flow diagram of STP at Gopalpuri

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:

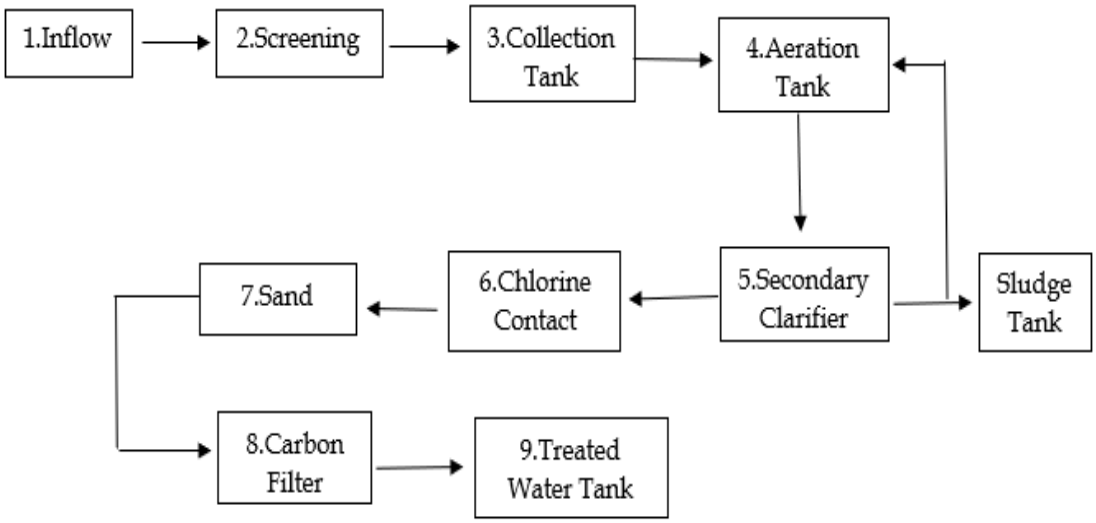
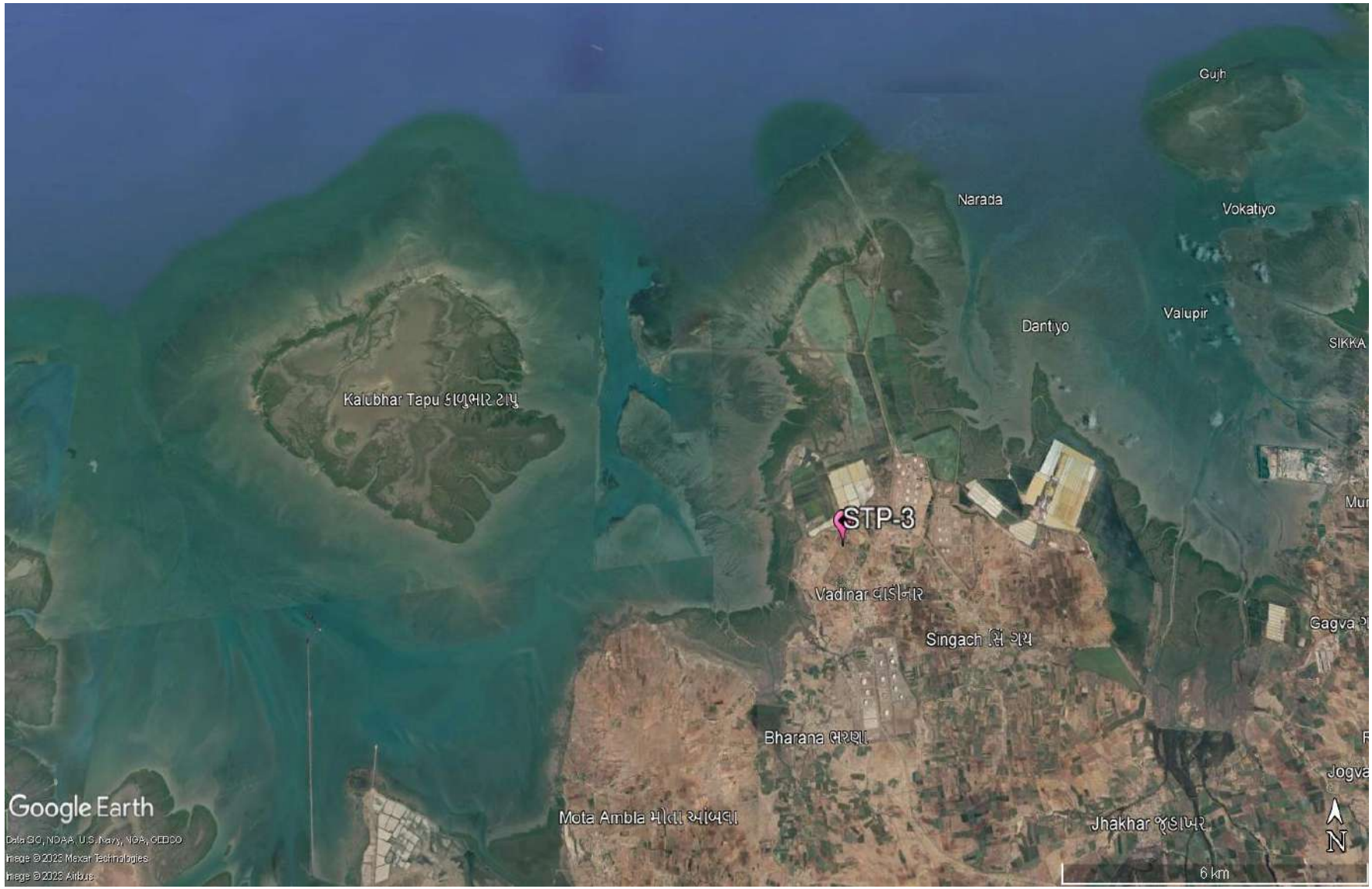


Figure 5: Process flowchart for the STP at Vadinar

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, 23rd edition, 4500- H^+ B, 2017	pH Meter
2.	TDS	mg/L	APHA, 23rd Edition, 2540 C: 2017	Vacuum Pump with filtration assembly and Oven
3.	TSS	mg/L		
4.	DO	mg/L	APHA, 23rd Edition, 4500 C: 2017	Titration Apparatus
5.	COD	mg/L	APHA, 23rd Edition, 5220 B: 2017	Titration Apparatus plus Digester
6.	BOD	mg/L	IS-3025, Part 44, 1993	BOD Incubator plus Titration Apparatus
7.	SAR	meq/L	IS 11624: 2019	Flame Photometer
8.	Total Coliforms	MPN/100ml	IS 1622: 2019	LAF/ Incubator

9.2 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 March				Week 4 of March				Week 1 of April				Week 2 of April			
				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**	7.15	6.48	6.96	7.12	7.32	6.42	6.96	7.12	7.14	7.12	7.19	6.17	7.45	7.16	7.08	7.11
2.	TDS	mg/L	-	1325	1311	998	978	1459	1384	998	978	1352	1284	1345	1328	1467	1364	912	886
3.	TSS	mg/L	**100**	57	14	164	16	63	19	164	16	31	20	168	19	48	12	212	18
4.	COD	mg/L	-	186	67	276.0	68.0	156	51	276.0	68.0	180	73.2	341.0	56.2	196.0	56.0	353.2	58.3
5.	DO	mg/L	-	BQL	2.1	BQL	2.5	BQL	3.5	BQL	2.5	BQL	3.2	BQL	1.1	BQl	2.5	BQL	4.0
6.	BOD	mg/L	**30**	53.26	7.2	82.80	6.80	68.17	9.6	82.80	6.80	42.58	26.8	128.45	6.59	45.34	8.40	110.38	7.29
7.	SAR	meq/L	-	14.57	6.32	6.00	5.43	13.24	6.18	6.00	5.43	11.15	9wsss .30	13.5	8.65	12.32	10.10	3.15	3.07
8.	Total Coliforms	MPN/ 100ml	**<1000**	1600	230	1600	360	1600	280	1600	280	1600	240	1600	320	1600	160	1600	300

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

Sr No.	Parameter	Units	GPCB Norms (Vadinar)	Vadinar							
				Week 3 of March		Week 4 of March		Week 1 of April		Week 2 of April	
				STP-3 (Inlet)	STP-3 (Outlet)	STP-3 (Inlet)	STP-3 (Outlet)	STP-3 (Inlet)	STP-3 (Outlet)	STP-3 (Inlet)	STP-3 (Outlet)
1.	pH	-	**5.5-9**	7.28	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	160	1600	140	1600	300	1600	100

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, pH values vary in the range of **6.17-7.16** at Kandla and **7.12–7.44** at Vadinar respectively.
- The **TDS** of treated sewage at Kandla was ranges from **886** to **1384** 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 100 and 20 mg/L respectively as mentioned in their respective CCA.
- **COD** value for Kandla was observed in the range of **51** to **73.2** 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 **1.10** to **4** mg/L, 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 **3.07** to **10.10** meq/L, whereas for Vadinar, it was observed in the range of **1.96** to **2.6** meq/L.
- The **Total Coliforms** was observed to exceed the norms at the locations of the STP-3 for the treated effluent at Vadinar.

During the monitoring period, COD and 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/H_2O_2 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.

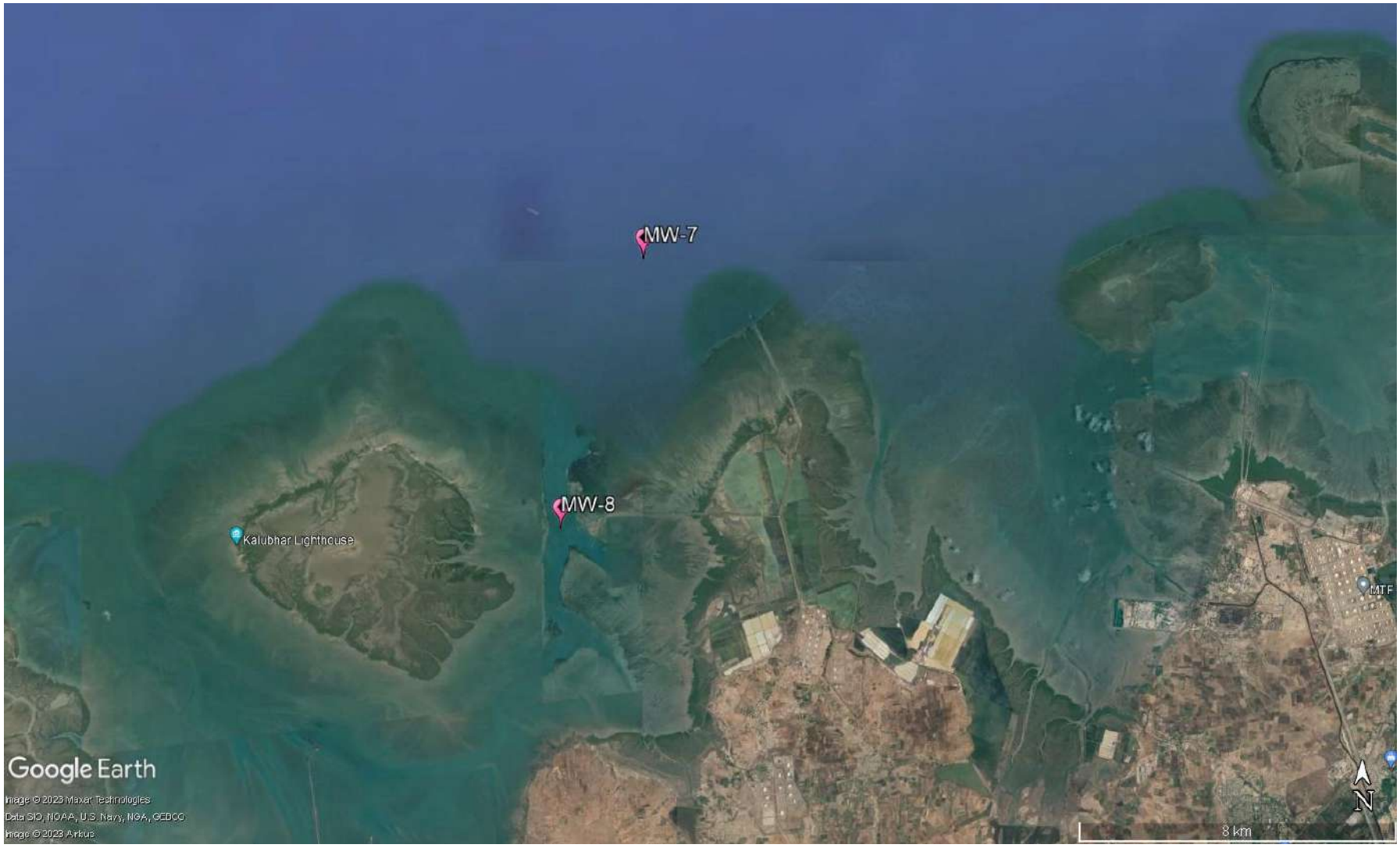
Major water quality concerns at ports include wastewater and leakage of toxic substances from ships, stormwater runoff, etc. This discharge of wastewater, combined with other ship wastes which includes sewage and wastewater from other on-board uses, is a serious threat to the water quality as well as 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	23.017729N 70.224306E
2.		MW-2	Kandla Creek (nr KPT Colony)	23.001313N 70.226263E
3.		MW-3	Near Coal Berth	22.987752N70.227923E
4.		MW-4	Khori Creek	22.977544N 70.207831E
5.		MW-5	Nakti Creek (nr Tuna Port)	22.962588N 70.116863E
6.		MW-6	Nakti Creek (nr NH-8A)	23.033113N 70.158528E
7.	Vadinar	MW-7	Near SPM	22.500391N 69.688089E
8.		MW-8	Near Vadinar Jetty	22.440538N 69.667941E

The map depicting the locations of Marine Water to be sampled and analysed 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, 23rd Edition (Section-2510 B):2017	Conductivity Meter
2.	Dissolved Oxygen (DO)	mg/L	APHA, 23rd Edition, 4500 O C, 2017	Titration Apparatus
3.	pH	-	APHA, 23rd Edition (Section-4500-H+B):2017	pH meter
4.	Color	Hazen	APHA, 23rd Edition, 2120 B: 2017	Color comparator
5.	Odour	-	IS 3025 Part 5: 2018	Heating mantle & odour bottle
6.	Turbidity	NTU	IS 3025 Part 10: 1984	Nephlo Turbidity Meter
7.	Total Dissolved Solids (TDS)	mg/L	APHA, 23rd Edition (Section-2540 C):2017	Vaccum Pump with Filtration Assembly and Oven
8.	Total Suspended Solids (TSS)	mg/L	APHA, 23rd Edition, 2540 D: 2017	
9.	Particulate Organic Carbon	mg/L	APHA, 23rd Edition, 2540 D and E	TOC analyser
10.	Chemical Oxygen Demand (COD)	mg/L	IS-3025, Part- 58: 2006	Titration Apparatus plus Digester
11.	Biochemical Oxygen Demand (BOD)	mg/L	IS-3025, Part 44,1993,	BOD Incubator plus Titration apparatus
12.	Silica	mg/L	APHA, 23rd Edition, 4500 C, 2017	UV- Visible Spectrophotometer
13.	Phosphate	mg/L	APHA, 23rd Edition, 4500 P-D: 2017	
14.	Sulphate	mg/L	APHA, 23rd Edition, 4500 SO4-2 E: 2017	
15.	Nitrate	mg/L	APHA, 23rd Edition, 4500 NO3-B: 2017	

Sr. No	Parameters	Units	Reference method	Instrument
16.	Nitrite	mg/L	APHA, 23rd Edition, 4500 NO2- B: 2017	
17.	Sodium	mg/L	APHA, 23rd Edition, 3500 Na-B: 2017	Flame photometer
18.	Potassium	mg/L	APHA, 23rd Edition, 3500 K-B: 2017	
19.	Manganese	µg/L	APHA, 23rd Edition, ICP Method 3120 B: 2017	ICP-OES
20.	Iron	mg/L	APHA, 23rd Edition, ICP Method 3120 B: 2017	
21.	Total Chromium	µg/L	APHA, 23rd Edition, 3500 Cr B: 2017	
22.	Hexavalent Chromium	µg/L		UV- Visible Spectrophotometer
23.	Copper	µg/L	APHA, 23rd 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, 23rd 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/m³	-	1.022	1.021	1.021	1.022	1.023	1.022	1.021	1.021
2.	pH	-	6.5-9.0	8.19	8.14	8.06	8.2	8.13	8.25	8.14	8.26
3.	Color	Hazen	No Noticeable	5	5	5	5	5	5	5	5
4.	EC	µS/cm	-	51,200	52,500	51,100	51,500	52,600	51,400	53,700	54,200
5.	Turbidity	NTU	-	94	120	143.25	201	136	117	4.16	3.35
6.	TDS	mg/L	-	33,568	36,245	32,568	33,145	33,586	32,589	31,542	32,513
7.	TSS	mg/L	-	338	419	274	372	325	413	129	183
8.	COD	mg/L	-	33.5	31.6	30.2	33.8	31.5	32.4	48.10	50.1
9.	DO	mg/L	3.0 mg/L	5.5	6.1	5.1	5.9	6.3	5.4	6.7	5.2
10.	BOD	mg/L	5.0 mg/L	8.21	8.26	8.34	8.77	10.26	9.83	7.40	7.11
11.	Oil & Grease	mg/L	-	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
12.	Sulphate	mg/L	-	2145.2	2568.4	2568.1	3149.8	2781.6	2415.6	2781.5	3159.6
13.	Nitrate	mg/L	-	4.59	3.42	3.4	4.870	3.78	4.29	3.36	2.880
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	-	3.13	2.66	3.27	3.10	3.78	2.64	0.86	0.71
17.	Sodium	mg/L	-	9345	9215	9874	9356	9654	9412	9,845	9,523
18.	Potassium	mg/L	-	357.00	321	320.00	361	342.00	286.00	435.0	402.00
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	BQL	BQL	BQL	6.68	BQL	BQL	BQL
24.	Iron	mg/L	-	1.845	2.265	2.415	1.785	1.895	2.236	0.451	0.268
25.	Lead	mg/L	-	0.003	0.003	0.002	0.002	0.002	0.003	0.0024	0.0028
26.	Manganese	mg/L	-	0.093	0.132	0.124	0.112	0.096	0.120	0.045	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	-	1.05	0.59	0.51	0.78	0.95	1.25	0.57	0.82
31.	Total Coliforms	MPN/ 100ml	500/100 ml	19	14	13	10	17	18	12	20

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 **1.021 to 1.023 kg/m³**, with the average of **1.021 kg/m³.** Whereas for the location of Vadinar, it was observed **1.021 kg/m³** at MW-7 and **1.021 kg/m³** at MW-8, with the average of **1.021 kg/m³**.
- **pH** at Kandla was observed in the range of **8.06 to 8.25**, with the average pH as 8.16. Whereas for the locations of Vadinar, it was observed in the range of be **8.14 to 8.26**, with the average pH as **8.2**. 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 **51100 to 52600 µS/cm**, with the average EC as **51716** µS/cm for the locations of Kandla, whereas for the locations of Vadinar, it was observed in the range of **53700 to 54200 µS/cm**, with the average EC as **53950** µS/cm.
- For all monitoring locations of Kandla the value of **Turbidity** was observed in the range of 94 **to 201 NTU**, with average value of **135.20** NTU. For Vadinar it ranges from 4.16 **to 3.35 NTU**, with average of **3.75** 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 **32568 to 36245 mg/L**, with an average value of **33616.83** mg/L. Similarly, at Vadinar, the TDS values ranged from **31542 to 32513 mg/L**, with an average value of **32027.5** mg/L.

- **TSS** values in the studied area varied between 274 **to 419 mg/L** at Kandla and **129 to 183 mg/L** at Vadinar, with the average value of **356.83** mg/L and **156** mg/L respectively for Kandla and Vadinar.
- **COD** varied between **30.2 to 33.8 mg/L** at Kandla and **48.10 to 50.1 mg/L** at Vadinar, with the average value as **32.16** mg/L and **49.1** mg/L respectively for Kandla and Vadinar.
- **DO** level in the studied area varied between **5.1 to 6.3 mg/L** at Kandla and **6.7 to 5.2 mg/L** at Vadinar, with the average value of **5.71** mg/L and **5.95** 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 **8.21 to 10.26 mg/L**, with average of **8.94** mg/L for the location of Kandla and for the locations of Vadinar, it was observed in the range of 7.40 **to 7.11 mg/L**, with an average value of **7.25** mg/L.
- The elevated Biochemical Oxygen Demand (BOD) values observed in the marine water samples, particularly exceeding 8 mg/L at multiple locations, can be attributed to a combination of anthropogenic activities and hydrodynamic limitations of the creek environment. The sampling points are located within tidal creeks and semi-enclosed water bodies near the Port of Kandla, where reduced water circulation leads to limited dilution and flushing of pollutants. Additionally, the area is subject to intensive industrial and port-related activities, possibly there might be effluent discharges, cargo handling waste, and domestic sewage from nearby settlements. These inputs introduce significant quantities of biodegradable organic matter into the water, which enhances microbial activity and oxygen consumption, thereby raising BOD levels.
- **Sulphate** concentration in the studied area varied between **2145.2 to 3149.8 mg/L** at Kandla and **2781.5 to 3159.6 mg/L** at Vadinar. The average value observed at Kandla was **2604.78** mg/L, whereas **2970.55** 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 **3.4 to 4.87 mg/L**, with the average of **4.05** mg/L. Whereas for the Vadinar, recorded value was observed in the range of **3.36 to 2.88 mg/L**, with the average of 3.12 mg/L.
- In the study area of Kandla the concentration of **Potassium** varied between **286 to 361 mg/L** and **435 to 402 mg/L** at Vadinar, with the average value as **331.16** mg/L and **418.5** mg/L respectively for Kandla and Vadinar.
- **Silica** in the studied area varied between **2.64 to 3.78 mg/L**, with the average of **3.09** mg/L, at Kandla. Vadinar, observed value was found to be **0.86** mg/L at location MW-7 and **0.71** mg/L at MS-8 location.
- **Sodium** in the study area varied between **9215 to 9874 mg/L**, with average of **9476** mg/L, at Kandla whereas at Vadinar the sodium concentration value was observed in the range of **9845** to **9523** 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 **1.785 to 2.415 mg/L**, with the average of **2.073** mg/L, at Kandla, and for Vadinar value were recorded **0.451** for location MW-7 and **0.268** mg/L for location MW-8.
- **Lead** concentration varied **0.0023 to 0.0033 mg/L**, with an average of **0.0029** mg/L at Kandla. At Vadinar location MW-7 observed **0.0024** mg/L and MW-8 observed **0.0028** mg/L with an average of **0.0026** mg/L
- **Manganese** in the studied area varied between 0.093 **to 0.13 mg/L**, with the average of **0.11** mg/L, at Kandla. At Vadinar location MW-7 observed **0.045** mg/L and MW-8 observed BQL.
- **Particulate Organic Carbon** in the study area was observed in the range of **0.51 to 1.25**, with the average value of **0.85**. Whereas for the Vadinar, the value observed was **0.57** at MW-7 and 0.82 at MW-8, with the average of **0.69**.
- 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	23.017729N 70.224306E
2.		MS-2	Kandla Creek	23.001313N 70.226263E
3.		MS-3	Near Coal Berth	22.987752N 70.227923E
4.		MS-4	Khori Creek	22.977544N 70.207831E
5.		MS-5	Nakti Creek (near Tuna Port)	22.962588N 70.116863E
6.		MS-6	Nakti Creek (near NH-8A)	23.033113N 70.158528E
7.	Vadinar	MS-7	Near SPM	22.500391N 69.688089E
8.		MS-8	Near Vadinar Jetty	22.440538N 69.667941E

The map depicting the locations of Marine Sediment sampling 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	Flame Photometer
12.	Potassium	mg/Kg	Methods Manual Soil Testing in India January, 2011	
13.	Aluminium	mg/Kg	EPA Method 3051A	ICP-OES
14.	Chromium	mg/Kg		
15.	Nickel	mg/Kg		
16.	Zinc	mg/Kg		
17.	Cadmium	mg/Kg		
18.	Lead	mg/Kg		
19.	Arsenic	mg/Kg		
20.	Mercury	mg/Kg		

11.2 Result and Discussion

The quality of Marine Sediment samples collected from the locations of Kandla and Vadinar 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	3.95	10.14	21.56	8.24	14.5	13.25	3.54	2.39
2.	Phosphate	mg/Kg	1123.5	1785.1	1569.2	563.4	820.9	641.8	215.6	257.8
3.	Organic Matter	%	0.78	0.33	0.21	0.48	0.71	0.38	0.58	0.77
4.	Sulphate as SO^{4-}	mg/Kg	185.62	175.26	218.45	154.78	96.58	116.52	81.56	105.49
5.	Calcium as Ca	mg/Kg	2045.86	2357.14	1789.52	1458.63	1456.37	2158.47	2345.98	2157.42
6.	Magnesium as Mg	mg/Kg	1568.34	1654.87	1785.24	1453.28	1578.46	1125.87	1269.47	1563.29
7.	Silica	g/Kg	578.1	456.2	478.9	315.4	248.3	336.5	287.15	415.75
8.	Nitrite	mg/Kg	0.25	0.35	0.39	0.45	0.41	0.55	0.21	0.33
9.	Nitrate	mg/Kg	20.19	17.64	24.86	21.05	19.67	18.72	15.26	10.02
10	Sodium	mg/Kg	3481	2356	2781	3125	3329	2841	6028	8753
11	Potassium	mg/Kg	2164.2	1845.4	2745.6	3125.9	2896.7	2541.3	2863.1	2356.1
12	Aluminium	mg/Kg	2145.8	1984.6	1356.4	2158.4	1789.2	1456.2	1586.4	1784.6
13	Chromium	mg/Kg	48.5	35.4	38.7	45.6	46.8	50.3	52.7	21.8
14	Copper	mg/Kg	3.21	3.45	4.15	3.86	4.87	5.1	4.26	3.67
15	Nickel	mg/Kg	41.58	35.41	20.45	26.94	21.56	22.35	15.86	27.46
16	Zinc	mg/Kg	60.23	51.27	47.67	42.68	49.82	42.51	25.64	41.29
17	Cadmium	mg/Kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
18	Lead	mg/Kg	4.71	5.06	3.8	5.16	4.75	4.2	4.69	5.34
19	Arsenic	mg/Kg	4.29	2.51	5.15	3.36	2.56	3.54	2.74	3.25
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 2025. The detailed interpretation of the parameters is given below:

- **Inorganic Phosphate** for the sampling period was observed in range of **3.95 to 21.56** Kg/ha for Kandla. Whereas for Vadinar the value observed at location MS-7 (Nakti creek) is 3.54 Kg/ha and MS-8 (Near Vadinar Jetty) is 2.29 Kg/ha. For Kandla and Vadinar the average value of Inorganic Phosphate was observed 11.94 and 2.96 Kg/ha respectively.
- The concentration of **Phosphate** was observed in range of **563.4 to 1785.1 mg/Kg** for Kandla and for Vadinar the value observed at location MS-7 (Nakti creek) as 215.6 mg/Kg and MS-8 (Near Vadinar Jetty) as 257.8 mg/Kg. For Kandla and Vadinar the average concentration of Phosphate was observed 1083.98 and 236.7 mg/Kg respectively.

- The **Organic Matter** for the sampling period was observed in the range of **0.21 to 0.78** % for Kandla with the average value of 0.48 % and for Vadinar the value recorded at location MS-7 and MS-8 was observed 0.58 % & 0.77 % respectively, with average concentration as 0.67 %.
- The concentration of **Sulphate** was observed in the range of **96.58 to 218.45 mg/Kg** for Kandla and for Vadinar the value observed at MS-7 is 81.56 mg/Kg and at MS-8 is 105.49 mg/Kg. For Kandla and Vadinar the average value of Sulphate was observed 157.86 and 93.52 mg/Kg respectively.
- The value of **Calcium** was observed in the range of **1456.37 to 2357.14 mg/Kg** for Kandla and for Vadinar the value observed at MS-7 is 2345.98 mg/Kg and at MS-8, is 2157.42 mg/Kg. The average value of Calcium for the monitoring period was observed 1877.66 mg/Kg and 2251.7 mg/Kg at Kandla and Vadinar, respectively.
- The value of **Magnesium** for the sampling period was observed in the range of **1125.87 to 1785.24 mg/Kg** for Kandla and for Vadinar the value observed at MS-7 is 1269.47 mg/Kg and at MS-8, is 1563.29 mg/Kg. For Kandla and Vadinar the average value of Magnesium was observed 1527.67 mg/Kg and 1416.38 mg/Kg respectively.
- For the sampling period **Silica** was observed in the range of **248.3 to 578.1 mg/Kg** for Kandla with average value 402.23 mg/Kg and for Vadinar the value observed to be 287.15 and 415.75 mg/Kg at MS-7 and MS-8, respectively with average 351.45 mg/Kg.
- The value of **Nitrate** was observed in the range of **17.64 to 24.86 mg/Kg** for Kandla with average value 20.35 mg/Kg and for Vadinar the value observed to be 15.26 and 10.02 mg/Kg at MS-7 and MS-8, respectively with average 12.64 mg/Kg.
- The value of **Nitrite** was observed in the range of **0.25 to 0.55 mg/Kg** for Kandla with average value 0.40 mg/Kg and for Vadinar the value observed to be 0.21 and 0.33 mg/Kg at MS-7 and MS-8, respectively with average 0.27 mg/Kg.
- The value of **Sodium** was observed in the range of 2356 **to 3481 mg/Kg** for Kandla with average value 2985.5 mg/Kg and for Vadinar the value observed to be 6028 and 8753 mg/Kg at MS-7 and MS-8, respectively with average 7390.5 mg/Kg.
- The value of **Potassium** was observed in the range of **1845.4 to 3125.9 mg/Kg** for Kandla with average value 2553.18 mg/Kg and for Vadinar the value observed to be 2863.1 and 2356.1 mg/Kg at MS-7 and MS-8, respectively with average 2609.6 mg/Kg.
- The value of **Aluminium**, was observed in the range of **1356.4 to 2158.4 mg/Kg** for Kandla with average value **1815.1** mg/Kg and for Vadinar the value observed to be **1586.4** and **1784.6** mg/Kg at MS-7 and MS-8, respectively with average **1685.5** 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	4.29	2.51	5.15	3.36	2.56	3.54	2.74	3.25
2.	Copper	mg/Kg	3.21	3.45	4.15	3.86	4.87	5.1	4.26	3.67
3.	Chromium	mg/Kg	48.5	35.4	38.7	45.6	46.8	50.3	52.7	21.8
4.	Nickel	mg/Kg	41.58	35.41	20.45	26.94	21.56	22.35	15.86	27.46
5.	Lead	mg/Kg	4.71	5.06	3.8	5.16	4.75	4.2	4.69	5.34
6.	Zinc	mg/Kg	72.18	60.23	51.27	47.67	42.68	49.82	25.64	41.29
7.	Cadmium	mg/Kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL

- **Arsenic** was observed in the range of **2.51 to 5.15 mg/Kg** for Kandla with average value **3.56** mg/Kg and for Vadinar the value observed to be **2.74** and **3.25** mg/Kg at MS-7 and MS-8, respectively with average **2.99** 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 **3.21 to 5.1 mg/Kg** for Kandla with average value **4.10** mg/Kg and for Vadinar the value observed to be **4.26** and **3.67** mg/Kg at MS-7 and MS-8, respectively with average 3.96 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 **35.4 to 50.3 mg/Kg** for Kandla with average value **44.21** mg/Kg and for Vadinar the value observed to be **52.7** and **21.8** mg/Kg at MS-7 and MS-8, respectively with average **37.25** 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 **20.45 to 41.58 mg/Kg** for Kandla with average value **28.04** mg/Kg and for Vadinar the value observed to be **15.86** and **27.46** mg/Kg at MS-7 and MS-8, respectively with average **21.66** 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 **3.8 to 5.16 mg/Kg** for Kandla with average value **4.61** mg/Kg and for Vadinar the value observed to be **4.69** and **5.34** mg/Kg at MS-7 and MS-8, respectively with average **5.01** mg/Kg. With reference to the guidelines mentioned in table 35, the sediment quality with respect to lead falls in non-polluted class.
- **Zinc** was observed in the range of **42.51 to 60.23 mg/Kg** for Kandla with average value 49.03 mg/Kg and for Vadinar the value observed to be **25.64** and **41.29** mg/Kg at MS-7 and MS-8, respectively with average **33.46** 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, ∑ = Summation symbol,
pi = Relative abundance of the species,
ln = Natural logarithm

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

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:

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

Where, ∑ = Summation symbol, pi = 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:

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

Where, N = total number of individuals collected

S = No. of taxa or species or genera

4. Berger-Parker index:

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

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

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

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.

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

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	120	75	62	119	95	91	81	116
2.	Net Primary Productivity	mg/L/hr	BQL	BQL	BQL	BQL	0.91	BQL	BQL	BQl
3.	Gross Primary Productivity	mg/L/hr	1.26	0.84	1.35	1.58	1.21	0.56	0.91	1.31
4.	Pheophytin	mg/m^3	BQL	BQL	0.61	1.2	1.33	0.48	1.27	1.36
5.	Chlorophyll-a	mg/m^3	0.58	0.89	1.48	1.22	1.46	1.1	1.66	1.4
6.	Particulate Oxidisable Organic Carbon	mg/L	0.7	1.16	0.61	0.75	1.32	0.85	0.73	0.81
7.	Secchi Depth	ft	0.55	0.63	0.51	0.40	0.47	0.74	1.11	1.02

- **Biomass:**
  With reference to the **Table 39**, the concentration of **Biomass** reported from location ME-1 to ME-6 in range between **62-120 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 81 mg/L at ME-7 (Near SPM) and 116 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 **0.56 to 1.58 mg/L/48 Hr** where the highest value recorded for ME-4 and lowest recorded at ME-6 (Nakti Creek (near NH - 8A)). In Vadinar, the value of **GPP** was observed 0.91 at ME-7 (Near SPM) and 1.31 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 estimated to be **0.91 mg/L/48 Hr**. While in Vadinar, the value of **NPP** was observed BQL at ME-7 (Near SPM) and ME-8 (Near Vadinar Jetty) monitoring station.

- **Pheophytin**
  The level of Pheophytin was detected in the range from **0.48 to 1.33 mg/m^3** 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 1.27 mg/m^3 at ME-7 and 1.36 at ME-8 monitoring station.

- **Chlorophyll-a**
  In the sub surface water, the value of Chlorophyll-a reported in range from **0.58 to 1.48 mg/m³**. The highest value observed at ME-3 (Near Coal Berth) while the lowest value observed at ME-1 (Near Passenger Jetty One). In Vadinar, the value of chlorophyll-a was observed 1.66 mg/m³ at ME-7 (Near SPM) and 1.4 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 **0.61 to 1.32 mg/L** from monitoring location ME-1 to ME-6 at Kandla, whereas for Vadinar, the value of POC observed 0.73 mg/L at ME-7 (Near SPM) and 0.81 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 **0.4 to 0.74 ft** whereas at Vadinar, the value recorded at ME-7 i.e. Near SPM is 1.11 ft and in Near Vadinar Jetty is 1.02 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
Bacillaria sp.	-	-	148	-	128	269	-	168
Biddulphia sp.	159	315	125	125	126	-	284	148
Chaetoceros sp.	-	166	-	-	-	248	145	-
Chlamydomonas sp.	172	-	-	149	228	-	-	259
Cyclotella sp.	110	468	168	-	-	156	350	247
Coscinodiscus sp.	-	-	-	-	-	-	-	-
Ditylum sp	-	-	245	165	210	135	267	-
Fragilaria sp.	486	174	-	-	-	-	-	143
Bacteriastrum sp.	252	125	-	148	114	145	146	-
Pleurosigma sp.	-	-	241	-	-	-	117	212
Navicula sp.	147	-	-	146	196	328	-	183
Merismopedia sp.	-	147	142	-	-	-	-	-
Synedra sp.	178	-	-	-	-	157	251	-
Skeletonema sp.	-	-	-	249	257	-	-	144
Oscillatoria sp.	-	256	-	-	-	153	-	-
Thallassiosira	187	-	158	-	175	123	-	156
Gomphonema sp.	-	187	-	178	-	-	135	-
Density-Units/L	**1691**	**1838**	**1227**	**1160**	**1434**	**1714**	**1695**	**1660**
No. of genera	**8**	**8**	**7**	**7**	**8**	**9**	**8**	**9**

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 14 genera; green algae were represented by 1 genera and filamentous Cynobacteria were represented by 2 genera during the sampling period.

The density of phytoplankton of the sampling stations from ME-1 to ME-6 (Kandla) varying from **1160 to 1838 units/L,** while for Vadinar its density of phytoplankton observed **1695 units/L at ME-7 and 1660 units/L at ME-8.** During the sampling, phytoplankton communities were dominated, *Cyclotella sp, Biddulphia sp., Bacteriastrum sp, Navicula sp & Thallassiosira, 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	8	8	7	7	8	9	8	9
Individuals	1691	1838	1227	1160	1434	1714	1695	1660
Shannon diversity	1.97	2.06	1.62	1.58	1.87	2.15	2.01	2.15
Simpson 1-D	0.84	0.85	0.85	0.85	0.87	0.88	0.86	0.88
Species Evenness	0.95	0.99	0.83	0.81	0.90	0.98	0.97	0.98
Margalef richness	0.94	0.93	0.84	0.85	0.96	1.07	0.94	1.08
Berger-Parker	0.29	0.25	0.20	0.21	0.18	0.19	0.21	0.16
Relative abundance	0.47	0.44	0.57	0.60	0.56	0.53	0.47	0.54

- **Shannon- Wiener's Index (H)** of phytoplankton communities was in the range of **1.58 to 2.15** between selected sampling stations from ME-1 to ME-6 with an average value of 1.88 at Kandla creek and its nearby creeks. While for Vadinar, Shannon Wiener's index of phytoplankton communities recorded to be **2.01** at location ME-7 and **2.15** at ME-8 with an average value of 2.08. 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 **0.84 to 0.88** 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 0.86 at location ME-7 and 0.88 at ME-8 with an average of 0.87.

- **Margalef's diversity index** (Species Richness) of phytoplankton communities in Kandla and nearby creeks sampling stations was varying from **0.84 to 1.07** with an average of 0.93 during the sampling period. While for Vadinar, Margalef's diversity index (Species Richness) of phytoplankton communities observed 0.94 at ME-7 and 1.08 at ME-8 with an average value of 1.01.

- **Berger-Parker Index (d)** of phytoplankton communities was in the range of **0.18 to 0.29** 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 0.16 to 0.21 with an average value of 0.19. 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 **0.81 to 0.99** for all the six-monitoring station of Kandla and for the Vadinar the species evenness is observed 0.97 at location ME-7 & 0.98 at ME-8 location.

- During the sampling period, **Relative Abundance** of phytoplankton communities was in range of **0.44 to 0.60** between selected sampling stations from ME-1 to ME-6 with an average value of 0.53 at Kandla creek and nearby creeks. Whereas for Vadinar the Index value 0.47 at ME-7 and 0.54 at ME-8 with an average value 0.51, 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
Acartia sp.	1	-	2	1	1	-	-	1
Acrocalanus	-	1	1	-	-	-	1	-
Amoeba	1	2	-	1	-	1	1	1
Brachionus sp.	1	1	1	-	2	1	-	1
Calanus sp.	-	1	1	1	1	1	2	-
Cladocera sp.	2	-	-	2	-	-	1	-
Cyclopoid sp.	1	1	1	-	1	1	-	1
Copepod larvae	-	1	-	1	-	1	2	1
Diaptomus sp.	2	-	1	-	1	-	1	-
Eucalanus sp.	-	1	-	1	-	1	-	2
Mysis sp.	-	-	-	1	1	2	-	1
Paracalanus sp.	1	1	1	-	-	1	1	-
Density Unit/L	**9**	**9**	**8**	**8**	**7**	**9**	**9**	**8**
No. of genera	**7**	**8**	**7**	**7**	**6**	**8**	**7**	**7**

A total of 12 zooplankton genera were recorded in Kandla and Vadinar during the study period. The zooplankton community was mainly composed of *Acartia sp., Amoeba, Cyclopoid sp., Copepod larvae, and Paracalanus sp.*, which showed the highest occurrence across stations. From **ME-1 to ME-6** (Kandla), the density of zooplankton ranged between **7 and 9 units/L**. In Vadinar (**ME-7 and ME-8**), the density ranged between at **8 to 9 units/L**. At Kandla stations, *Acartia sp., Amoeba, Cyclopoid sp., Copepod larvae*, *Brachionus sp, Calanus sp.*, and *Paracalanus sp*. were the most frequently observed genera, while *Acartia sp, Acrocalanus, Cyclopoid sp*. and *Eucalanus sp.*. also had strong representation at Vadinar stations.

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	7	6	8	7	7
Individuals	9	9	8	8	7	9	9	8
Shannon diversity	1.89	2.04	1.8	1.8	1.55	2.04	1.89	1.8
Simpson (1-D)	0.94	0.97	0.96	0.96	0.95	0.97	0.94	0.96
Species Evenness	0.97	0.98	0.93	0.93	0.87	0.98	0.97	0.93
Margalef	2.73	3.19	2.89	2.89	2.57	3.19	2.73	2.89
Berger-Parker	0.22	0.22	0.25	0.25	0.29	0.22	0.22	0.25
Relative abundance	77.78	88.89	87.5	87.5	85.71	88.89	77.78	87.5

- **Shannon- Wiener's Index (H)** of zooplankton communities was in the range of **1.55 to 2.04** between selected sampling stations from ME-1 to ME-6 with an average value of 1.85 at Kandla creek and its nearby creeks. While for Vadinar, Shannon Wiener's index of

zooplankton communities recorded to be 1.89 at ME-7 and 1.8 at ME-8 with an average value of 1.84. 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 **0.94 to 0.97** at all sampling stations in the Kandla creek and nearby creeks, with an average of 0.95 Similarly, for Vadinar Simpson diversity index (1-D) of zooplankton communities was 0.94 at ME-7 and 0.96 at ME-8 with an average of 0.95.

- **Margalef's diversity index** (Species Richness) of zooplankton communities in Kandla and nearby creeks sampling stations was varying from **2.57 to 3.19** with an average of 2.91 during the sampling period. While for Vadinar, Margalef's diversity index (Species Richness) of zooplankton communities observed 2.73 at ME-7 and 2.89 at ME-8 with an average value of 2.81.

- **Berger-Parker Index (d)** of zooplankton communities was in the range of **0.22 to 0.29** between selected sampling stations from ME-1 to ME-6 with an average value of 0.24 at Kandla creek and nearby creeks. Berger-Parker Index (d) of zooplankton communities in the sampling stations of Vadinar, was in the 0.22 at ME-7 and 0.25 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 0.98** for all the six-monitoring station of Kandla whereas, for the Vadinar the species evenness was observed in the 0.95, during the monitoring month.

- During the sampling period, **Relative Abundance** of zooplankton communities was in range of 77.78 to 88.89 between selected sampling stations from ME-1 to ME-6 with an average value of 86.04 at Kandla creek and nearby creeks. Whereas for Vadinar the Index value 77.78 at ME-7 and 87.5 at ME-8 with an average value 82.64, 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	-	1	-	2	1	1
Lymnidae	2	1	2	-	1	1	2	-
Planorbidae	1	-	-	2	-	-	-	2
Talitridae	-	-	1	1	1	-	1	1
Trochidae	1	1	-	-	1	1	-	-

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

Few benthic organisms were observed in the collected samples using Van-Veen grabs at Deendayal Port (Kandla and Vadinar). The dominant macro-benthic groups included *Mollusca, Lymnidae, Gammaridae and Odonata*, which were present across multiple stations. *Odonata* was observed at all sites (**ME-1 to ME-8**) except **ME-5**, similarly *Thiaridawas* observed at all sites **(ME-1 to ME-8)** except **ME-4**. while *Talitridae* occurred at 6 out of 8 locations, indicating their broad distribution. The number of benthic families/classes varied between 6 to 9 across all stations.

At ME-1, the most dominant groups were *Thiaridae, Planorbidae, Gammariade* and *Odonata*, each with a density of **2 units/L**. The least represented benthic fauna included *Mollusca Sp., atydae, Turbinidae*, which was observed only at ME-1 with a Density of **1 units/L**

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	6	6	6	6	5	6	6	5
Individuals	7	7	7	7	6	7	7	6
Shannon diversity	1.75	1.75	1.75	1.75	1.47	1.75	1.75	1.47
Simpson 1-D	0.95	0.95	0.95	0.95	0.93	0.95	0.95	0.93
Species Evenness	0.98	0.98	0.98	0.98	0.91	0.98	0.98	0.91
Margalef	2.57	2.57	2.57	2.57	2.23	2.57	2.57	2.23
Berger-Parker	0.29	0.29	0.29	0.29	0.33	0.29	0.29	0.33
Relative abundance	85.71	85.71	85.71	85.71	83.33	85.71	85.71	83.33

- **Shannon- Wiener's Index (H)** of benthic organism was in the range of **1.47 to 2.03** between selected sampling stations from ME-1 to ME-6 with an average value of 1.79 at Kandla creek and its nearby creeks. While for Vadinar, Shannon Wiener's index of benthic organism recorded to be 1.75 at ME-7 & 1.47 at ME-8 location with an average value of 1.61. 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 **0.93 to 0.95** at all sampling stations in the Kandla creek and nearby creeks, with an average of 0.95. 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 **2.23 to 2.89** with an average of 2.62 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 0.28 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 **0.91 to 0.98** for all the six-monitoring station of Kandla and for the Vadinar the species evenness is observed to be 0.98 at ME-7 and 0.91 at ME-8 location with an average of 0.94.

- During the sampling period, **Relative Abundance** of Benthic organisms was in range of **83.33 to 87.5** between selected sampling stations from ME-1 to ME-6 with an average value of 85.91 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

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Gujarat Environment Management Institute (GEMI)

(An Autonomous Institute of Government of Gujarat)

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

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"We Provide Environmental Solutions"

ANNEXURE C

Details of Hazardous Waste generated during the financial year 2024-25

MARINE DEPARTMENT

Sub : Annual Return Showing the collection & disposal of Hazardous and Non-Hazardous Wastes carried out by various parties for the year 04/2024 to 03/2025.

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 from 01-04-2024 to 31-03-2025 of Marine Department is enclosed herewith.

Encl : As above

Deputy Conservator
Deendayal Port Authority

EMC (I/C)
No. MR/WK/1316/ 427 Date : 13.05.2025.

Deendayal Port Authority
Marine Department

Statement of Hazardous and Non hazardous Waste disposal from the Vessels at Kandla Port for the Period April 2024 to March 2025 – 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	2024	1124.53	281.13	843.40	170.96
2.	May	2024	1004.00	251.00	753.00	265.01
3.	June	2024	2194.23	548.56	1645.67	174.14
4.	July	2024	1330.64	332.66	997.98	247.80
5.	August	2024	2333.80	583.45	1750.35	302.37
6.	September	2024	2055.17	513.79	1541.38	285.17
7.	October	2024	2198.00	549.50	1648.50	405.24
8.	November	2024	1024.58	256.15	768.44	368.41
9.	December	2024	1283.96	320.99	962.97	404.33
10.	January	2025	1214.05	303.51	910.54	245.46
11.	February	2025	1328.61	332.15	996.46	294.38
12.	March	2025	904.06	226.01	678.04	111.33
Total			**17995.63**	**4498.91**	**13496.72**	**3274.60**

Deputy Conservator
Deendayal Port Authority

Marine Department

(IN MT)

Statement showing the Collection and disposal of Hazardous and Non-Harardous Wastes carried out by 2024-25

Sr. No.	Name of Party	Type of Licence	Apr-24	May-24	Jun-24	Jul-24	Aug-24	Sep-24	Oct-24	Nov-24	Dec-24	Jan-25	Feb-25	Mar-25	Total
1	Alicid Organic Industries Limited	Hazardous	-	-	-	-	-	-	-	-	-	-	-	-	-
2	Amar Hydrocarbon Pvt. Ltd	Hazardous	-	-	-	-	81.08	-	-	-	-	-	62.32	-	143.40
3	Atlas Organics Pvt. Ltd	Hazardous	-	17.62	-	-	-	62.74	33.00	72.24	32.49	96.83	-	-	314.92
4	Aviation Corporation	Hazardous	-	-	-	-	-	-	-	-	-	-	-	-	-
5	Mahalaxmi Asphalt Pvt Ltd	Hazardous	85.73	98.06	341.38	112.90	93.29	39.25	130.21	61.47	159.73	189.88	176.28	98.08	1,586.26
6	Priyansi Corporation	Hazardous	-	-	-		-	-	-	-	-	-	-	-	-
7	Revolution Petrochem LLP	Hazardous	736.28	721.55	1,635.77	1,021.52	2,033.29	1,792.89	1,855.24	701.58	839.45	658.23	790.31	729.14	13,515.25
8	Shana Oil Process	Hazardous	-	-	-	-	-	-	-	-	-	88.00	132.64	-	220.64
9	United Shipping Company	Hazardous	358.75	216.97	285.83	227.57	233.45	263.05	249.85	231.88	263.26	241.81	233.49	122.04	2,927.95
10	Kutch Energies Pvt.Ltd.	Hazardous	-	-	40.96	35.18	9.38	-	39.60	8.64	53.23	-	-	-	186.99
11	Pureflow Greens Private Limited	Hazardous											44.38	156.80	201.18
12	Jay Ambe Industries, Sanand	Hazardous													
13	Chitrakut Trading & Industries	Non-Hazardous	5.65	17.52	11.44	27.20	30.02	5.56	12.11	54.50	28.00	-	-	-	192.00
14	Golden Shipping Services	Non-Hazardous	13.97	24.68	51.63	24.81	40.86	34.77	169.57	38.96	35.50	21.56	48.15	28.41	532.87
15	Green Earth Marine Solutions	Non-Hazardous	5.33	12.80	3.80	-	19.98	41.22	3.30	9.59	7.70	10.73	3.74	—	118.19
16	Harish A. Pandya	Non-Hazardous	6.30	17.84	1.10	12.36	4.17	21.83	37.53	55.06	86.48	-	-	-	242.67
17	K M Enterprise	Non-Hazardous	73.16	153.62	50.10	85.46	163.77	109.71	124.14	134.78	157.50	131.16	197.01	-	1,380.41
18	Naaz Shipping Services Ent	Non-Hazardous	-	-	-	11.00	-	8.93	4.57	3.94	4.57	4.58	-	-	37.59
19	New India Marine Works	Non-Hazardous	21.10	-	9.29	31.32	6.84	17.35	7.60	10.08	7.16	11.45	11.95	14.69	148.83
20	Omega Marine Services	Non-Hazardous	28.58	29.10	36.86	39.89	28.03	25.34	27.11	41.88	33.68	37.58	25.34	63.19	416.58
21	V K Enterprise	Non-Hazardous	-	-	-	-	-	-	-	-	-	-	-	-	-
22	Vishwa Trade-link Inc.	Non-Hazardous	16.87	9.45	9.92	15.76	8.70	15.38	12.11	14.36	34.83	18.14	8.19	-	163.71
23	Bhavya Engg.Work & Multi.	Non-Hazardous	-	-	-	-	-	5.08	7.20	5.26	3.91	-	-	5.04	31.49
24	Shri Ganesh Traders, Anjar	Non-Hazardous	-	-	-	-	-	-	-	-	-	4.26	7.36	—	11.62
25	Nar Narayan Multiservics	Non-Hazardous	-	-	-	-	-	-	-	-	-	6.00	-	8.50	14.50
26	Mohanlal & Co, Jamnagar	Non-Hazardous	-	-	-	-	-	-	-	-	-	-	-	-	-
27	M/s. Kiyara Ship Chandleers & Marine Services, Meghpar-	Non-Hazardous													
		Hazardous - Total	**1,180.76**	**1,054.20**	**2,303.94**	**1,397.17**	**2,450.49**	**2,157.93**	**2,307.90**	**1,075.81**	**1,348.16**	**1,274.75**	**1,395.04**	**949.26**	**18,895.41**
		Non-Hazardous - Total	**170.96**	**265.01**	**174.14**	**247.80**	**302.37**	**285.17**	**405.24**	**368.41**	**404.33**	**245.46**	**294.38**	**111.33**	**3,274.60**

Copy to : GPCB, Gandhidham / Harbour Master

ANNEXURE D

Details of domestic waste water generation for 2024-25

Statement Showing the quantity of Domestic Waste Water Generation (STP - Kandla) for the period from April 2024 to March 2025

Sr.No.	Month	Average Quantity of Domestic Waste Water Generation in KLD
1.	April 2024	215
2.	May 2024	210
3.	June 2024	255
4.	July 2024	250
5.	August 2024	240
6.	September 2024	220
7.	October 2024	225
8.	November 2024	210
9.	December 2024	215
10.	January 2025	225
11.	February 2025	220
12.	March 2025	210
Total		224.58

12/05/25

XEN (Road)