

**DEENDAYAL PORT AUTHORITY**  
(Erstwhile: DEENDAYAL PORT TRUST)

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EG/WK/5202 (D)/Part (CRZ)/ 115

Dated: 12/08/2024

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

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

**Ref.:** (1) Letter No. ENV-10-2018-24-T Cell dated 30/7/2020 of Director (Environment) & Additional Secretary, Forest & Environment Department, GoG.  
(2) DPT letter no. EG/WK/5202 (D)/ Part (CRZ 2)/28 dated 29/06/2021  
(3) DPT letter no. EG/WK/5202 (D)/ Part (CRZ 2)/142 dated 08/02/2022  
(4) DPA letter no. EG/WK/5202 (D)/ Part (CRZ 2)/128 dated 30/06/2022  
(5) DPA letter no. EG/WK/5202 (D)/ Part (CRZ 2)/296 dated 05/05/2023  
(6) DPA letter no. EG/WK/5202 (D)/ Part (CRZ 2)/363 dated 18/09/2023  
(7) DPA letter no. EG/WK/5202 (D)/ Part (CRZ 2)/44 dated 27/03/2024

Sir,

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

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

Now, as directed under Specific Condition No. 26 mentioned in the CRZ Clearance letter dated 30/7/2020 i.e. ***A six-monthly report on compliance of the conditions mentioned in this letter shall have to be furnished by the DPA on a regular basis to this Department and MoEF&CC, GoI***, please find enclosed herewith compliance report of the stipulated conditions for period upto May, 2024 along with necessary annexures, for kind information & record please **(Annexure I)**.

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

Accordingly, we are submitting herewith soft copy of the same via e-mail in ID [gczma.crz@gmail.com](mailto:gczma.crz@gmail.com) & [direnv@gujarat.gov.in](mailto:direnv@gujarat.gov.in) .

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

Yours Faithfully,

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

**Copy to: -**

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

### **CURRENT STATUS OF WORK PROGRESS (Up to May, 2024)**

<b>Sr.No</b>	<b>Name of Project</b>	<b>Status</b>
1	Oil Jetty No. 8 (Jetty & allied facilities)	Construction work is completed
2	Oil Jetties no. 9, 10 & 11 to be implemented on BOT/PPP Mode.	<p>The SFC recommendation and the MoPSW, GoI approval for Oil Jetties 9, 10 &amp; 11, under PPP mode, has been received on 19/04/2021.</p> <p>a) The bid for OJ – 09 is invited fourth time. In the meeting with MoPSW, GoI, it was decided that project may be restructured, if bids are not received.</p> <p>b) Restructured project proposal for OJ 9, 10 &amp; 11 are under consideration of the SFC for their final approval.</p> <p>c) No construction activity started yet on project site.</p>
3	Development of Land (area 554 acres) for associated facilities for storage.	Initially, partial development of embankment for road network along with reclamation of Land is undertaken.

**Note : The construction activity has been carried out as per EC & CRZ Clearance accorded by the MoEF&CC, GoI vide file no. 10-1/2017-IA-III dated 20/11/2020.**

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**Annexure 1**

**Compliance Report (For the period up to May, 2024)**

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

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

<b>S. No</b>	<b>CRZ Conditions</b>	<b>Compliance Status</b>
	<b>SPECIFIC CONDITIONS</b>	
1.	The DPA shall strictly adhere to the provisions of the CRZ Notification, 2011 issued by the Ministry of Environment, Forests and Climate Change, Government of India	It is assured that, the provisions of the CRZ Notification, 2011 shall be strictly adhere to by the DPA.
2.	Necessary permissions from different departments/ agencies under different laws/ acts shall be obtained before commencing any activity (including the construction)	The Consent to Establish (CTE) from the GPCB had already been obtained vide CTE No. 94118 granted by the GPCB vide letter no. PC/CCA-KUTCH 1524/GPCB ID 56985 dated 23/7/2018 with a validity period 3/4/2023.  DPA also obtained validity extension vide GPCB order no. PC/CCA-KUTCH 1524/GPCB ID 56985 dated 30/09/2023 valid up to 19/11/2030.  Further, Construction activity of Oil Jetty 08 is completed, accordingly DPA had applied for the CCA – fresh application vide inward no. 310134 dated 23/04/2024. A copy of forwarding letter is attached herewith as <b>Annexure A</b>
3.	The DPA shall ensure that the all the provisions of CRZ Notification 2011 shall be complied with and storage facilities in CRZ areas shall be in compliance with Annexure-II of the above said Notification	It is assured that all the provisions of CRZ Notification, 2011 will be complied with and only storage of permissible cargo as per CRZ Notification, 2011, Annexure II will be allowed to store in storage facilities to be developed.
4.	There shall not be any blockage of creek due to laying of pipeline. and free flow of water shall be maintained.	Due care is being taken while carrying out construction activity (Construction of Oil Jetty No. 8 and partial development of embankment for road network along with reclamation of Land) on Project site so that there is no blockage of the creek due to lying of pipeline
5.	There shall not be any mangrove destruction/ damage due to proposed activities and adequate buffer zone of 70 metres shall be maintained from mangrove areas	It is assured that all the proposed activities shall be carried out strictly as per the EC & CRZ Clearance accorded by the MoEF&CC, GoI dated 20/11/2020.
6.	The DPA shall effectively implement the Mangrove Development, Protection & Management plan for control of indirect impact on mangrove habitat	As per the directions of the GCZMA and MoEF&CC, GoI, DPA had already undertaken Mangrove Plantation in an area of 1600 Ha. till date since the year 2005. A statement showing details of mangrove plantation at various locations with cost incurred is placed at <b>Annexure B</b>  It is also relevant to submit here that, as per the direction of the Gujarat Coastal Zone Management Authority, DPA had already prepared & submitted a report on mangrove



		<p>conservation and management plan formulated by Gujarat Institute of Desert Ecology during the study period of Jan-April, 2015 (Report already submitted along with earlier compliance reports submitted).</p> <p>In addition to the above, DPA appointed M/s GUIDE, Bhuj for "Regular Monitoring of Mangrove Plantation carried out by DPA" (period 15/9/2017 to 14/9/2018 vide work order dated 1/9/2017 and 24/5/2021 to 23/5/2022 vide work order dated 3/5/2021). The final report for the year 2021 to 2022 is attached herewith as <b><u>Annexure Copy submitted along with the compliance report submitted with 05/05/2023</u></b></p> <p>Further DPA has assigned work to M/s GUIDE, Bhuj vide work order dated 10/06/2024 for "Monitoring of Mangrove Plantation 1600 Ha carried out by DPA" for the Period of 10/06/2024 to 09/06/2025. The work order is attached herewith as <b><u>Annexure C</u></b></p>
7.	The DPA shall have to make a provision that mangrove areas get proper flushing water and free flow of water shall not be obstructed	Due care is being taken while carrying out construction activity (Construction of Oil Jetty No. 8 and partial development of embankment for road network along with reclamation of Land) on Project site mangrove area get proper flushing of water and to maintain free flow of water.
8.	The DPA shall have to dispose of the dredged material at the designated dredged material disposal point based on scientific study and approved by the MOEF&CC, GOI	No dredging activity has been started yet. However, it is assured that dredging activity will be carried out strictly as per the requirement of the condition and the same shall be disposed at designated dumping ground (25° 51' 00" N & 70°10' 00" E).
9.	The DPA shall have to maintain the record for generation and disposal of capital dredging and maintenance dredging	No dredging activity has been started yet. However, it is assured that necessary record will be maintained as per the requirement of the condition.
10.	No dredging, reclamation or any other project related activities shall be carried out in the CRZ area categorized as CRZ I (i) (A) and it shall have to be ensured that the mangrove habitat and other ecologically important and significant areas, if any, in the region are not affected due to any of the project activities.	It is assured that all the project related activities will be strictly carried out as per the EC & CRZ Clearance accorded by the MoEF&CC, GoI dated 20/11/2020.
11.	The DPA shall ensure that construction activities like dredging etc. shall be carried out in confined manner to reduce the impact on marine environment.	No dredging activities have been started yet. However, it is assured that construction activities like dredging will be carried out as per the requirement of the condition.
12.	The DPA shall ensure that the dredging shall not be carried out during the fish breeding season.	No dredging activities have been started yet. Point Noted for compliance.
13.	Construction waste including debris and dredged material shall be disposed safely in the designed areas as approved by MoEF&CC, GoI and it shall be ensured that there shall be no impact on flora and fauna	DPA had already issued general circular vide dated 3/9/2019 regarding Construction and Demolition Waste Management for strict implementation in DPA. <b><u>Copy submitted along with the compliance report submitted with 05/05/2023</u></b>

14.	No effluent or sewage shall be discharged into the sea / creek or in the CRZ area and shall be treated to conform the norms prescribed by the Gujarat Pollution Control Board and would be reused / recycled as per the approval of the Board.	It is assured that No effluent or sewage will be discharged into the Sea/creek or in the CRZ area. Further, Generated waste water from the oil jetty no. 8 will be treated in septic tank/soak pit.  However, after completion of entire project facility (Oil Jetties 8 to 11 & associated area for storage), possibility may be explored to treat the waste water generation (about 16 KLD) through existing STP of DPA
15.	All the recommendations and suggestions given by the Cholamandalam MS Risk Services Limited in their Environment Impact Assessment report shall be implemented strictly by DPA	The compliance of the recommendations and suggestions is given by the EIA Consultant, M/s SV Enviro, Vizag in EIA Report is attached herewith as <b>Annexure D</b>
16.	The DPA shall exercise extra precautions to ensure the navigation safety and mitigation of the risk associated with the project activities especially due to collision, sinking or accidents of the vessels and would deploy the latest communication and navigation aids for this purpose. The proposed facilities shall also be covered under the VTMS being developed by the GMB	In this regard, it is to state that, Deendayal Port Authority had already contributed Rs. 41.25 crores for installing and operating the VTMS in the Gulf of Kachchh.
17.	The cost of the external agency that may be appointed by this department for supervision / monitoring of the project activities during construction/ operational phases shall be paid by DPA	Point Noted.
18.	The DPA shall contribute financially for any common study or project that may be proposed by this Department for environmental management / conservation / improvement for the Gulf Kutch	Point noted for compliance.
19.	The piling activities debris and any other type of waste shall not be discharged into the sea or creek or in the CRZ areas. The debris shall be removed from the site immediately after the piling activities are over.	DPA has included clause in the tender for the Contractor to undertake precautions for safeguarding the environment during the course of the construction work.
20.	The camps shall be located outside the CRZ area and the labour shall be provided with the necessary amenities, including sanitation, water supply and fuel and it shall be ensured that the environmental conditions are not deteriorated by the labours.	DPA has included clause in the tender for the Contractor to undertake precautions for safeguarding the environment during the course of the construction work.
21.	The DPA shall prepare and regularly update their Local Oil Spill Contingency and Disaster Management Plan in consonance with the National Oil Spill and Disaster Contingency Plan	Point Noted for compliance.  DPA is already having Local Oil Spill contingency plan and updated DMP.
22.	The DPA shall bear the cost of the external agency that may be appointed by this Department for supervision / monitoring of proposed activities and the environmental impacts of the proposed activities	Point noted for compliance.
23.	The groundwater shall not be tapped to meet with the water requirements in any case	Water requirements will be met through procurement from GWSSB or private tankers. It is hereby assured that no groundwater shall be tapped.
24.	DPA shall take up greenbelt development activities in consultation with the Gujarat institute of Desert Ecology / Forest Department / Gujarat Ecology Commission	DPA has already developed Green belt in and around the Port area.  Further, DPA assigned work for Green belt development in an area of about 32 hectares to the Forest Department, Govt. of Gujarat during August, 2019 at the cost of Rs. 352.32 lakhs. The work is completed. Further, DPA also undertook massive green belt

		<p>development in and around the Port area and at Gandhidham area.</p> <p>Further, DPA also assigned the work of <b>"Greenbelt Development in Deendayal Port Authority and its surrounding areas Charcoal Site (Phase I)"</b> vide Work Order dated 31/05/2022 at the cost of Rs. 33.22 lakhs . The work is completed. The final report is submitted along with the compliance submitted on 18/09/2023.</p> <p>Further DPA has accorded the work of "Green belt development in DPA and its surrounding area (Phase II) to Gujarat Institute of Desert Ecology (GUIDE), Bhuj for the plantation of 10000 saplings of suitable species vide work order dated 23/06/2023. The same is in process</p>
25.	The DPA shall have to contribute financially for taking up the socio-economic upliftment activities in this region in consultation with the Forests and Environment Department and the District Collector / District Development Officer	As per the CSR Guidelines issued by the Ministry of Ports, Shipping & Waterways, Government of India, from time to time, DPA had undertaken CSR activities since the year 2011-12. The details of CSR Activities undertaken & planned is attached herewith as <b>Annexure E</b>
26.	A six-monthly report on compliance of the conditions mentioned in this letter shall have to be furnished by DPA on a regular basis to this Department and MoEF&CC, Gol.	DPA has been regularly submitting the six-monthly report on compliance of the conditions mentioned in the CRZ Recommendation letter dated 30/7/2020 to the CRZ Authority and to the MoEF&CC, GoI. Last compliance submitted on 27/03/2024.
27.	The DPA shall ensure that the numbers of the Vessels and machinery deployed during marine construction, which are a source of low level organic and PHC pollution will be optimized to minimize risks of accidents involving these vessels.	Point Noted for compliance.
28.	The noise level during transport and construction of marine facilities shall be kept minimum.	<p>DPA appointed NABL Accredited laboratory for regular Monitoring of environmental parameters since the year 2016 in continuation of this DPA appointed M/s Gujarat Environment Management Institute (GEMI), Gandhinagar (NABL Accredited laboratory) for regular Monitoring of environmental parameters vide work order dated 15/02/2023. The work is in progress &amp; DPA is submitting the monitoring data regularly to all the concerned authorities along with compliance reports submitted.</p> <p>The latest Environmental Monitoring Reports are attached herewith as <b>Annexure F</b></p>
29.	The DPA shall regularly conduct the surveys to identify changes in the channel bathymetry to minimize navigation hazards. Proper navigational aids and guidance should be provided to ships navigating the channel and there should be a properly structured vessels traffic management strategy to avoid accidents.	<p>Point noted for compliance.</p> <p>Further, it is to state that, Deendayal Port Authority had already contributed Rs. 41.25 crores for installing and operating the VTMS in the Gulf of Kachchh.</p>
30.	The DPA shall carry out separate study for further erosion and deposition pattern in the area after dredging through a reputed agency and shall follow the suggestions of the study done by reputed agency, for maintenance dredging, the recommendations/ suggestions of the reputed agency shall be follow by the DPA.	No dredging activity has been started yet. However, it is assured that necessary will be conducted as per the requirement of the condition.

31.	Any other condition that may be stipulated by this Department and MoEF&CC, Gol from time to time for environmental protection / management purpose shall also have to be complied with by DPA.	Point noted.
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# **Annexure -A**

# Forwarding & Undertaking Letter from Industry

Application for consent for establishing / operation the industrial plant / plants under Section 21 of the Air (prevention & Control of Pollution ) Act, 1981

**Important** This Document or its copy does "NOT" serve as a Supporting Document Proof of Industry's Submission of an  
**Note :** Application for a NOC / Consent. This Letter does "NOT" ensure that the Application FEES has been paid.

**Application Purpose :** CCA- Fresh- for the "Operation of Oil Jetty No. 8 ( Capacity 3.5 MMTPA) for handling of all type of Liquid Cargo DPA had obtained consent to establish for the "Creation of water front facilities of Oil Jetties 8,9,10 & 11 & development of land " Vide GPCB letter no. GPCB/CCA-kutch-1524/GPCB ID 56985/462839 dated 23/7/18 & its extension & correction vide GPCB letter dated 30/09/2023 with validity period of 19/11/2030 Also, DPA had obtained EC&CRZ Clearance dated 20/11/2020 for the above mentioned project from the MoEF&CC, GOI In this connection it is to state that, out of 4 oil jetties the work of "Construction of Oil Jetty No. 8" has been completed. However, for the remaining oil jetties viz 9,10 & 11 (to be implemented under PPP mode) no construction activities have been started yet. Therefore, this application is for obtaining CCA- Fresh for the operation of "Oil Jetty no. 8 (Capacity 3.5 MMTPA) for handling of all type of liquid cargo"

From : **Deendayal Port Trust, Category: RED / LARGE**  
**PLOT NO:Kandla Port Trust land,**  
**a.o.building,p.o.box no. 50, -,**  
**Gandhidham - 370201**  
**Contact Person: B Rajendra Prasad, Mob:9727754360, Ph:02836220038**  
**DIST: Kutch East, TAL: Gandhidham, SIDC: Not In Gidc**

Print Date: 23/04/2024

**PCB-ID : 56985**  
**INWARD : 310134**  
**Dt:23/04/2024**

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

Scrutinized By: B.M.Dolasiya,SSA(M)(452)

**I / We here by Submitting application for CCA ,Inward No : 310134 ,Date : 23/04/2024 for COF(CCA-Fresh).**

Applying For : A,W,H Validity : 5 Years Grant By : CHR

Air Sector :20000~Large Scale Industry Water Consumption : 20.000 klpd

Haz Sector : 5000~Large Scale Industry No of Plants : 1 Incenerator : 0

<u>Investment</u>	<u>Air</u>	<u>Water</u>	<u>Hazardous</u>
150574 Crs	20000	4000	5000+2500
0 Rs	5 Years	5 Years	5 Years

**Payable Fees : Air : 100000, Water : 20000, Haz : 37500**

**Paid Amount : 157500, DD No : YSBI2307321972, Dt: 4/22/2024, at SBI , \*\*\***

**Query / Reply:**

	<b>I / We have Uploaded the following PDFs</b>	<b>Date</b>	<b># Files</b>	<b>Size(kb)</b>	<b>#Page</b>
1	SSI - SSI-IEM-C.A Certi / Investment Proofs	09/04/24	0	783	3
2	PLL - Plan LayOut + Site Plan	09/04/24	0	3109	2
3	000 - Any Specific Information Called for [in SCRUTINY]	02/08/23	0	17491	66
4	ETP - ETP Details+Diagram	06/02/18	1	95	2
5	ENV - Environment Statement , Form-V	30/01/18	1	0	0
6	ANN - Annual Return : Form 4	30/01/18	1	0	0
7	C&A - Previous Consent-Reject / CCA Order / NOC Order	30/01/18	1	130	4
8	APC - Air Pollution Control Measures-Details	30/01/18	1	532	14
9	MFG - Details of Mfg Processes & Diagrams	26/10/17	1	28	1
10	DIR - List of Directors / Partners	26/10/17	1	119	4
11	UNT - Undertaking of Non Applicability of Air/Water/Haz		0	0	0

I, the applicant declare that I have submitted full and complete documents and information in conformity to the applicable acts / rules. I am aware that, any delay / rejection in the processing of application on account of incorrect / incomplete information shall be mine responsibility.



**(Mr. RajendraPrasad Bethi, SED & EMC(I/C))**

**Note: I am hereby enclosing Form-I(AIR),Form-D(WATER),Form-1(HAZARDOUS) along with my application.**

**Please Attach Copy of NEFT/RTGS Challan with this Letter if you are paying through NEFT/RTGS.**

# **Annexure -B**

## DEENDAYAL PORT TRUST

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

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



**(A) Proposed Mangrove Plantation**

<b>1.</b>	<b>CRZ recommendation outfitting jetty &amp; floating dry Dock at Vadinar by DPA</b>	<b>100 Ha by GEC (work in progress)work order dated 02/06/2022</b>	<b>Rs 50 Lakhs</b>
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# **Annexure -C**

# DEENDAYAL PORT AUTHORITY



Administrative Office Building  
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[www.deendayalport.gov.in](http://www.deendayalport.gov.in)

NO.EG/WK/4751/Part (Marine Ecology Monitoring)/70 Dated : 10/06/2024

To,  
The Gujarat Institute of Desert Ecology,  
P.O.Box No. 83,  
Opp. Changleshwar Temple, Mundra Road,  
Bhuj (Kachchh)- 370 001, Gujarat (India).  
Tel.: 02832-329408, 235025.  
Tele/Fax: 02832-235027

**Email: [desert\\_ecology@yahoo.com](mailto:desert_ecology@yahoo.com)**

Kind Attn.: Dr.V.Vijay Kumar, Director, GUIDE, Bhuj.

**Sub:** Monitoring of Mangrove Plantation 1600 Hectares carried out by DPA (Statutory Requirement) reg.

**Ref.:** 1) DPA request vide letter no. EG/WK/4751/Part (Marine Ecology Monitoring)/23 dated 12/2/2024.  
2) Offer submitted by GUIDE, Bhuj vide letter no. GUIDE/DPA/Offer/ Mang. Plant/13 dated 4/4/2024.

Sir,

Your offer for the subject work submitted vide above referred letter dated 4/4/2024 (**Copy attached - Annexure A**) amounting to Rs. 33,60,000.00 + 18% GST (Rupees Thirty-Three Lakhs and Sixty Thousand only plus eighteen percent GST) with all terms & conditions mentioned in the offer letter, has been accepted by the competent authority in DPA.

## **2. Scope of work :**

Monitoring of Mangrove Plantation (1600 Hectares) carried out by DPA (statutory requirement). The monitoring study will cover components such as density, diversity and abundance. Other variables such as canopy cover, GBH, height, along with the recruitment and regeneration classes will also be investigated. Additionally, carbon sequestration potential of the plantation will also be studied in view of Climate Change mitigation measures.

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**3. The terms of payment:**

- i) 50 % of the project budget should be paid within 15 days from the date of Submission of Inception Report by GUIDE, Bhuj.
- ii) 25% of the project budget should be paid within 15 days from the date of submission of Draft report by GUIDE, Bhuj.
- iii) 25% of the project budget should be paid within 15 days from the date of submission of Final report by GUIDE, Bhuj.

**4. Obligation of DPA :**

- Assistance regarding the statutory clearance from concerned authorities to be rendered by DPA for field visits.
- Study area map along with GPS co-ordinates is to be provided by the DPA.

**5. Time Period:** One year (One time monitoring in a year) i.e. from 10 /6/2024 to 09/6/2025.

**6.** Kindly send the acknowledgement of this work order & start the work immediately.

Thanking you.

Yours faithfully,

  
10/6/24  
Dy. Chief Engineer & EMC (I/c)  
Deendayal Port Authority

# **Annexure -A**



Dr. V. Vijay Kumar  
Director



# Gujarat Institute of Desert Ecology

GUIDE/DPA/Offer/Mang.Plant/ 13 / 2024  
04.04.2024

To

Sh. Rajendraprasad Bethi  
Deputy Chief Engineer & EMC (I/c)  
Deendayal Port Authority  
Administrative Office Building  
Post Box No.50, Gandhidham, Kachchh-370201

Sir,

**Sub.** : Offer for "Regular Monitoring of Mangrove Plantation (1600 Ha) carried out by DPA (Statutory Requirement)" - reg.

**Ref** : Your Letter No. EG/WK/4751/Part (Marine Ecology Monitoring)/ 23. Dt. 12.02.2024

Sir,

We are thankful for considering us to carry out "Regular Monitoring of Mangrove Plantation (1600 Ha) carried out by DPA (on yearly basis)".

In this regard, during 2021-22, we have quoted the budget of Rs. 28,00,000/- for monitoring 1400 Ha. Further, considering the escalation charges in the manpower, transportation, boat charges and suitable Personal Protective Equipment (PPE's) for the team members during the mangrove monitoring, the budget for the same is revised.

Hence, kindly find enclosed herewith our offer to carry out the said study, with a budget of Rs. 33,60,000/ (Rupees Thirty-Three Lakhs Sixty Thousand only) plus GST as applicable for the period 2024-25.

Kindly consider our offer and revert back to us for any further clarifications.

Thanking you,

Sincerely yours

Director  
DIRECTOR

Gujarat Institute of Desert Ecology  
Bhuj - Kachchh.



*Managers (Env)/ Shri. Vinay D. B. EMC*  
*04/04/24*

PO. Box No. 83, Opp. Changleshwar Temple, Mundra Road, Bhuj (Kachchh) - 370 001, Gujarat (India)

Tel : 02832 - 235025-29

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Dr. V. Vijay Kumar  
Director



Gujarat Institute  
of Desert Ecology

**COMMERICAL OFFER**

Consignee address	Our Quotation Ref. No.	Date
Deendayal Port Authority Administrative Office Building Post Box No.50, Gandhidham, Kachchh-370201.	GUIDE/DPA/Offer/MM/ 13 / 2024	04.04.2024

**Kind Attention:** Sh. Rajendraprasad Bethi, Deputy Chief Engineer & EMC (I/c)

**Sub.** : Offer for "Regular Monitoring of Mangrove Plantation (1600 Ha) carried out by DPA (Statutory Requirement)" - Reg.

**Ref.** : Your Letter No. EG/WK/4751/Part (Marine Ecology Monitoring)/ 23. Dt. 12.02.2024

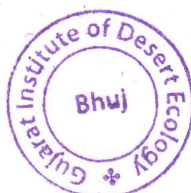
S. No	Service Description	Unit Rate (in Rs./Ha)	Area to be covered (in Ha)	Total Value (in Rs.)
1.	Quotation prepared for conducting Regular Monitoring of Mangrove Plantation (1600 Ha) carried out by DPA (Statutory Requirement)". The monitoring study will cover components such as density, diversity and abundance. Other variables such as canopy cover, GBH, height, along with the recruitment and regeneration classes will also be investigated. Additionally, Carbon sequestration potential of the plantation will also be studied in view of Climate Change mitigation measures. The quote is prepared based on one time monitoring in a year	2,100.00	1600	33,60,000
<b>Total Amount</b>				<b>33,60,000</b>
<b>Amount in words:</b> Rupees Thirty-Three Lakh Sixty Thousand only				
GST extra as applicable				

**GUIDE: Scope of work**

Complying with the conditions imposed by the DPA as per the above-mentioned Letter No. EG/WK/4751/Part (Marine Ecology Monitoring)/ 23. Dt. 12.02.2024

**DPA: Scope of Work**

- Assistance regarding the statutory clearance from concerned authorities to be rendered by DPA for field visits.
- Study area map along with GPS co-ordinated is to be provided by the DPA.

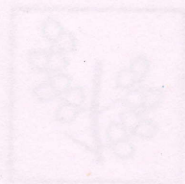


PO. Box No. 83, Opp. Changleshwar Temple, Mundra Road, Bhuj (Kachchh) - 370 001, Gujarat (India)

Tel : 02832 - 235025-29

www.gujaratdesertecology.com, E-mail : desert\_ecology@yahoo.com





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

**Terms and Mode of Payment:**

- 50% of the project budget should be paid within 15 days from the date of Submission of Inception Report.
- 25% of the project budget should be paid within 15 days from the date of submission of Draft report.
- 25% of the project budget should be paid within 15 days from the date of submission of Final report.

**GUIDE's Recognitions / Accreditations:**

- Recognized as SIRO-DSIR, Ministry of Science and Technology, New Delhi.
- Recognized as Schedule I- Environmental Auditors by GPCB, Gandhinagar.

Yours Sincerely,

  
**Director**



**Dr. DIRECTOR**  
**Gujarat Institute of Desert Ecology**  
**Bhuj - Kachchh.**

We are interested in conducting 'Regular Monitoring of Mangrove Ecosystem (1400 Ha) carried out by SIRO-DSIR, Ministry of Science and Technology, New Delhi' - reg. No. EG/WK/475/Par (Monitoring)/ 23. Dt. 22.02.24

In this regard, during 2021-22, we have quoted the budget of Rs. 28,00,000/- for monitoring 1400 Ha. Further, considering the escalation charges in the manpower, transportation, boat charges and suitable Personal Protective Equipment (PPE's) for the team members during the mangrove monitoring, the budget for the same is revised.

Hence, kindly find enclosed herewith our offer to carry out the said study, with a budget of Rs. 33,60,000/- (Rupees Thirty Three Lakh Sixty Thousand only) plus GST as applicable for the period 2024-25.

Kindly consider our offer and revert back to us for any further clarifications.

Thanking you,

Sincerely yours,



**DIRECTOR**  
**Gujarat Institute of Desert Ecology**  
**Bhuj - Kachchh.**



# **Annexure -D**

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

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

**Table 9.1: EMP for Construction Phase**

Sr. no.	Environmental Aspect	Project activity and source of impact /and impact	Mitigation measures and reporting and records check required to be in place	Responsibility	Compliance
1.	Air	<b>Construction of Jetty</b> Emissions from generator sets (NO <sub>x</sub> , SO <sub>2</sub> , hydrocarbons and CO) for operation of barges; <ul style="list-style-type: none"> <li>▪ Emissions from other construction equipment and machinery (cranes, anchored piling barges etc.);</li> <li>▪ Dust emissions from on land vehicular movement (PM);</li> </ul>	Ensuring frequent water sprinkling on roads to reduce dust during vehicular movement on land	Contractor & DPA	• DPA has installed Mist Canon at the Port area to minimize the dust. To control dust pollution, regular sprinkling of water through tankers on roads and other area is being done
2.			Minimization of movement of project vehicles at night and especially during peak hour traffic (9-11 am, 2-3 pm and 5-6 pm)	Contractor & DPA	Point noted. it is relevant to mention here that, for diversion of port-related traffic and transportation, DPA has obtained Environmental & CRZ Clearance from SEIAA, GoG vide letter dated 19/06/2020 for construction of Interchange cum Road Over Bridge. The construction work of ROB is ongoing
3.			Covering Vehicles / Barges with tarpaulin during transportation of construction material to site	Contractor & DPA	In this regard, it is to state that, vehicles are being covered with tarpaulin during transportation of construction material to site.
4.			Ensuring that contractors are maintaining engines and that machinery deployed during construction are complying with emission standards	Contractor & DPA	DPA has included clause in the tender for the Contractor to ensure supply, use and maintenance of all construction plant and equipment for its efficient working. <b>Details submitted along with compliance submitted on 05/05/2023.</b>
5.			The diesel generator (DG) sets will be provided with adequate stack height as per applicable regulations and will use low sulphur diesel in DG sets Regular maintenance of diesel generators engines	Contractor & DPA	DG sets are used only during power failure and vent of sufficient height are provided in line with the guidelines
6.			Regular maintenance of diesel	Contractor & DPA	DPA has included clause in the tender



Sr. no.	Environmental Aspect	Project activity and source of impact /and impact	Mitigation measures and reporting and records check required to be in place	Responsibility	Compliance
			generators engines		for the Contractor to ensure supply, use and maintenance of all construction plant and equipment for its efficient working. <b>Details submitted along with compliance submitted on 05/05/2023.</b>
			Monitoring of stack emissions at intervals as specified in the CFE and its comparison with the emission standards as specified in CFE; and		DPA has been conducting regular Monitoring of environmental parameters since the year 2016. The Environmental Monitoring Reports is enclosed with the EC compliance report
			Regular Ambient air quality monitoring as per conditions stipulated in the CFE		
			<u>Documentation:</u> <ul style="list-style-type: none"> <li>▪ Construction contractor will be required to prepare a Pollution Prevention and Control Plan to address the prevention and control of pollution, including exhaust emissions.</li> <li>▪ Maintain Construction Equipment Maintenance Records.</li> <li>▪ Inspection of Maintenance Records</li> </ul>		DPA has included clause in tender for the Contractor to maintain Construction progress Documentation comprising of Detailed Construction Sequence and Methodology, Daily site records, weekly progress reports, and environmental monitoring report. <b>Details submitted along with compliance submitted on 05/05/2023.</b>
		<b>Capital Dredging</b> <ul style="list-style-type: none"> <li>▪ Emissions from generators Sets (NOx, SO2, hydrocarbons and CO) for operation of dredgers/ rigs;</li> <li>▪ Drilling Rig Engine Emissions</li> </ul>	<ul style="list-style-type: none"> <li>▪ The dredging activities will be performed by the specialist contractors using purpose-built dredgers and under the active supervision of the port operator.</li> <li>▪ Providing adequate stack height of diesel generators for proper dispersion of pollutants;</li> <li>▪ Ensuring diesel generator sets are maintained and low sulphur content diesel is used;</li> <li>▪ Monitoring of stack emissions at intervals as specified in the Consent for Establishment</li> </ul>	Contractor & DPA	Point noted  Dredging activity not yet started

Sr. no.	Environmental Aspect	Project activity and source of impact /and impact	Mitigation measures and reporting and records check required to be in place	Responsibility	Compliance
			<p>(CFE) and its comparison with the emission standards as specified in CFE;</p> <ul style="list-style-type: none"> <li>▪ Ensuring that dredging contractors are maintaining equipment maintenance records; and</li> </ul> <p>Documentation:</p> <ul style="list-style-type: none"> <li>▪ Inspection of condition of contractors dredging equipment before start of work.</li> <li>▪ Inspection of Maintenance Records</li> </ul>		
	Noise	<p><b>Construction of Jetty</b> Hammering during piling activity and noise generated from other construction equipment</p>	<ul style="list-style-type: none"> <li>▪ Regular Ambient Noise Monitoring as per conditions stipulated in the CFE at receptors and construction site.</li> <li>▪ If noise levels are above acceptable limits, adequate measures will be implemented (eg. Use of sound dampening blanket, physical barriers etc.).</li> </ul>	Contractor & DPA	<ul style="list-style-type: none"> <li>• DPA has been conducting regular Monitoring of environmental parameters since the year 2016. The Environmental Monitoring Reports is enclosed with the EC compliance report.</li> </ul>
		<p><b>Capital Dredging</b> Noise generated from equipment's used during Dredging activity (Dredger-Mechanical/Hydraulic, generator, pumps etc.)</p>	<ul style="list-style-type: none"> <li>▪ Avoiding high noise activity during night time;</li> <li>▪ Provide Diesel generators with acoustic enclosure;</li> <li>▪ Use of ear plugs by personnel working onsite in high noise generating areas (above 75 dB (A));</li> <li>▪ Encourage and support the workers to also use ear plugs during day time activities;</li> <li>▪ Use of low speed rotary equipment;</li> <li>▪ Use of high suction performance</li> </ul>	Contractor & DPA	<p>Point Noted.</p> <ul style="list-style-type: none"> <li>• Dredging activity not yet started</li> </ul>

Sr. no.	Environmental Aspect	Project activity and source of impact /and impact	Mitigation measures and reporting and records check required to be in place	Responsibility	Compliance
			<p>pump;</p> <ul style="list-style-type: none"> <li>▪ Use of grease free bearings for all on board equipment;</li> <li>▪ Maintenance of equipment used for dredging.</li> <li>▪ Regular Ambient Noise Monitoring as per conditions stipulated in the CFE.</li> </ul> <p><u>Documentation</u></p> <ul style="list-style-type: none"> <li>▪ Inspection of Maintenance Records</li> <li>▪ Maintain Equipment Maintenance Records</li> </ul>		
	Surface/ Groundwater/ Marine Water	<b>Construction of Jetty</b>	A method statement will be developed for the piling activity.		DPA has included clause in tender/ Concession agreement for the contractor to undertake piling installation in accordance with IS 2911 and maintain record of installation of Piles. <b>Details submitted along with compliance submitted on 05/05/2023.</b>
		<p><b>Capital Dredging</b></p> <ul style="list-style-type: none"> <li>▪ Disturbance of seafloor, the suspension of fine sediments and the re-deposition of coarse fractions causing turbidity in marine water;</li> <li>▪ Siltation and erosion along the coastline resulting in change of coastal morphology; (this was not anticipated as an impact in the chapter 5)</li> <li>▪ Turbidity in Marine water is expected to have an impact on Marine flora and fauna and other ecological issues</li> </ul>	<ul style="list-style-type: none"> <li>▪ Prior to dredging, dredge area co-ordinates will be delineated, climatic conditions will be noted, and condition of equipment etc. will be checked;</li> <li>▪ Use of Sophisticated Dredgers to avoid or minimize scattering of dredge sediments during dredging;</li> <li>▪ Controlled dredging operations during high tidal disturbances;</li> <li>▪ Continuous monitoring of turbidity and suspended sediment concentration;</li> </ul> <p>Regular check on Turbidity Levels &amp; Dissolved Oxygen</p>	Contractor & DPA	<p>Point Noted.</p> <p>Dredging activity not yet started</p>

Sr. no.	Environmental Aspect	Project activity and source of impact /and impact	Mitigation measures and reporting and records check required to be in place	Responsibility	Compliance
			levels;		
	<b>Biological Environment (Terrestrial &amp; Marine)</b>	<b>Construction of Jetty</b> Seabed disturbance due to piling activity, increased turbidity, and impact on benthic habitat.	<ul style="list-style-type: none"> <li>▪ Regular monitoring of Marine Water &amp; Sediment quality;</li> <li>▪ Positioning of jack-up barge primarily in areas where the seabed has recently been dredged, rather than in previously less disturbed areas to avoid unnecessary disturbance to more established benthic habitat.</li> </ul>	Contractor & DPA	<ul style="list-style-type: none"> <li>• DPA has been conducting regular Monitoring of environmental parameters since the year 2016. The Environmental Monitoring Reports is enclosed with the EC compliance report.</li> </ul> <p>Point noted for compliance</p>
		<b>Capital Dredging</b> <ul style="list-style-type: none"> <li>▪ Siltation and erosion during dredging activity</li> <li>▪ Increased in turbidity levels of sea</li> </ul> Impact on fishing activity	<ul style="list-style-type: none"> <li>▪ Use of sophisticated dredgers to avoid or minimize scattering of dredge sediments during dredging;</li> <li>▪ Controlled dredging operations at the time of high tidal disturbances;</li> <li>▪ Check sediment quality for presence of heavy metals;</li> <li>▪ Disposal at approved dumping ground in the sea as per Central Water and Power Research Station (CWPRS).</li> </ul>	Contractor & DPA	<p>Point Noted.</p> <p>Dredging activity not yet started</p> <ul style="list-style-type: none"> <li>• Dredged Material will be disposed of at designated location as identified by the CWPRS, Pune.</li> </ul>
	<b>Land / Soil</b>	<b>Construction of Jetty</b> No impacts being offshore activity	<ul style="list-style-type: none"> <li>▪ --</li> </ul>	--	--
		<b>Capital Dredging</b> No impacts being offshore activity	<ul style="list-style-type: none"> <li>▪ --</li> </ul>	--	--
	<b>Socio-economic and cultural</b>	<b>Construction of Jetty</b> <ul style="list-style-type: none"> <li>▪ Damages to fishing nets</li> <li>▪ Navigational problems to the fishing community</li> <li>▪ Loss of marine species, especially fishes</li> <li>▪ Immigration of construction workforce seeking proper</li> </ul>	<ul style="list-style-type: none"> <li>▪ Being an existing port, the fishing activity is very limited.</li> </ul>	Contractor & DPA	<ul style="list-style-type: none"> <li>• There is no fishing in the proposed project area, being no fishing zone. Kindly refer Point No. 13 of Standard Compliance under Compliance to the Terms of Reference specified in the EIA report. <b>Details submitted along with compliance submitted on 05/05/2023.</b></li> </ul>

Sr. no.	Environmental Aspect	Project activity and source of impact /and impact	Mitigation measures and reporting and records check required to be in place	Responsibility	Compliance
		facility	<ul style="list-style-type: none"> <li>▪ Planned marine traffic management by the port authorities,</li> <li>▪ If there is any loss of fishing net due to the said construction then same to be suitably compensated.</li> <li>▪ Rest rooms with canteen facility and potable water to be provided to construction labour.</li> </ul>		<ul style="list-style-type: none"> <li>• Deendayal Port Authority had already installed and operates the Vessel Traffic Management System in the Gulf of Kachchh.</li> </ul> <p>There is no fishing in the proposed project area, being no fishing zone. Kindly refer Point No. 13 of Standard Compliance under Compliance to the Terms of Reference specified in the EIA report. <b>Details submitted along with compliance submitted on 05/05/2023.</b></p> <ul style="list-style-type: none"> <li>• DPA has included clause in the tender for the contractor to make arrangement for water requirement for labours and also make provisions for the construction labour with necessary infrastructure including canteen facility. <b>Details submitted along with compliance submitted on 05/05/2023.</b></li> </ul>
		<p><b>Capital Dredging</b></p> <ul style="list-style-type: none"> <li>▪ Damages to fishing nets</li> <li>▪ Navigational problems to the fishing community</li> </ul> <p>Loss of marine species, especially fishes</p>	<ul style="list-style-type: none"> <li>▪ Prior to dredging, dredge area co-ordinates will be delineated, climatic conditions will be noted, and condition of equipment etc. will be checked;</li> <li>▪ Controlled Dredging operations during at the time of hightidal disturbances;</li> <li>▪ Any damages to nets and equipment would be promptly compensated after a fair negotiation;</li> <li>▪ Any disruption of fishing movement will need to be communicated in a timely manner, and minimized</li> </ul>	Contractor & DPA	<p>Point Noted.</p> <ul style="list-style-type: none"> <li>• Dredging activity not yet started</li> </ul>

Sr. no.	Environmental Aspect	Project activity and source of impact /and impact	Mitigation measures and reporting and records check required to be in place	Responsibility	Compliance
			<ul style="list-style-type: none"> <li>during peak fishing season;</li> <li>▪ The process of dredging and dumping to be taken by experienced personnel and should be carefully done to minimize impact on marine ecology;</li> <li>▪ Regular monitoring of Marine Water and Sediment Quality especially for heavy metals for taking necessary corrective measures if significant changes are observed;</li> <li>▪ Constant check on Turbidity Levels &amp; Dissolved Oxygen levels;</li> </ul>		

#### 9.4 Environmental Management Plan during Operation Phase

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

**Table 9.2 : EMP for operation Phase**

Sr. no	Environmental Aspect	Project activity and source of impact /and impact	Mitigation measures and reporting and records check required to be in place	Responsibility	Compliance
	<b>Air</b>	<b>Maintenance Dredging</b> <ul style="list-style-type: none"> <li>▪ Emissions from generator sets (NO<sub>x</sub>, SO<sub>2</sub>, hydrocarbons and CO) for operation of dredgers/rigs;</li> <li>▪ Drilling Rig Engine Emissions;</li> </ul>	<ul style="list-style-type: none"> <li>▪ Providing adequate stack height of diesel generators for proper dispersion of pollutants in compliance with CPCB standards;</li> <li>▪ Use of Low sulphur diesel in DG sets;</li> <li>▪ Regular maintenance of diesel generators engines;</li> <li>▪ Monitoring of stack emissions at regular intervals as specified in Consent for Operation (CFO) and its comparison with the emission standards as specified in CFO;</li> <li>▪ Regular Ambient air quality monitoring as per conditions stipulated in the CFO.</li> <li>▪ Follow Dredging Management Plan;</li> </ul> <u>Documentation:</u> <ul style="list-style-type: none"> <li>▪ Inspection of condition of contractors dredging equipment;</li> </ul>	Dredging Contract and DPA	Point noted. Construction phase ongoing for Oil Jetty No. 8. No activity started yet for Oil jetty 9,10,11

			<ul style="list-style-type: none"> <li>▪ Inspection of Maintenance Records</li> <li>▪ Same as followed for Capital Dredging during construction phase Please refer to Table 9.1.</li> </ul>	Dredging Contract orand DPA	Point noted. Construction phase ongoing for Oil Jetty No. 8 No activity started yet for Oil jetty 9,10,11
<b>Surface/ Ground water /Marine Water</b>	<b>Maintenance Dredging</b> Turbidity in marine water is expected to have an impact on Marine fauna	<ul style="list-style-type: none"> <li>▪ Same as for Capital Dredging.</li> <li>▪ Use of sophisticated dredgers to avoid or minimize scattering of dredge sediments during dredging;</li> <li>▪ Controlled dredging operations during high tidal disturbances;</li> <li>▪ No open discharge of oily wastes in marine waters;</li> <li>▪ Constant check on Turbidity Levels &amp; Dissolved Oxygen levels;</li> <li>▪ Inspection of Analysis Records.</li> </ul> <p><b><u>Documentation</u></b></p> <ul style="list-style-type: none"> <li>▪ Wastewater Monitoring as per Monitoring Plan</li> <li>▪ Inspection of Monitoring Records</li> </ul>	Dredging Contract orand DPA	Point noted. Construction phase ongoing for Oil Jetty No. 8 No activity started yet for Oil jetty 9,10,11	
<b>Socio-Cultural</b>	<b>Maintenance Dredging</b> <ul style="list-style-type: none"> <li>▪ Damages to fishing nets</li> <li>▪ Navigational problems to the fishing community</li> <li>▪ Loss of marine species.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Planned marine traffic management by the port authorities, and if any loss of fishing net occurs due to the dredging activity, then same to be suitable compensated.</li> <li>▪ Dredging Plan to be followed</li> </ul>	Dredging Contract or, DPA	Point noted. Construction phase ongoing for Oil Jetty No. 8  No activity started yet for Oil jetty 9,10,11	

# **Annexure -E**



**CSR Works for the year 2018-19**

<b><u>Sr. No</u></b>	<b><u>Activity/Work</u></b>	<b><u>Approved Cost (In lakhs)</u></b>
1.	CSR work to Donate 100 Nos of Computers to Daughters of Martyred Soldiers in the country under the "BETI BACHAO BETI PADHAO" program by Atharva Foundation, Mumbai	24.00
2.	CSR work to Donate ONE (40 Seater) School Bus for Deaf Children Students for the Institute of Mata Lachmi Rotary Society, Adipur	18.00
3.	CSR work to Providing One R.O Plant with Cooler at Panchyat Prathmik Sala, Galpadar Village for the ANARDE Foundation, Kandla & Gandhidham Center.	1.50
4.	CSR work for Providing Drainage Line at Meghpar Borichi village, Anjar Taluka.	25.00
5.	CSR work for Construction of Health Centre at Kidana Village	13.00
6.	CSR work to provide 4 Nos. of Big Dust Bin for Mithi Rohar Juth Gram Panchayat.	3.40
7.	CSR work for Renovation & construction of shed at Charan Samaj, Gandhidham –Adipur.	10.00
8.	CSR Work for Renovation/Repairing of Ceiling of School Building at A. P Vidhyalay, Kandla.	10.00
9.	CSR work for Construction of Over Head Tank & Providing 10 Nos of Computers (for students) of Navjivan Viklang Sevashray, Bhachau, Kutch	9.50
10.	CSR work to Provide Books & Tuition fees for Educational facilities to weaker section children of Valmiki Samaj, Kutch.	2.00
11.	CSR work to provide Water Purifier & Cooler for the ST. Joseph's Hospital, Gandhidham	1.50
12.	CSR work for Construction of Second Floor (Phase – I) for Training Centre of "Garbh Sanskran Kendra" "Samarth Bharat Abhiyan" of Kutch KalyanSangh, Gandhidham	37.00
	<b>Total Approved Work Amount:</b>	154.90 Lakh

**CSR Works for the year 2019-20**

<b><u>Sr. No</u></b>	<b><u>Name of Scheme</u></b>	<b><u>Approved Cost (Rs. In Lakhs)</u></b>
1.	CSR activities for Providing Drainage line at Nani Nagalpar village.	3.00
2.	CSR activities for Development of ANGANWADI Building at School no- 12 at Ward no 3 & 6 at Anjar.	7.00
3.	CSR activities for Improving the facilities of Garden at Sapna Nagar(NU-4) & (NU-10 B), Gandhidham.	18.00
4.	CSR activities for development of School premises of Shri Guru Nanak Edu. Society, Gim.	30.00
5.	CSR activities for the improvement of the facilities at St JOSEPH Hospital & Shantisadan at Gandhidham	20.00
6.	Consideration of Expenditure for running of St Ann's High School at Vadinar of last five years 2014 to 2019 under CSR.	825.00
7.	CSR activities for development of school premises of Shri Adipur Group Kanya Sala no-1 at Adipur	6.50
8.	CSR activities for development of school premises of Shri Jagjivan Nagar Panchyat Prathmiksala, Gandhidham.	16.50
9.	CSR activities for development of school premises of Ganeshnagar Government high school, Gandhidham.	9.00
10.	CSR activities for improving greenery, increase carbon sequestration and beat Pollution at Kandla, DPT reg.	352.32
11.	CSR activities for providing infrastructures facilities at "Bhiratna Sarmas Kanya Chhatralaya" under the Trust of SamajNav- Nirman at Mirjapur highway, Ta Bhuj.	46.50
	<b>Total Approved Work Amount:</b>	1333.82 Lakh

**CSR Works for the year 2020-21**

<b><u>Sr. No</u></b>	<b><u>Name of Scheme</u></b>	<b><u>Approved Cost (Rs. In Lakhs)</u></b>
1.	CSR Proposal for earmarking of 15% Funds for National Maritime Heritage Complex, Lothal, Gujarat (NMHC) from allocated CSR Fund of Rs 3.46 Cr	51.90
2.	PM Care Fund	800.00
3.	Other COVID related exp.	188.00
	<b>Total Approved Work Amount:</b>	1039.90 Lakh

**CSR Works for the year 2021-22**

<b><u>Sr. No</u></b>	<b><u>Name of Scheme</u></b>	<b><u>Approved Cost (Rs. In Lakhs)</u></b>
1.	CSR Activities for providing Water supply pipe line for drinking water facilities for poor people & Fishermen at VANDI Village.	20
2.	CSR activities for providing facilities in Girls Hostel of Kasturba Gandhi Balika Vidhyalay, Gandhidham.	30
3.	CSR works for Construction of Auditorium Hall at RSETI (Rural Self Employment Training Institute) at Bhujodi-Bhuj.	16
4.	CSR works for the providing of SOLAR POWER SYSTEM and other facilities for Othe JEEV SEVA SAMITI at Gandhidham.	9.3
5.	CSR Activities for providing HD projector for KANYA MAHA VIDYALAYA, Adipur	1.5
6.	CSR works for Construction of New Building for Setting up of skill development centre at Rajkot (Sewa Gujarat).	250
7.	CSR Works for Ladies Environment Action Foundation (LEAF) Trust for providing infrastructure to the primary school at Gandhinagar District	46.5
8.	CSR works lor Providing of Furniture for the School "Shri Galpadar Panchayat Prathmic Kumar group Sala" at Galpadar village, Taluka: Gim	5
	<b>Total Approved Work Amount:</b>	378.30 Lakh

**CSR Works for the year 2022-23**

<b><u>Sr. No</u></b>	<b><u>Name of Scheme</u></b>	<b><u>Approved Cost (Rs. In Lakhs)</u></b>
1.	CSR work for providing One Bore hole with construction one room along with Motor pump at Village MOTI NAGALPAR, Anjar.	18.00
2.	CSR work for Construction of Shamashan bhoomi (Crematorium) at Gandhidham.	49.50
3.	CSR work for providing metallic sheet DOME in Community Hall at Old Sunderpuri for Shri Juni Sundarpuri Maheshwari Samaj at Gandhidham.	15.00
4.	CSR Activities for construction of Samajwadi at village: Rampar, Taluka: Anjar.	15.00
5.	Financial assistance under CSR for providing basic facilities at Gandhidham GSRTC bus station.	25.00
6.	CSR Activities for construction of School Building for physically disabled, deaf & mute children, Shri & Shrimati Chhaganlal Shyamjibhai Virani Behera Munga Shala Trust, Virani Deaf School at Rajkot.	5.00

7.	CSR work for construction of new Administrative staff block for the Maitri Maha Vidhyalaya, Adipur.	80.10
8.	Financial support under CSR for providing 60 seater school bus for "Aadhaar Sankul", Manav Seva Trust, Gandhidham.	25.00
9.	Financial assistance under CSR for Rooftop Solar System & Afforestation under clean energy & sustainable development in 10 villages around DPA	63.72
10.	CSR works for Shree Kachchh Mahila Kalyan Kendra, Bhuj-Kutch	55.00
11.	CSR works for Installation of 125 no. Sanitary Pad Vending Machines at Women Hostels, NGOs etc, in Kutch District.	15.00
12.	CSR Fund for Vadinar Village & surrounding	128.54
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14.	CSR request for Allotment of fund for construction of Community hall at Adipur.	25.00
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25.	CSR Request for fund Under CSR for Railway institute, Gandhidham, Western Railway	5.00
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28.	CSR Funds for support for Procurement of kitchen Equipment & machineries to Serve Mid-day meals to Govt. School children in Bhuj-Kutch	55.31
29.	CSR support for the Junagadh Hospital Project under the CSR Initiatives	30.24
30.	CSR Request for financial Assistance on menstrual Hygiene for girls, Assam-TIPKAI	20.00
31.	CSR Request received from Anjar Education Society to the Extent of Rs 35 Lakhs for Installation of 75 KVA Capacity Solar power system.	35.00
	<b>Total Approved Work Amount:</b>	1118.42 Lakh

# **Annexure -F**

**Environmental Monitoring Annual Report**  
**prepared under**  
**“Preparing and monitoring of environmental monitoring and management plan for Deendayal Port Authority at Kandla and Vadinar for a period of 3 years”**

**Monitoring Period: April 2023 - March 2024**



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

**Submitted to:**  
**Deendayal Port Authority (DPA), Kandla**



**Gujarat Environment Management Institute (GEMI)**

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



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## About this Document

Gujarat Environment Management Institute (GEMI) has been assigned with the work of “Preparing and monitoring of Environmental monitoring and Management plan for Deendayal Port Authority (DPA) at Kandla and Vadinar for a period of 3 years” by DPA, Kandla. Under the said project the report titled “*Environment Monitoring Annual Report (Monitoring Period: April 2023 - March 2024)*” is prepared.

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



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## List of Abbreviations

A	Acceptable Limits as per IS: 10500:2012
AAQ	Ambient Air Quality
AWS	Automatic Weather monitoring stations
BIS	Bureau of Indian Standards
BOD	Biochemical Oxygen Demand
BQL	Below Quantification Limit
CCA	Consolidated Consent & Authorization
CO	Carbon Monoxide
COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
DO	Dissolved Oxygen
DPA	Deendayal Port Authority
EC	Electrical Conductivity
EMMP	Environmental monitoring and Management Plan
EMP	Environment Management Plan
FPS	Fine Particulate Sampler
FY	Financial Year
GEMI	Gujarat Environment Management Institute
IFFCO	Indian Farmers Fertiliser Cooperative Limited
IMD	India Meteorological Department
IOCL	Indian Oil Corporation Limited
LNG	Liquefied Natural Gas
MGO	Marine Gas Oil
MMTPA	Million Metric Tonnes Per Annum
MoEF	Ministry of Environment & Forests
MoEF&CC	Ministry of Environment, Forest and Climate Change
NAAQS	National Ambient Air Quality Standards
NO <sub>x</sub>	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 <sub>x</sub>	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 31<sup>st</sup> March 2016, Deendayal Port created history by handling 100 MMT cargo in a year and became the first Major Port to achieve this milestone. Deendayal Port Authority (DPA), India's busiest major port in recent years, is gearing up to add substantial cargo handling capacity with private sector participation. DPA has created new record by handling 137 MMTPA (at Kandla and Vadinar) during the financial year 2022-23. The DPA had commissioned the Off-shore Oil Terminal facilities at Vadinar in the year 1978, for which M/s. Indian Oil Corporation Limited (IOCL) provided Single Bouy Mooring (SBM) system, with a capacity of 54 MMTPA. Further, significant Quantum of infrastructural upgradation has been carried out & excellent maritime infrastructure has been created at Vadinar for the 32 MMTPA Essar Oil Refinery in Jamnagar District.

## 1.2 Green Ports Initiative

DPA is committed to sustainable development and adequate measures are being taken to maintain the Environmental well-being of the Port and its surrounding environs. Weighing in the environmental perspective for sustained growth, the Ministry of Shipping had started, Project Green Ports" which will help in making the Major Ports across India cleaner and greener. "Project Green Ports" will have two verticals - one is "Green Ports Initiatives" related to environmental issues and second is "Swachh Bharat Abhiyaan".

The Green Port Initiatives include twelve initiatives such as preparation and monitoring plan, acquiring equipment required for monitoring environmental pollution, acquiring dust suppression system, setting up of sewage/waste water treatment plants/ garbage disposal plant, setting up Green Cover area, projects for energy generation from renewable energy sources, completion of shortfalls of Oil Spill Response (OSR) facilities (Tier-I), prohibition of disposal of almost all kind of garbage at sea, improving the quality of harbour wastes etc.

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

## 1.3 Importance of Environmental monitoring and management plan (EMMP)

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

1. Air pollutant emissions due to ship emissions, loading and unloading activities, construction emission and emissions due to vehicular movement.



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

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

It identifies the principles, approach, procedures and methods that will be used to control and minimize the environmental and social impacts of operational activities associated with the port. An EMP is a required part of environmental impact assessment of a new port project but could also be evolved for existing ports. It is useful not only during the construction and operational phases of the new port but also for operation of existing ports to ensure the effectiveness of the mitigation measures implemented and to further provide guidance as to the most appropriate way of dealing with any unforeseen impacts.

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

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

This document presents the Environmental Monitoring Report (EMR) for Kandla and Vadinar for the environmental monitoring done during the period from April 2023-March 2024.

#### 1.4 Objectives and scope of the Study

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

The scope of work includes not limited to following:

1. To review the locations/stations of Ambient Air, Ambient Noise, drinking water, and Marine Water, Soil and Sediments monitoring within the impacted region in-and-around DPA establishment, in view of the developmental projects.
2. To assess the Ambient Air quality, quality at 6 stations at Kandla and 2 at Vadinar in terms of gases and particulate matter.
3. To assess the DG stack emissions (gases and particulate matter).
4. To assess Drinking water quality at twenty locations (18 at Kandla and 2 at Vadinar) in terms of Physical, Chemical and Biological parameters viz., Color, Odor, turbidity, conductivity, pH, Total Dissolved Solids, chlorides, Hardness, total iron, sulphate,  $\text{NH}_4$ ,  $\text{PO}_4$ , and bacterial count on a monthly basis.
5. To assess the Marine water quality in terms of aquatic Flora and Fauna and Sediment quality in terms of benthic flora and fauna.
6. To assess Marine Water Quality and sediment in term of physical and chemical parameter.
7. To assess the trends of water quality in terms of Marine ecology by comparing the data collected over a specified time period.
8. Weekly sample collection and analysis of inlet & Outlet points of the Sewage Treatment Plant (STP) to check the water quality being discharged by DPA as per the CC&A.
9. Carrying out monthly Noise monitoring; twice a day at the representative stations for a period of 24 hours.
10. Meteorological parameters are very important from air pollution point of view, hence precise and continuous data collection is of utmost importance. Meteorological data on wind speed, wind direction, temperature, relative humidity, solar radiation and rainfall shall be collected from one permanent station at DPA, Kandla and one permanent station at Vadinar.
11. To suggest mitigation measures, based on the findings of this study and also check compliance with Environmental quality standards, Green Port Initiatives, MIV 2030, and any applicable Statutory Compliance.
12. To recommend Environment Management Plans based on Monitoring programme and findings of the study.



## **CHAPTER 2: METHODOLOGY**

## 2.1 Study Area

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

### a. Kandla

Deendayal Port (Erstwhile Kandla Port) is one of the twelve major ports in India and is located on the West Coast of India, in the Gulf of Kutch at 23001'N and 70013'E in Gujarat. The Major Port Authorities Act 2021 is the governing statute for Administration of Major Ports, under which, Deendayal Port Trust (DPT) has become Deendayal Port Authority (DPA). At Kandla, DPA has sixteen (16) cargo berths for handling various types of Dry Bulk Cargo viz, fertilizer, food grains, Coal, sulphur, etc.

- **Climatic conditions of Kandla**

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

### b. Vadinar

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

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

- **Climatic conditions of Vadinar**

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

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



SS



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:



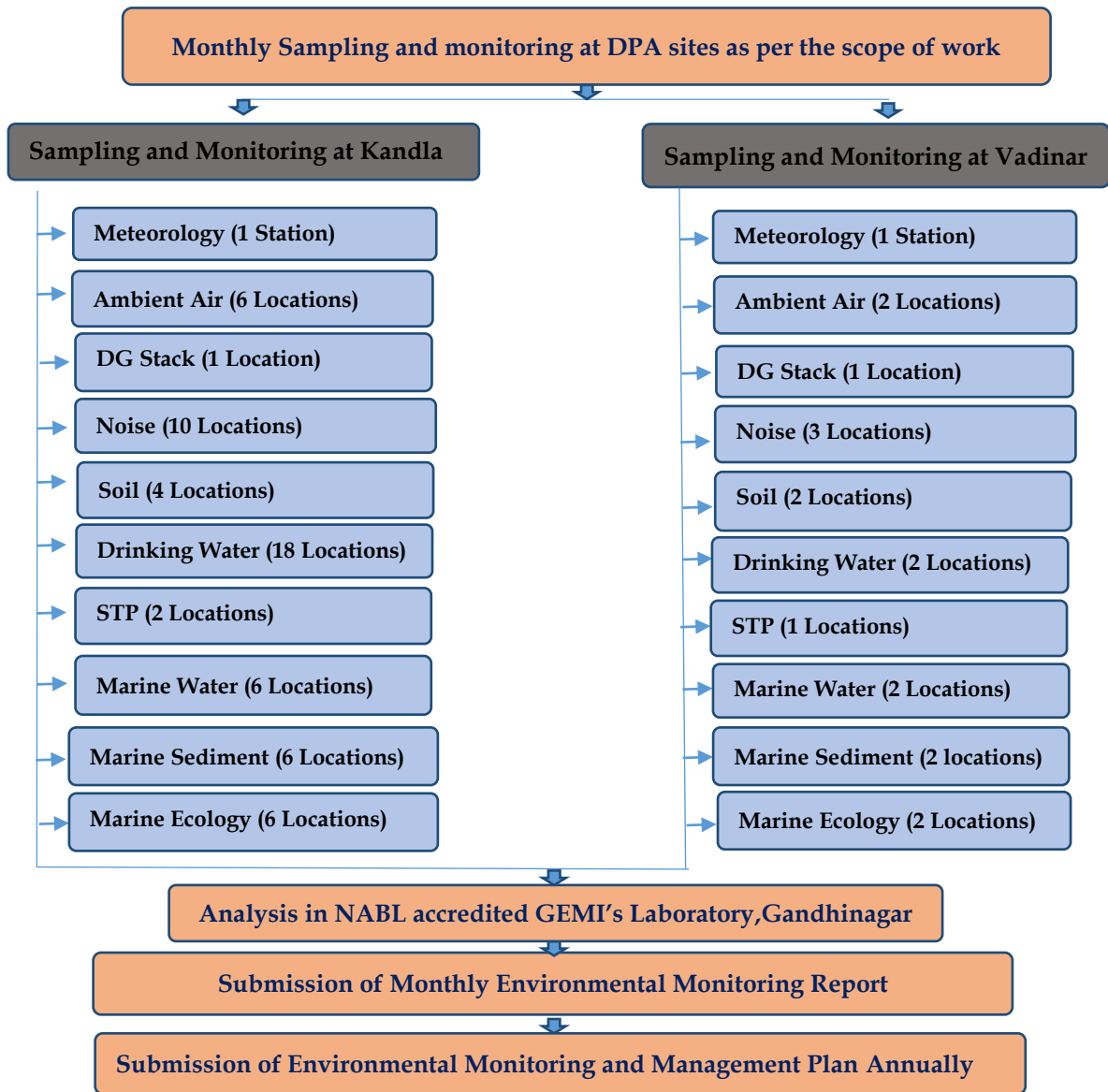


Figure 1: Methodology flow chart

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	of Instrument	Frequency
1.	Wind Direction	degree	Automatic Weather Monitoring Station (Envirotech WM280)	Hourly Average
2.	Wind Speed	Km/hr		
3.	Rainfall	mm/hr		
4.	Relative Humidity	% RH		
5.	Temperature	°C		
6.	Solar Radiation	W/m <sup>2</sup>		

#### Monitoring Frequency:

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



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

### 3.2 Results and discussion

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

**Table 3: Meteorological data for Kandla and Vadinar**

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



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

### 3.3 Data Interpretation and Conclusion

#### 1) Kandla:

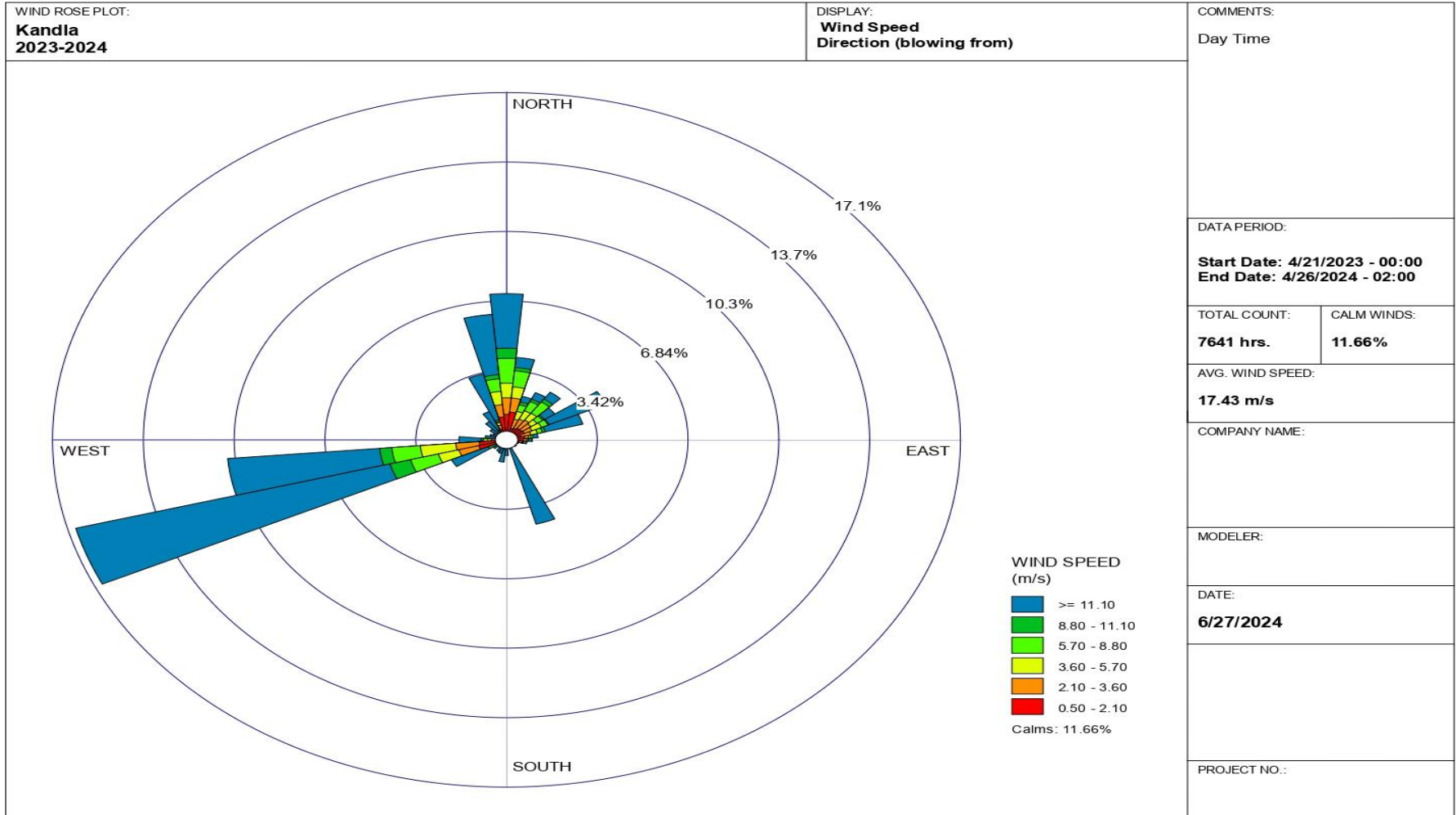
- a. The ambient temperature for the summer season varies in the range of **21.68** to **48.44** °C; in the monsoon season, the temperature varies between **29.32** and **33.38** °C; and in the winter season, the temperature varies between **21.68** and **31.24** °C. The yearly average temperature at Kandla is observed to be around **29.217** °C, with a standard deviation of 4.31.
- b. The relative humidity for the summer season was recorded in the range of **30.59%** to **76.32%**; in the monsoon season, relative humidity was recorded in the range of **66.85%** to **84.57%**; and in the winter season, relative humidity was recorded in the range of **49.02** to **59.69%**; the yearly average humidity at Kandla was **61.75%** with a standard deviation of **10.635**.
- c. The maximum rainfall at Kandla was observed at **21.89** mm for the monitoring period of August to September 2023; the yearly average rainfall was found to be **3.72** mm.
- d. Wind speed and direction play a significant role in transporting pollutants and thus determining the air quality. In the summer season, wind blew from the North and North North West directions; in the monsoon season, wind blew from the West South West; and in the winter season, wind blew from the North direction.
- e. The wind speed recorded ranges from **0.025** to **48.85** km/h in the summer season; in the monsoon season, the wind speed recorded ranges from **0.16** to **37.52** km/h; and in the winter season, the wind speed recorded ranges from **0** to **15.75** km/h. The yearly average wind speed at Kandla is **5.77** km/h, with a standard deviation of 3.55.
- f. The **maximum** solar radiation at Kandla was observed at **105.42** W/m<sup>2</sup> during the monitoring period **April to May 2023**; the **minimum** solar radiation at Kandla was observed at **54.28** W/m<sup>2</sup> for the monitoring period **November to December 2023**; **and** the yearly **average** solar radiation was found to be **73.445** W/m<sup>2</sup> with a standard deviation of 15.19.

#### Wind rose diagram:

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

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





WRPLOT View - Lakes Environmental Software



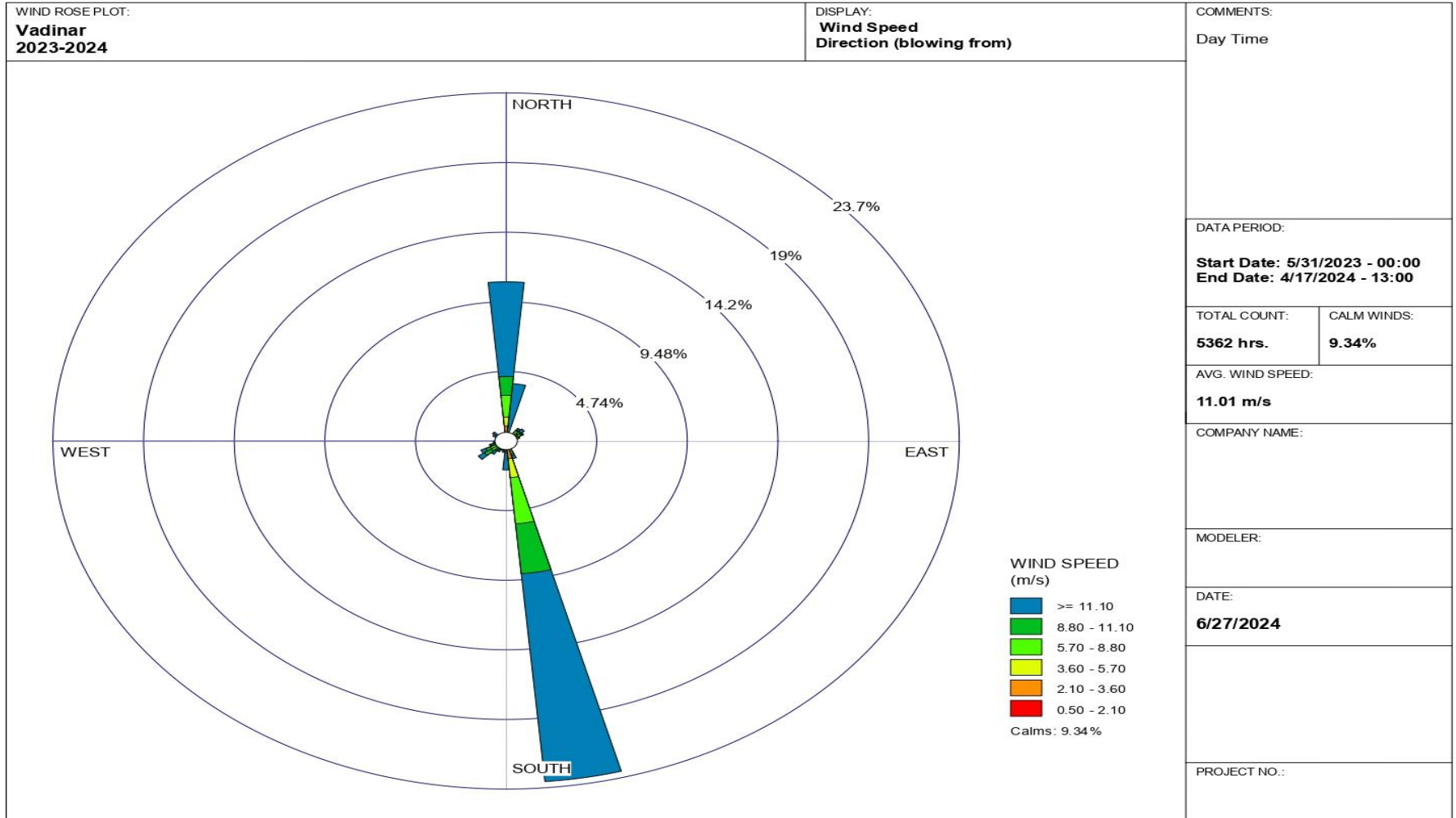
## 2) Vadinar:

- a. The ambient temperature for the summer season varies between **23.6** and **29.96** °C; in the monsoon season, it varies between **27.18** and **28.62** °C; and in the winter season, it varies between **22.14** and **27.89** °C. The yearly average temperature at Vadinar is **2.347** °C with standard deviation of **2.4**.
- b. The relative humidity for the summer season was recorded in the range of **57.41**% to **82.36**%; in the monsoon season, relative humidity was recorded in the range of **72.87**% to **79.51**%; and in the winter season, relative humidity was recorded in the range of **59.25**% to **65.66**%; the yearly average humidity at Vadinar was **68.7**% with a standard deviation of 6.38.
- c. The **maximum** rainfall at Vadinar was observed at **0.27** mm for the monitoring period from **June to July 2023**; the yearly **average** rainfall was found to be **0.08** mm.
- d. In Summer Season wind blew from South Direction, in Monsoon season wind blew from South and in Winter Season wind blew from South and South West direction. The recorded wind speed ranges from **0.31** to **34.08** km/hr in the summer season, **4.64** to **31.69** km/hr, and in the monsoon season, the recorded wind speed ranges from **1** to **19.37** km/hr. The yearly average wind speed at Vadinar is 9.014 km/h with a standard deviation of **4.49**.
- e. The maximum solar radiation at Vadinar was observed at **114.77** W/m<sup>2</sup> for the monitoring period April to May 2024; the minimum solar radiation at Vadinar was observed at **60.86** W/m<sup>2</sup> for the monitoring period July to August 2023; and the yearly average solar radiation was found to be **88.182** W/m<sup>2</sup>.

### Wind rose diagram:

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

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



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## **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<sup>(1)</sup>.

##### 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



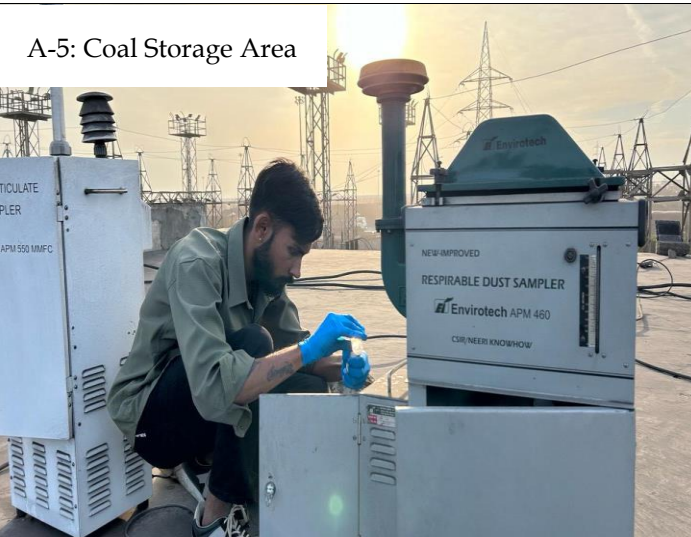
A-3: Kandla Port Colony



A-4: Marine Bhavan



A-5: Coal Storage Area



A-6: Gopalpuri Hospital





### Vadinar

A-7: Admin Building



A-8: Vadinar Colony

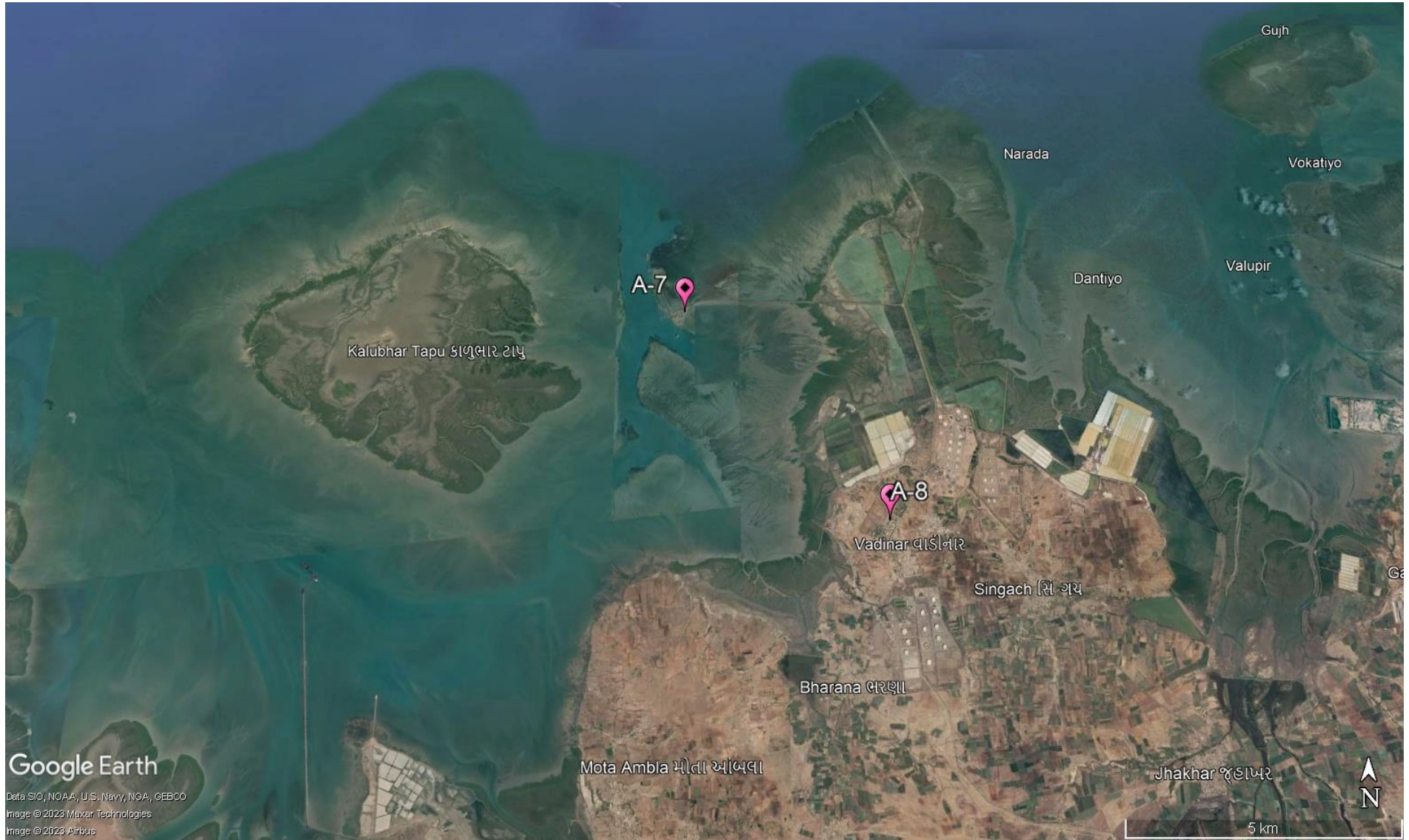






Map 4: Ambient Air Monitoring locations at Kandla





Map 5: Ambient Air Monitoring locations at Vadinar



## Monitoring Frequency

The sampling for Particulate matter, i.e., PM<sub>10</sub> and PM<sub>2.5</sub>, and gaseous components like SO<sub>x</sub>, NO<sub>x</sub>, and CO, as well as the total VOCs, was monitored twice a week for a period of 24 hours a day. Whereas, the sampling for the components of PAH, benzene, and non-methane VOCs was conducted on a monthly basis. The monitoring period for this study is from April 15, 2023, to April 15, 2024. During this period, 95 air samples were taken from six locations in Kandla, and 97 samples were taken from two locations in Vadinar.

## Sampling and Analysis

The Sampling of the Ambient Air Quality parameters and analysis is conducted as per the CPCB guidelines of National Ambient Air Quality Monitoring. The sampling was performed at a height of 3.5 m (approximately) from the ground level. For the sampling of PM<sub>10</sub>, 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<sub>x</sub> and NO<sub>x</sub>. The Fine Particulate Sampler for collection of PM<sub>2.5</sub> 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<sub>2</sub> 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<sub>x</sub> 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<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>x</sub> and NO<sub>x</sub> 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 <sub>10</sub>	µg/m <sup>3</sup>	IS 5182 (Part 23): 2006	Respirable Dust Sampler (RDS) conforming to IS:5182 (Part-23): 2006	Twice in a week
2.	PM <sub>2.5</sub>	µg/m <sup>3</sup>	IS:5182 (Part:24):2019	Fine Particulate Sampler (FPS) conforming to IS:5182 (Part-24): 2019	
3.	Sulphur Dioxide (SO <sub>x</sub> )	µg/m <sup>3</sup>	IS 5182 (Part:2): 2001	Gaseous Attachment conforming to IS:5182 Part-2	
4.	Oxides of Nitrogen (NO <sub>x</sub> )	µg/m <sup>3</sup>	IS:5182 (Part-6): 2006	Gaseous Attachment conforming to IS:5182 Part-6	
5.	Carbon Monoxide (CO)	mg/m <sup>3</sup>	GEMI/SOP/AAQM/11; Issue no 01, Date 17.01.2019: 2019	Sensor based Instrument	
6.	VOC	µg/m <sup>3</sup>	IS 5182 (Part 17): 2004	Low Flow Air Sampler	
8.	PAH	µg/m <sup>3</sup>	IS: 5182 (Part 12): 2004	Respirable Dust Sampler (RDS) conforming to IS:5182 (Part-12): 2004	Monthly
7.	Benzene	µg/m <sup>3</sup>	IS 5182 (Part 11): 2006 RA: 2017	Low Flow Air Sampler	
9.	Non-methane VOC	µg/m <sup>3</sup>	IS 5182 (Part 11): 2006	Low Volume Sampler	

## 4.2 Result and Discussion

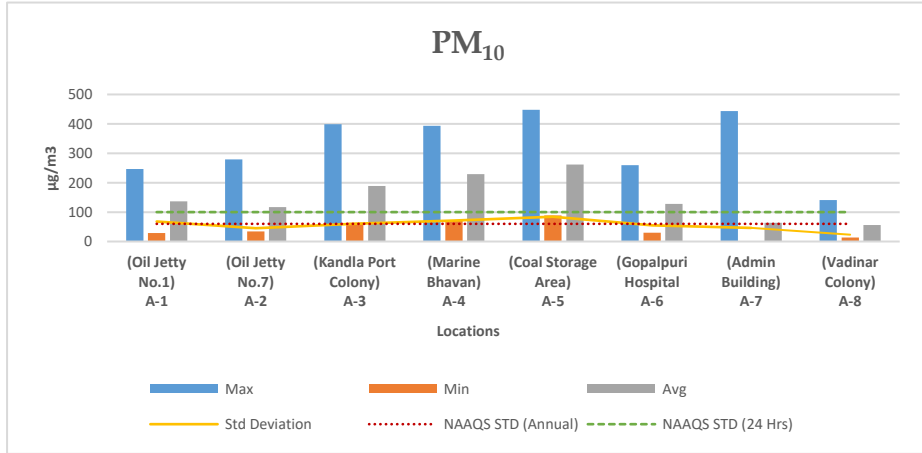
The summarized results of ambient air quality monitoring for the study period are presented in **Table-6 to 9** along with the graphical representation from **Graph 1 to Graph 6**. Various parameters monitored during the study have been presented by their maximum, minimum, average and Standard deviation.



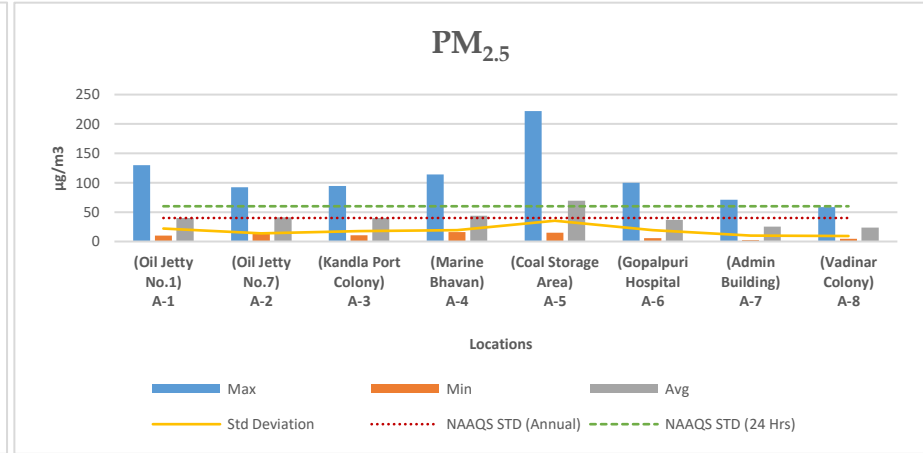
Table 6: Summarized results of PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub>, NO<sub>x</sub>, VOC and CO for Ambient Air quality monitoring

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

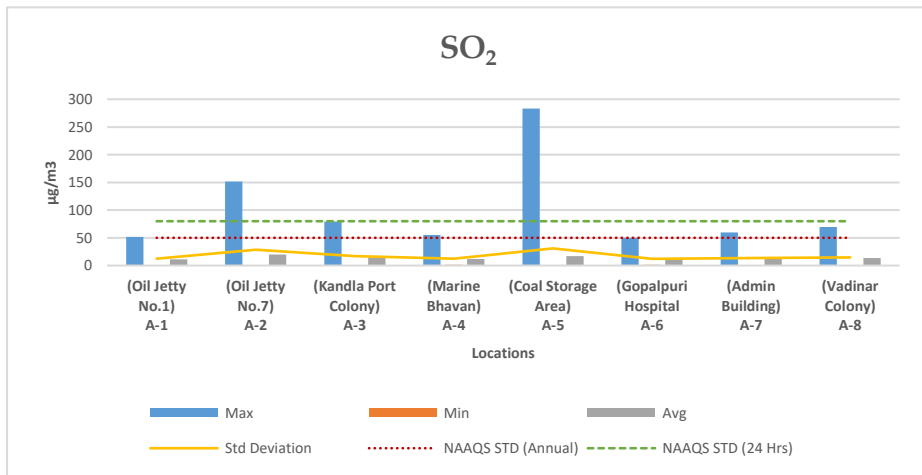
Graphs 1-6 shows spatial trend of ambient air parameter at all the eight-monitoring location (six at Kandla and 2 at Vadinar)



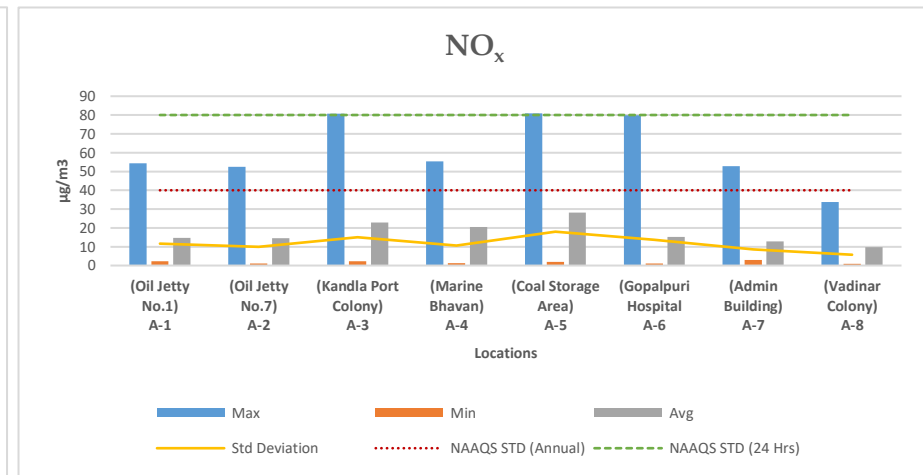
Graph 1 Spatial trend in Ambient PM<sub>10</sub> Concentration



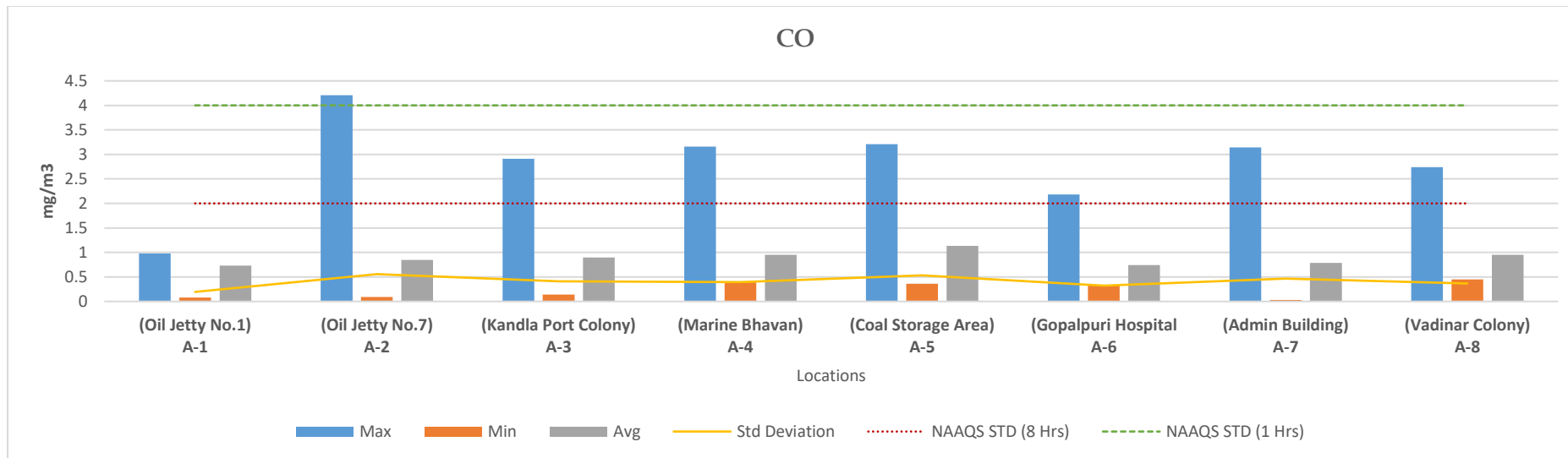
Graph 2 Spatial trend in Ambient PM<sub>2.5</sub> Concentration



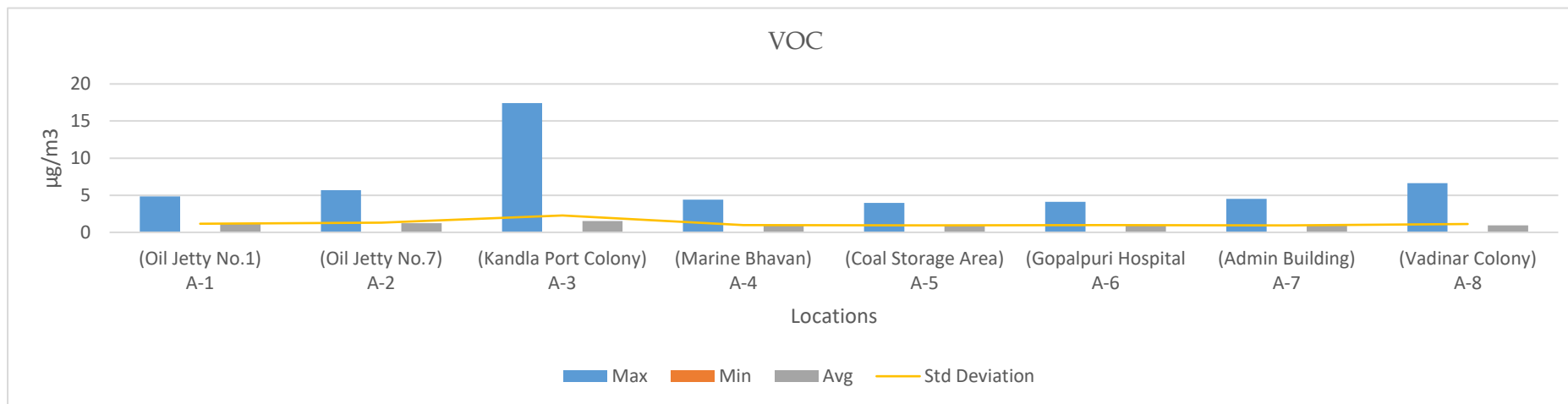
Graph 3 Spatial trend in Ambient SO<sub>x</sub> Concentration



Graph 4 Spatial trend in Ambient NO<sub>x</sub> 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**

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

**Table 8: Summarized results of Polycyclic Aromatic Hydrocarbons**

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



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

Table 9: Summarized results of Non-methane VOC

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

### 4.3 Data Interpretation and Conclusion

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

#### 1) Kandla:

##### Particulate matter:

- The concentration of PM<sub>10</sub> varies very widely and is reported in the range of **28.68** to **448.12** µg/m<sup>3</sup>, with a yearly average value of **176.83** with standard deviation **64.185** µg/m<sup>3</sup>. As shown in Graph 1, the highest concentration (value) of PM<sub>10</sub> is reported at location A-5 (coal storage area) during the winter. It can be seen that PM<sub>10</sub> exceeds the NAAQS annual limit, i.e., 60 µg/m<sup>3</sup>, in all locations. It can be seen that location A-5 (coal storage area) had the maximum percentage exceedance, and location A-1 (oil jetty No. 1) had the minimum percentage exceedance while comparing with the NAAQS 24-hour limit, i.e., 100 µg/m<sup>3</sup>.
- The concentration of PM<sub>2.5</sub> varies in the range of 5.51 to 221.9 µg/m<sup>3</sup>, with a yearly average value of 45.35 with standard deviation 21.16 µg/m<sup>3</sup>. As shown in Graph 2, the highest concentration of PM<sub>2.5</sub> is at location A-5 (the coal storage area) in winter. It can be seen that PM<sub>2.5</sub> exceeds the NAAQS annual limit, i.e., 40 µg/m<sup>3</sup>, on five locations, and location A-6, i.e., Gopalpuri hospital, falls within the NAAQS annual limit. It can be seen that location A-5 (coal storage area) had the maximum percentage exceedance, and location A-6 (Gopalpuri hospital) had the minimum percentage exceedance while comparing with the NAAQS 24-hour limit, i.e., 60 µg/m<sup>3</sup>.
- The highest concentration of Particulate matter at locations **A-5, (the coal storage area)**, could be attributed to the presence of heavy vehicular traffic in upwind areas, which have a higher impact, causing the dispersion of emitted particulate matter in the ambient air. The activities observed in the surrounding such as The unloading of coal directly into the truck using grabs, construction in the vicinity causes the dust to disperse in the air as well as coal dust to fall and settle on the ground. This settled coal dust again mixes with the air while trucks travel through it. Also, the coal-loaded trucks are generally not always covered with tarpaulin sheets, and this might result in increased suspension of coal from trucks or dumpers during their transit from vessel to yard or storage site. This might increase the PM in and around the coal storage area and Marine Bhavan.

##### Gaseous Pollutants:

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



$\mu\text{g}/\text{m}^3$ . As shown in Graph 4, the highest concentration of  $\text{NO}_x$  is at location A-5 (the coal storage area) in winter. It can be seen that on all locations's  $\text{NO}_x$  within the NAAQS annual limit, i.e.,  $40 \mu\text{g}/\text{m}^3$ , it can be seen that all locations comply with the standards (complied more than 98% times) while comparing with the NAAQS 24-hour limit, i.e.,  $80 \mu\text{g}/\text{m}^3$ .

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

**Polycyclic Aromatic Hydrocarbons (PAHs):** are ubiquitous pollutants in urban atmospheres. Anthropogenic sources of total PAHs in ambient air emissions are greater than those that come from natural events. These locations are commercial areas where Vehicular activity and dust emission is common. PAHs are a class of chemicals that occur naturally in coal, crude oil, and gasoline. The higher concentration which results from burning coal, oil, gas, road dust, etc. Other outdoor sources of PAHs may be the industrial plants in-and-around the DPA premises.

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

## 2) Vadinar:

**Particulate matter:** The concentration of PM<sub>10</sub> at Vadinar varies in the range of **1.45 to 443.2**  $\mu\text{g}/\text{m}^3$ , with a yearly average value of **63.49** with a standard deviation of **34.76**  $\mu\text{g}/\text{m}^3$ . As shown in Graph 1, the highest concentration of PM<sub>10</sub> is at location A-7 (Admin Building Vadinar) in the winter. It can be seen that at location A-7 (Admin Building Vadinar), PM<sub>10</sub> exceeds the NAAQS annual limit, i.e., 60  $\mu\text{g}/\text{m}^3$ , and at location A-8 (Vadinar Colony), it falls within the annual standards. It can be seen that locations A-7 (Admin Building Vadinar) and A-8 (Vadinar Colony) had a 5.15% percentage exceedance while comparing with the NAAQS 24-hour limit, i.e., 100  $\mu\text{g}/\text{m}^3$ .

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

### Gaseous Pollutants:

- The concentration of SO<sub>x</sub> varies from **0.52 to 69.91**  $\mu\text{g}/\text{m}^3$ , with a yearly average concentration of 13.146 with a standard deviation of 14.14  $\mu\text{g}/\text{m}^3$ . As shown in Graph 3, the highest concentration of SO<sub>x</sub> is at location A-8 (Vadinar Colony) in the winter. It can be seen that in all locations, SO<sub>x</sub> are within the NAAQS annual limit, i.e., 50  $\mu\text{g}/\text{m}^3$ . It can be seen that both locations comply with the standards (compliance more than 98% times) while comparing with the NAAQS 24-hour limit, i.e., 80  $\mu\text{g}/\text{m}^3$ .
- The concentration of NO<sub>x</sub> varies from **0.9 to 52.76**  $\mu\text{g}/\text{m}^3$ , with a yearly average concentration of **11.28** with a standard deviation of **7.17**  $\mu\text{g}/\text{m}^3$ . As shown in Graph 4, the highest concentration of NO<sub>x</sub> is at location A-7 (Admin Building Vadinar) in the winter. It can be seen that in all locations, NO<sub>x</sub> is within the NAAQS annual limit, i.e., 40  $\mu\text{g}/\text{m}^3$ . It can be seen that all locations comply with the standards (compliance more than 98% of the time) while comparing with the NAAQS 24-hour limit, i.e., 80  $\mu\text{g}/\text{m}^3$ .
- The concentration of CO varies from **0.03 to 3.14**  $\text{mg}/\text{m}^3$ , with a yearly average concentration of **0.87** with a standard deviation **0.41**  $\text{mg}/\text{m}^3$ . As shown in Graph 5, the highest concentration of CO is at location **A-7, (Admin Building Vadinar)** in winter. It can be seen that at all locations they are complying (Compliance more than 98% times) with the NAAQS 1 hour limit, i.e., 4  $\text{mg}/\text{m}^3$ . Both **locations A-7, (Admin building Vadinar)** and **A-8, (Vadinar Colony)** had **5.16%** exceedance, which is about 5 days out of 97 days of monitoring, while comparing with the NAAQS 8-hour limit, i.e., 2  $\text{mg}/\text{m}^3$ .
- The concentration of **Total VOCs** levels was recorded in a range of **0 to 6.62**  $\mu\text{g}/\text{m}^3$  with a yearly average value of **0.96** with a standard deviation of **1.051**  $\mu\text{g}/\text{m}^3$  at Vadinar. As shown in graph 6, the **highest** concentration of **VOCs** is at

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

#### **Polycyclic Aromatic Hydrocarbons (PAHs):**

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

With reference to the Ambient Air Quality monitoring conducted under the study, it may be concluded that the particulate matter  $\text{PM}_{10}$ , were reported in higher concentration and apparently exceeds the NAAQS particularly at locations of Kandla., whereas  $\text{PM}_{2.5}$  complies with the NAAQS at majority of the locations. For both the ambient air monitoring parameters ( $\text{PM}_{10}$  and  $\text{PM}_{2.5}$ ), the major exceedance was observed at location A-5 i.e. Coal Storage Area. The gaseous pollutants ( $\text{NO}_x$ ,  $\text{SO}_x$ , 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  $\text{NO}_x$ , 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  $\text{NO}_x$ , PM, CO, and other pollutants such as PAH, VOCs etc. Vehicle traffic and congestion in and around port areas can exacerbate the air quality issues.
3. **Coal Handling:** Resuspension of dust occurs due to the transportation of coal and the handling of coal.
4. **Construction Activities:** Another reason for the high particulate matter content in this area is due to high construction activities in the surrounding area.

#### **4.4 Remedial Measures:**

Efficient mitigation strategies need to be implementation for substantial environmental and health co-benefits. To improve air quality, DPA has implemented a number of precautionary measures, such as maintaining Green zone, initiated Inter-Terminal Transfer of tractor-trailers, Centralized Parking Plaza, providing shore power supply to tugs and port crafts, the use of LED lights at DPA area helps in lower energy consumption and decreases the carbon foot prints in the environment, time to time cleaning of paved and unpaved roads, use of tarpaulin sheets to cover dumpers at project sites etc. are helping to achieve the cleaner and green future at port. To address air pollution from port shipping activities, various measures that can be implemented are as follows:

- Practice should be initiated for using mask as preventative measure, to avoid Inhalation of dust particle-Mask advised in sensitive areas. Covering vehicles with tarpaulin during transportation will help to reduce the suspension of pollutants in air.
- Ensuring maintenance of engines and machinery to comply with emission standards.
- Frequent water sprinkling on roads to reduce dust suspension due to vehicular movement, this can be use during transporting coal to avoid suspension of coal dust.
- Use of proper transport methods, such as a conveyor belt, for excavated material and screens around the construction site.
- End to End pavement of roads in construction site could considerably reduce dust emission. Prohibition of use of heavy diesel oil as fuel could be possibly reduce pollutants. Encouraging use of low-sulfur fuels (viz. Marine Gas Oil (MGO)/Liquefied Natural Gas (LNG), can significantly reduce sulfur and PM emissions from ships.
- Retrofitting ships with exhaust gas cleaning systems can help reduce sulfur emissions. Engine upgrades, such as optimizing fuel combustion and improving engine efficiency, can reduce overall emissions.
- Investing in infrastructure for cold ironing allows ships to connect to the electrical grid while docked, reducing the need for auxiliary engines and associated emissions.
- Implementing efficient cargo-handling processes, optimizing logistics to reduce congestion and idling times, and encouraging use of cleaner port machinery and vehicles can all contribute to reducing air pollution in port areas.
- Shrouding shall be carried out in the work site enclosing the dock/proposed facility area. This will act as dust curtain as well achieving zero dust discharge from the site. These curtain or shroud will be immensely effective in restricting disturbance from wind in affecting the dry dock operations, preventing waste dispersion, improving working conditions through provision of shade for the workers.
- Dust collectors shall be deployed in all areas where blasting (surface cleaning) and painting operations are to be carried out, supplemented by stacks for effective dispersion.
- Periodic vacuum-sweeping mechanisms shall be adopted.



## **CHAPTER 5: DG STACK MONITORING**

## 5.1 DG Stack Monitoring

A diesel generator is a mechanical-electrical machine that produces electrical energy (electricity) from diesel fuel. They are used by the residential, commercial, charitable and governmental sectors to provide power in the event of interruption to the main power, or as the main power source. Diesel generating (DG) sets are generally used in places without connection to a power grid, or as an emergency power supply if the grid fails. These DG sets utilize diesel as fuel and generate and emit the air pollutants such as Suspended Particulate Matter, SO<sub>2</sub>, NO<sub>x</sub>, CO, etc. from the stack during its functioning. The purpose of stack sampling is to determine emission levels from plant processes to ensure they are in compliance with any emission limits set by regulatory authorities to prevent macro environmental pollution. The stack is nothing but chimney which is used to disperse the hot air at a great height, emissions & particulate matters that are emitted. Hence, monitoring of these stacks attached to DG Sets is necessary in order to quantify the emissions generated from it.

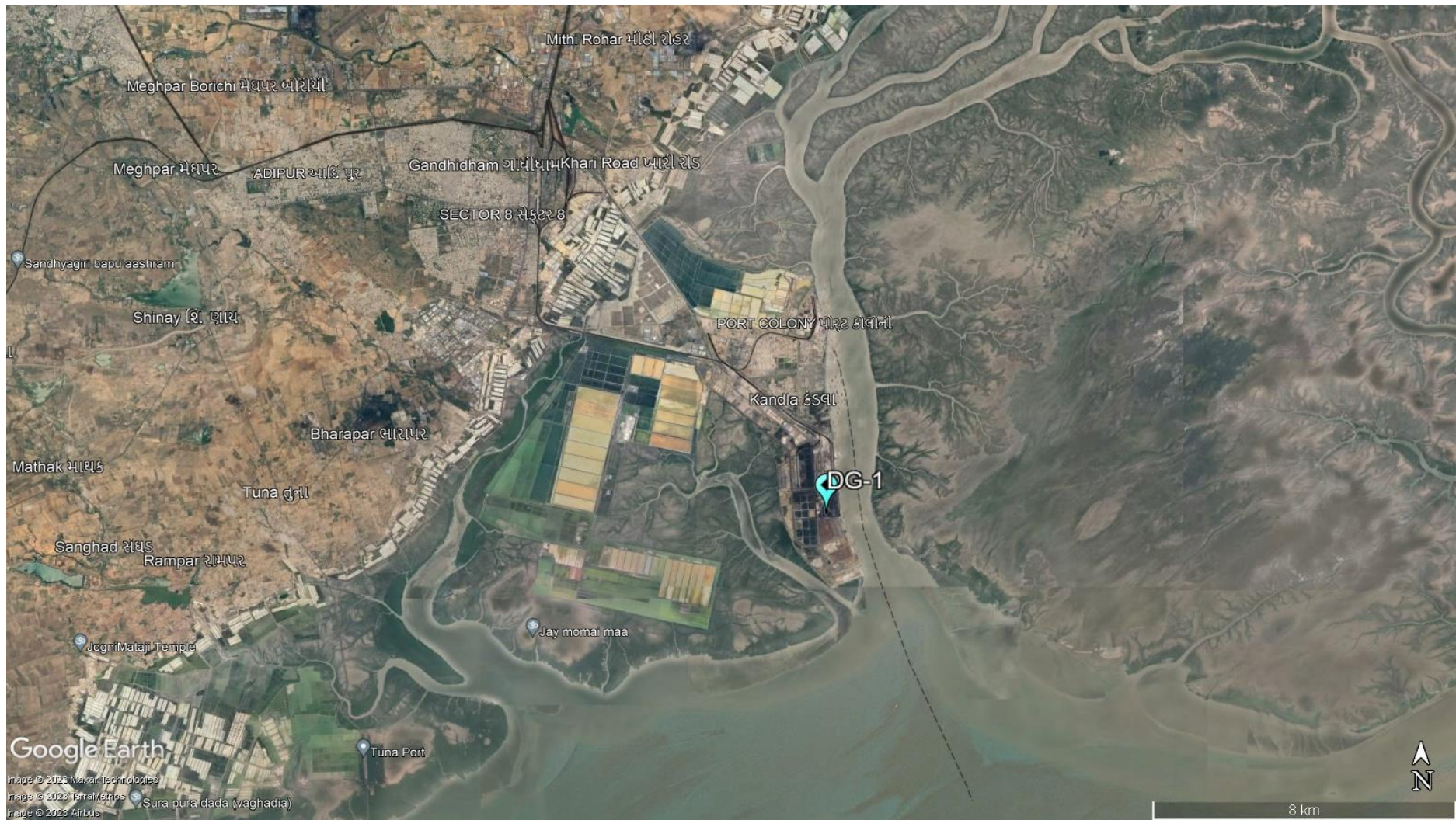
As defined in scope by DPA, the monitoring of DG Stack shall be carried out at two locations, one at Kandla and one at Vadinar. The details of the DG Sets at Kandla and Vadinar have been mentioned in Table 10 as follows:

**Table 10: Details of DG Stack monitoring locations**

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

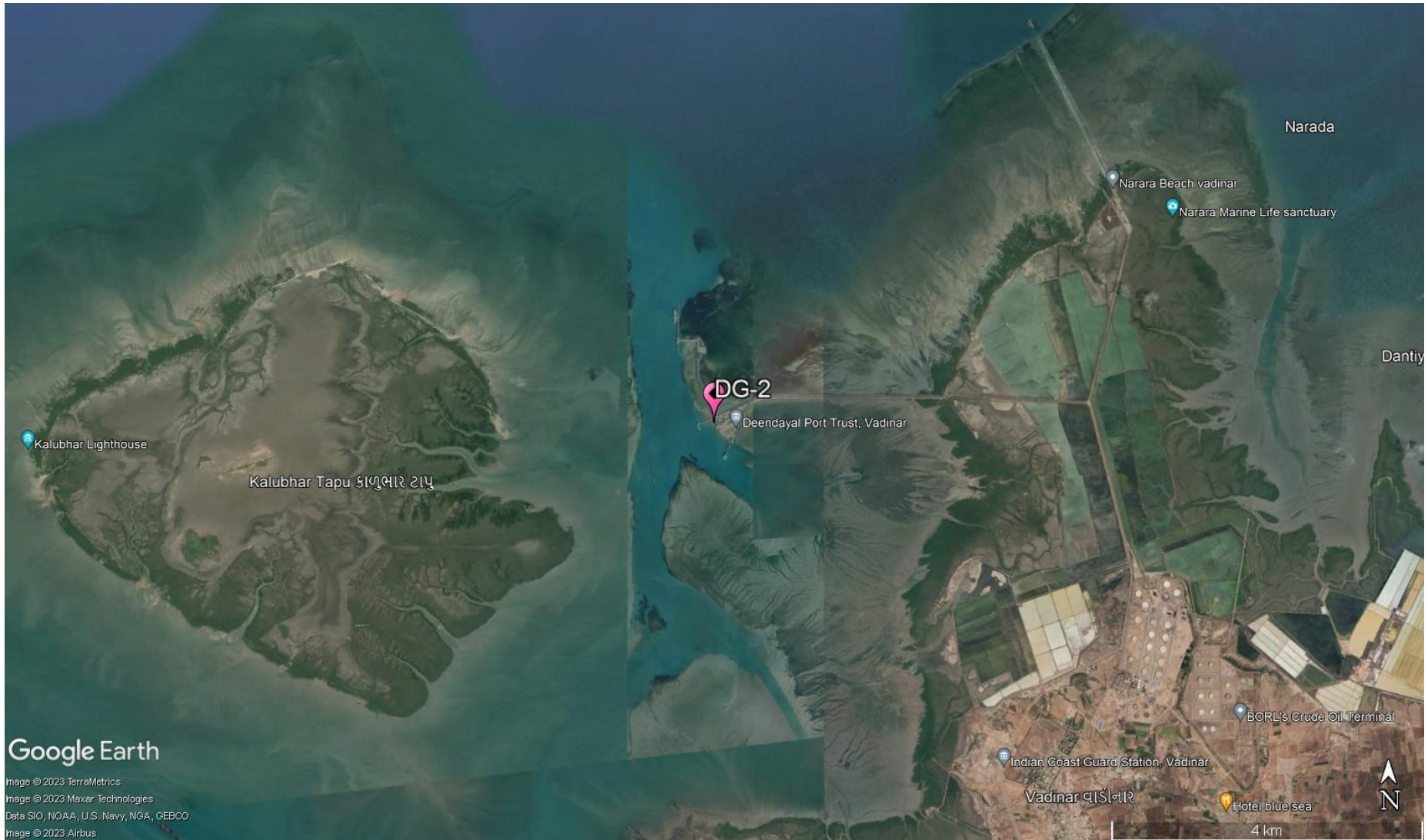
The map depicting the locations of DG Stack Monitoring to be monitored in Kandla and Vadinar have been mentioned in **Map 6 and 7** as follows:





Map 6: DG Stack monitoring Locations at Kandla





Map 7: DG Stack monitoring Locations at Vadinar



## Methodology:

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

**Table 11: DG stack parameters**

Sr. No.	Parameter	Unit	Instrument
1.	Suspended Particulate Matter	mg/Nm <sup>3</sup>	Stack Monitoring Kit
2.	Sulphur Dioxide (SO <sub>2</sub> )	PPM	Sensor based Flue Gas Analyzer (Make: TESTO, Model 350)
3.	Oxides of Nitrogen (NO <sub>x</sub> )	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<sub>x</sub>), Carbon Monoxide and Carbon Dioxide, the monitoring is carried out by using the sensor-based Flue Gas Analyzer.

## Monitoring Frequency

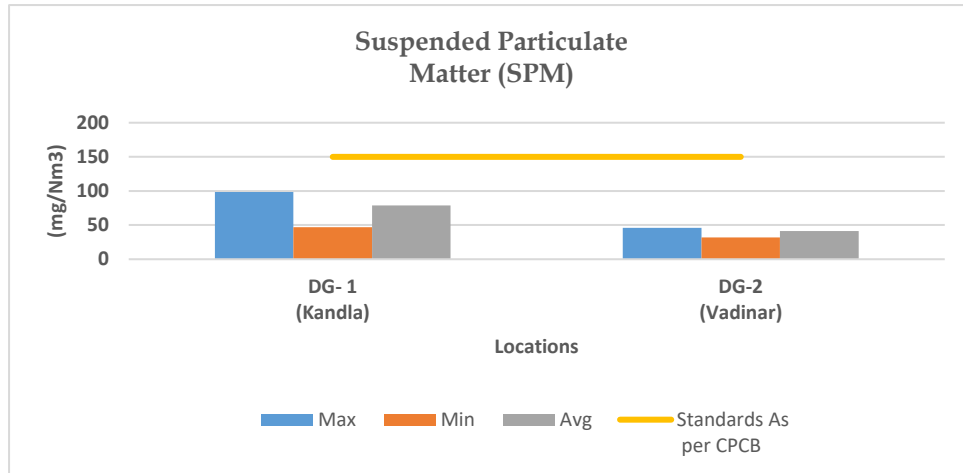
Monitoring is required to be carried out once a month for both the locations of Kandla and Vadinar for a period of April 2023 to March 2024.

## 5.2 Result and Discussion

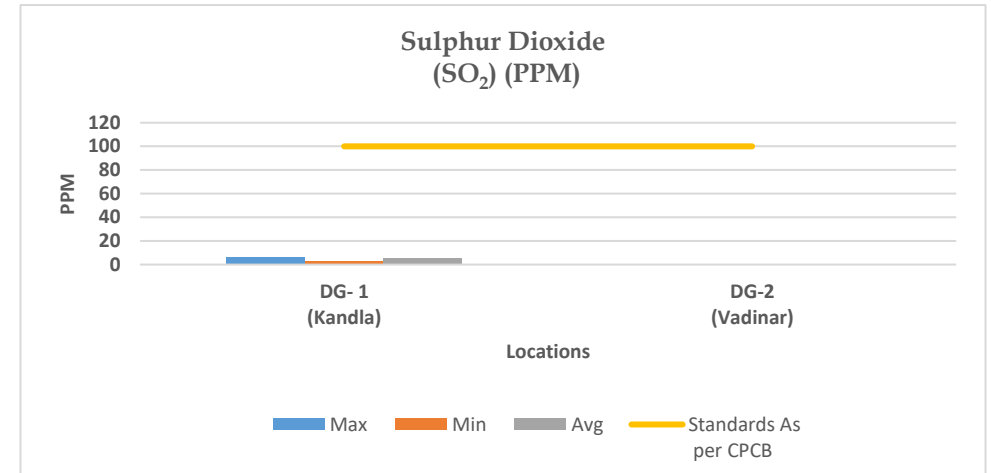
The sampling and monitoring of DG stack emission was carried out for monitoring period at Kandla and Vadinar and its comparison with CPCB or Indian standards for Industrial Stack Monitoring the flue gas emission from DG set has given in **Table 12**.

**Table 12: DG monitoring data**

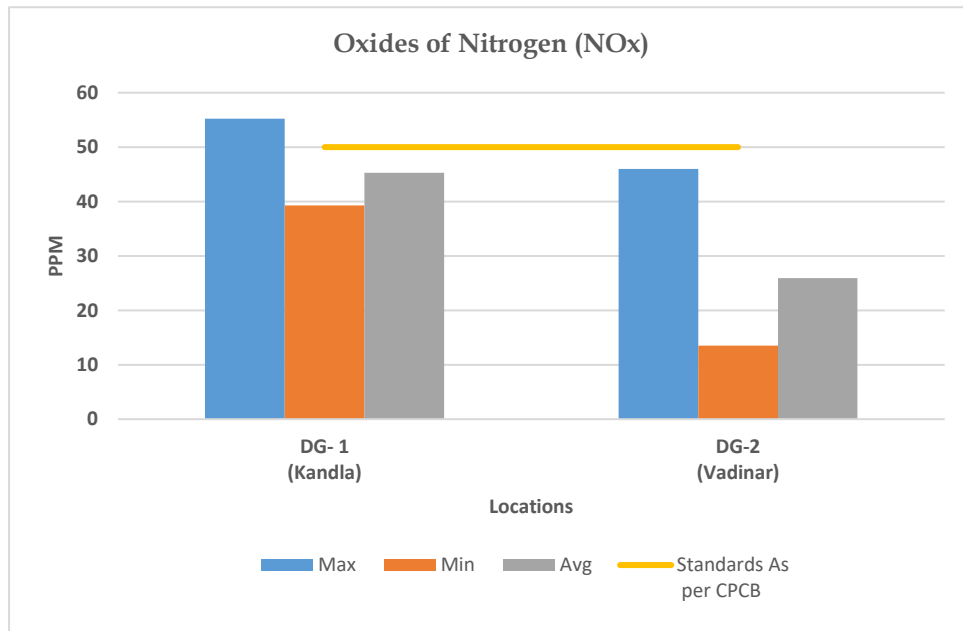
Sr. No.	Stack Monitoring Parameters for DG Sets		DG- 1 (Kandla)	DG-2 (Vadinar)	Stack Monitoring Limits /Standards As per CPCB
1.	Suspended Particulate Matter (SPM) (mg/Nm <sup>3</sup> )	Max	98.47	45.32	150
		Min	46.82	31.85	
		Avg.	78.96	41.33	
2.	Sulphur Dioxide (SO <sub>2</sub> ) (PPM)	Max	6.45	N.D.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



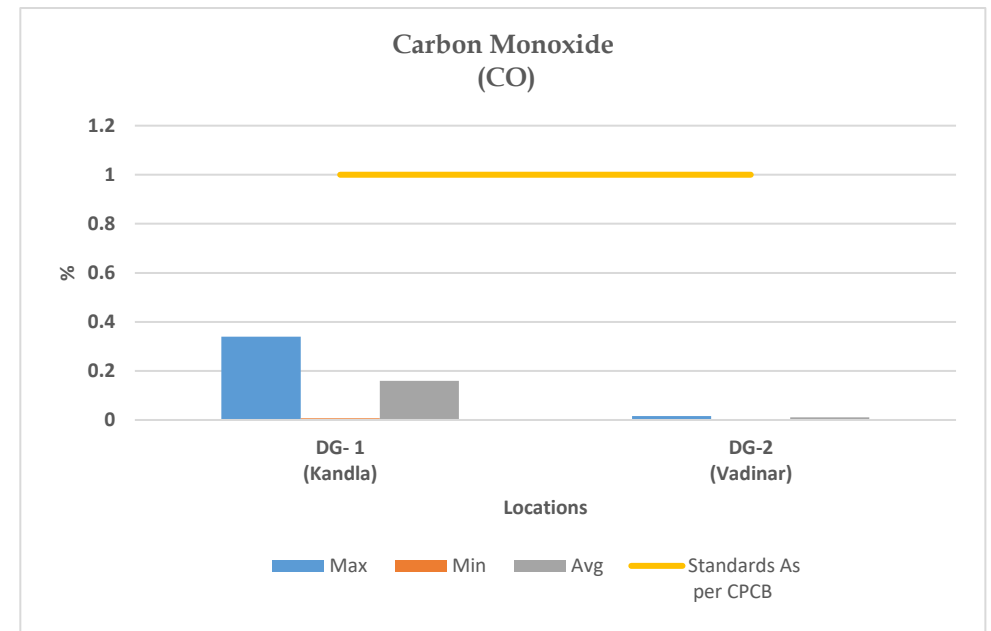
Graph 7 Spatial trend in SPM Concentration



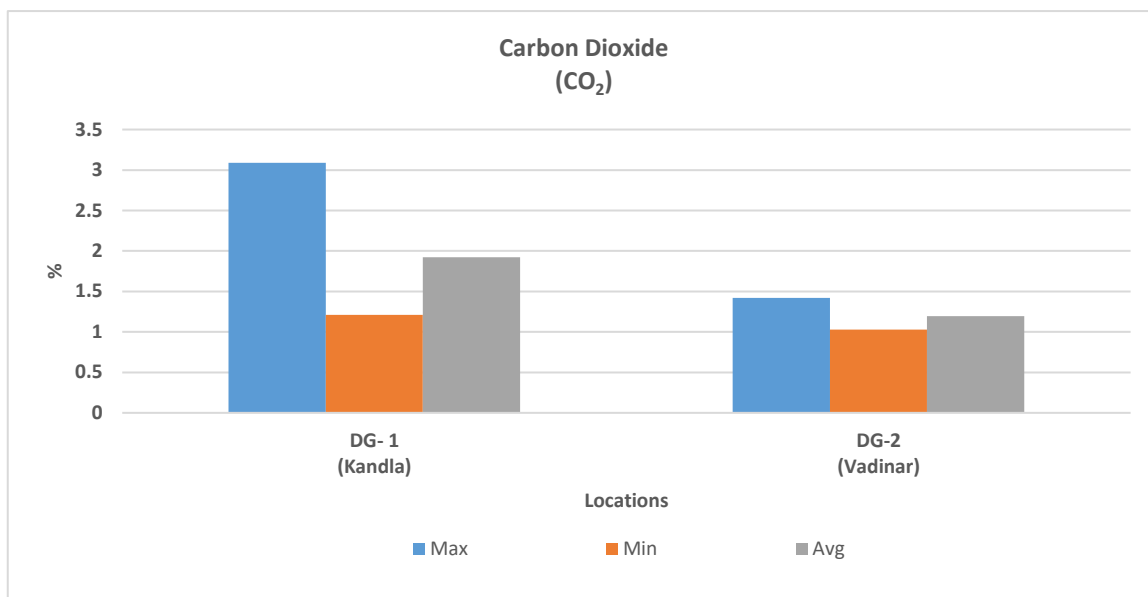
Graph 8 Spatial trend in SO<sub>x</sub> Concentration



Graph 9 Spatial trend in NO<sub>x</sub> Concentration



Graph 10 Spatial trend in CO Concentration



Graph 11 Spatial trend in CO<sub>2</sub> Concentration

### 5.3 Data Interpretation and Conclusion

#### 1) Kandla:

The Suspended Particulate Matter (SPM) varies in the range of **46.82** to **98.47** mg/m<sup>3</sup>. The yearly average SPM of D.G stack-1 is **78.96** mg/m<sup>3</sup>. The maximum concentration for SPM was observed in the monitoring period of October to November 2023. The Sulphur dioxide (SO<sub>x</sub>) varies in the range of **3.25** to **6.45** PPM. The yearly average SO<sub>x</sub> of D.G stack-1 is **4.95** PPM. The maximum concentration of SO<sub>x</sub> observed in the monitoring period of October to November 2023.

The NO<sub>x</sub> varies in the range of **39.27** to **55.2** PPM. The yearly average of NO<sub>x</sub> of D.G stack-1 at Kandla is **45.31** PPM. The maximum concentration of NO<sub>x</sub> observed in the monitoring period of July to August 2023.

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

The CO<sub>2</sub> at Kandla varies in the range of **1.21** to **3.09** %. The yearly average of CO<sub>2</sub> of D.G stack-1 at Kandla is **1.92** %. The maximum concentration of CO<sub>2</sub> observed in the monitoring period of March to April 2024.

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

#### 2) Vadinar:

The Suspended Particulate Matter (SPM) in the range of **31.85** to **45.32** mg/m<sup>3</sup>. The yearly average SPM of D.G stack-2 at Vadinar is **41.33** mg/m<sup>3</sup>. The maximum concentration of SPM was observed in the monitoring period of March to April 2024. There is no Sulphur dioxide (SO<sub>x</sub>) concentration detected at Vadinar.

The NO<sub>x</sub> at Vadinar varies in the range of **13.52** to **46** PPM. The yearly average of NO<sub>x</sub> of D.G stack-2 at Vadinar is **25.928** PPM. The maximum concentration of NO<sub>x</sub> observed in the monitoring period of June to July 2023.



The CO at Vadinar varies in the range of **0.002 to 0.016** %. The yearly average of CO of D.G stack-2 at Vadinar is **0.0106** % The maximum concentration of CO observed in the monitoring period of October to November 2023.

The CO<sub>2</sub> at Vadinar varies in the range of **1.03 to 1.42** %. The yearly average in CO<sub>2</sub> of D.G stack-2 at Vadinar is **1.92** % The maximum concentration of CO<sub>2</sub> observed in the monitoring period of June to July 2024.

The results of all the above parameters of DG stack-2 at Vadinar emission are compared with the permissible limits mentioned in the consent issued by GPCB, and have been found within the prescribed limit for all the monitored parameters.



## **CHAPTER 6: NOISE MONITORING**

## 6.1 Noise Monitoring

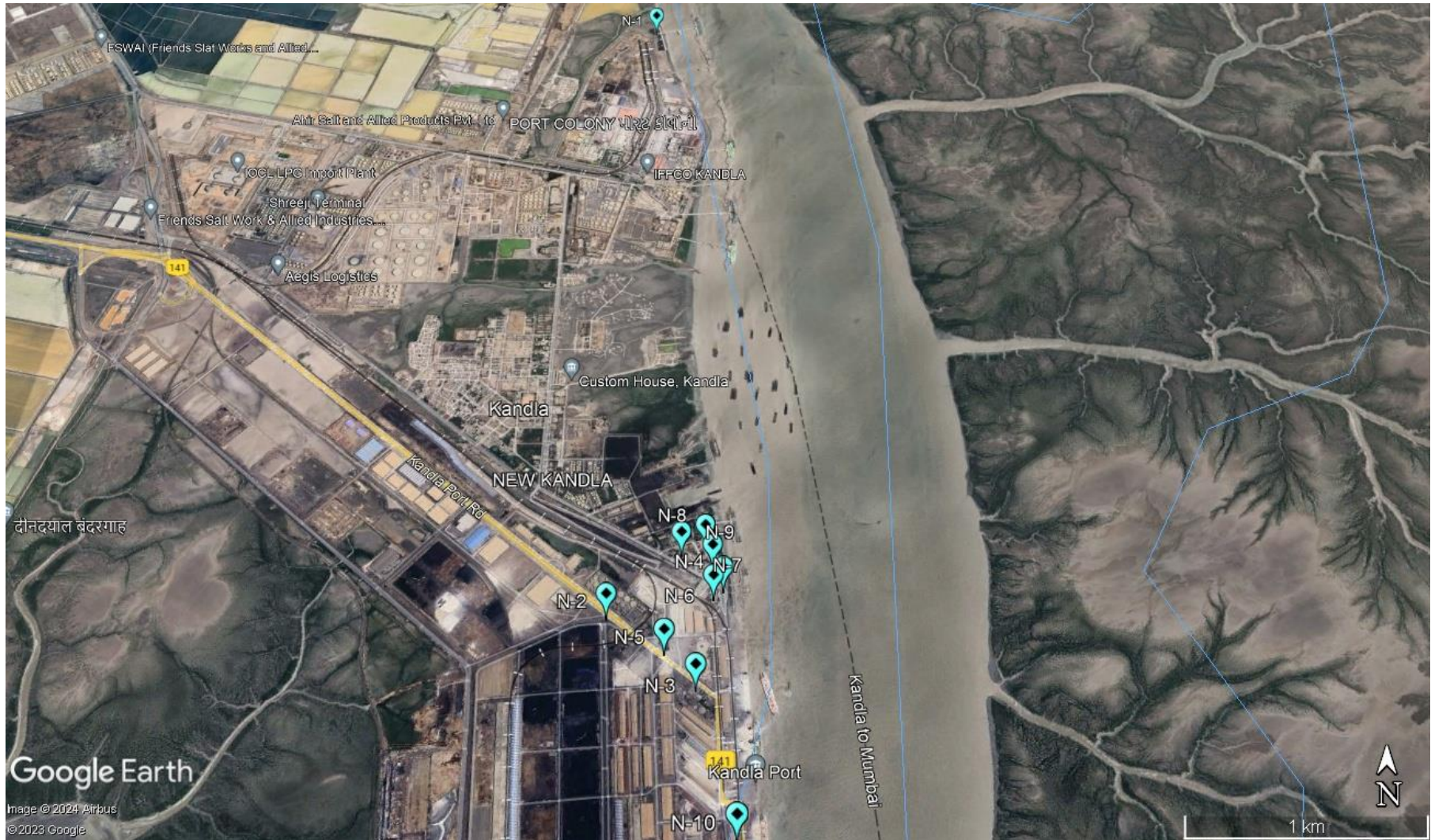
Noise can be defined as an unwanted sound, and it is therefore, necessary to measure both the quality as well as the quantity of environmental noise in and around the study area. Noise produced during operation stage and the subsequent activities may affect surrounding environment impacting the fauna and as well as the human population. Under the scope, the noise monitoring is required to be carried out at 10 locations in Kandla and 3 locations in Vadinar. The sampling locations for noise are not only confined to commercial areas of DPA but also the residential areas of DPA.

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

**Table 13: Details of noise monitoring locations**

Sr. No.	Location Code	Location Name	Latitude/ Longitude
1.	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.	N-11	Near Main Gate	22.441544N 69.674495E
12.	N-12	Near Vadinar Jetty	22.441002N 69.673147E
13.	N-13	Port Colony Vadinar	22.399948N 69.716608E





Map 8: Locations for Noise Monitoring at Kandla





**Map 9: Locations for Noise Monitoring at Vadinar**

**Methodology:**

The intensity of sound energy in the environment is measured in a logarithmic scale and is expressed in a decibel (dB(A)) scale. The ordinary sound level meter measures the sound energy that reaches the microphone by converting it into electrical energy and then measures the magnitude in dB(A). Whereas, in a sophisticated type of sound level meter, an additional circuit (filters) is provided, which modifies the received signal in such a way that it replicates the sound signal as received by the human ear and the magnitude of sound level in this scale is denoted as dB(A). The sound levels are expressed in dB(A) scale for the purpose of comparison of noise levels, which is universally accepted. Noise levels were measured using an integrated sound level meter of the make Envirotech Sound Level Meter (Class-I) (model No. SLM-109). It has an indicating mode of Lp and Leq. Keeping the mode in Lp for few minutes and setting the corresponding range and the weighting network in “A” weighting set the sound level meter was run for one-hour time and Leq was measured at all locations.

**Monitoring Frequency**

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

**Table 14: Details of the Noise Monitoring**

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

**Standard for Noise**

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

**Table 15: Ambient Air Quality norms in respect of Noise<sup>(2)</sup>**

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

## 6.2 Result and Discussion

The details of the Noise monitoring conducted during the monitoring period April 2023 to March 2024 have been summarized in the **Table 16** as below:

**Table 16: The Results of Ambient Noise Quality**

Sr. No.	Station Code	Station Name	Category of Area	Standard	Day Time in dB(A)			Standard	Night Time in dB(A)		
					Max.	Min.	Avg.		Max.	Min.	Avg.
1	N-1	Oil Jetty 7	A	75	65.7	36.5	47.75	70	57.5	33	41.801
2	N-2	West Gate No.1	A	75	68.4	36.5	54.35	70	54.2	36.1	47.02
3	N-3	Canteen Area	B	65	66.2	38	52.61	55	52.1	33	43.46
4	N-4	Main Gate	A	75	61.4	35.3	50.69	70	50.8	36.1	43.33
5	N-5	Main Road	A	75	66.1	33.5	51.67	70	55.5	33.6	43.7
6	N-6	Marin Bhavan	B	65	62.3	38.9	52.52	55	52.3	31.9	43.23
7	N-7	Port & Custom Building	B	65	66.3	37.6	50.89	55	54.3	33.9	38.91
8	N-8	Nirman Building	B	65	60.8	40.9	51	55	58.9	35.2	43.02
9	N-9	ATM Building	B	65	65.1	35.1	49.7	55	53.4	34.1	39.25
10	N-10	Wharf Area/ Jetty	A	75	74.5	36.9	52.9	70	52.7	36	42.3
11	N-11	Near Main Gate	A	75	72.3	34	62.51	70	71.2	34.3	55.71
12	N-12	Near Vadinar Jetty	A	75	76.3	39.2	64.98	70	68.5	34.7	56.38
13	N-13	Port Colony Vadinar	C	55	77.5	37.7	50.05	45	65.9	36.2	49.5

### 6.3 Data Interpretation and Conclusion

- 1) **Kandla:** The noise level was compared with the standard limits specified in NAAQS by CPCB. During the Day Time, the average noise level at all 10 locations at Kandla ranged from **33.5 dB(A)** to **74.5 dB(A)** while, during Night Time the average Noise Level ranged from **31.9 dB(A)** to **58.9 dB(A)**, of which six locations out of ten locations, noise level were within the permissible limits for the industrial, commercial area and residential zone for Day time and night time. Other Four locations such as i.e., **N-3 (Canteen Area)**, **N-7 (Port & Custom Building)**, **N-8 (Nirman Building)** and **N-9 (ATM building)** which are Commercial areas, slightly exceed the standard limits prescribed by NAAQS by CPCB, in the monitoring period of **April to May 2023 and May to June 2023**.
- 2) **Vadinar:** The noise level was compared with the standard limits specified in NAAQS by CPCB. During the Day Time, the average noise level at all 3 locations at Vadinar ranged from **34 dB(A)** to **77.5 dB(A)** while, during Night Time the average Noise Level ranged from **34.3 dB(A)** to **71.2 dB(A)** at Vadinar, on location **N-11 (Near main gate)** noise level was within the permissible limits for the industrial zone for Day time and night time. On locations of Vadinar such as i.e., **N-12 (Near Vadinar jetty)**, which are considered as industrial area slightly exceed the standard limits prescribed by NAAQS by CPCB, in the monitoring period of **June to July 2023**. And on location **N-13 (Port Colony Vadinar)**, most frequently exceed the permissible limit during the day time as well as night time.

### 6.4 Remedial Measures

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



## **CHAPTER 7: SOIL MONITORING**



### 7.1 Soil Quality Monitoring:

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

As defined in scope by Deendayal Port Authority (DPA), Soil Quality Monitoring shall be carried out at Six locations, four at Kandla and two at Vadinar. The details of the soil monitoring locations within the Port area of DPA are mentioned in **Table 17**:

**Table 17: Details of the Soil quality monitoring**

Sr. No.	Location Code	Location Name	Latitude Longitude	
1.	Kandla	S-1	Oil Jetty 7	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:

### Monitoring Frequency

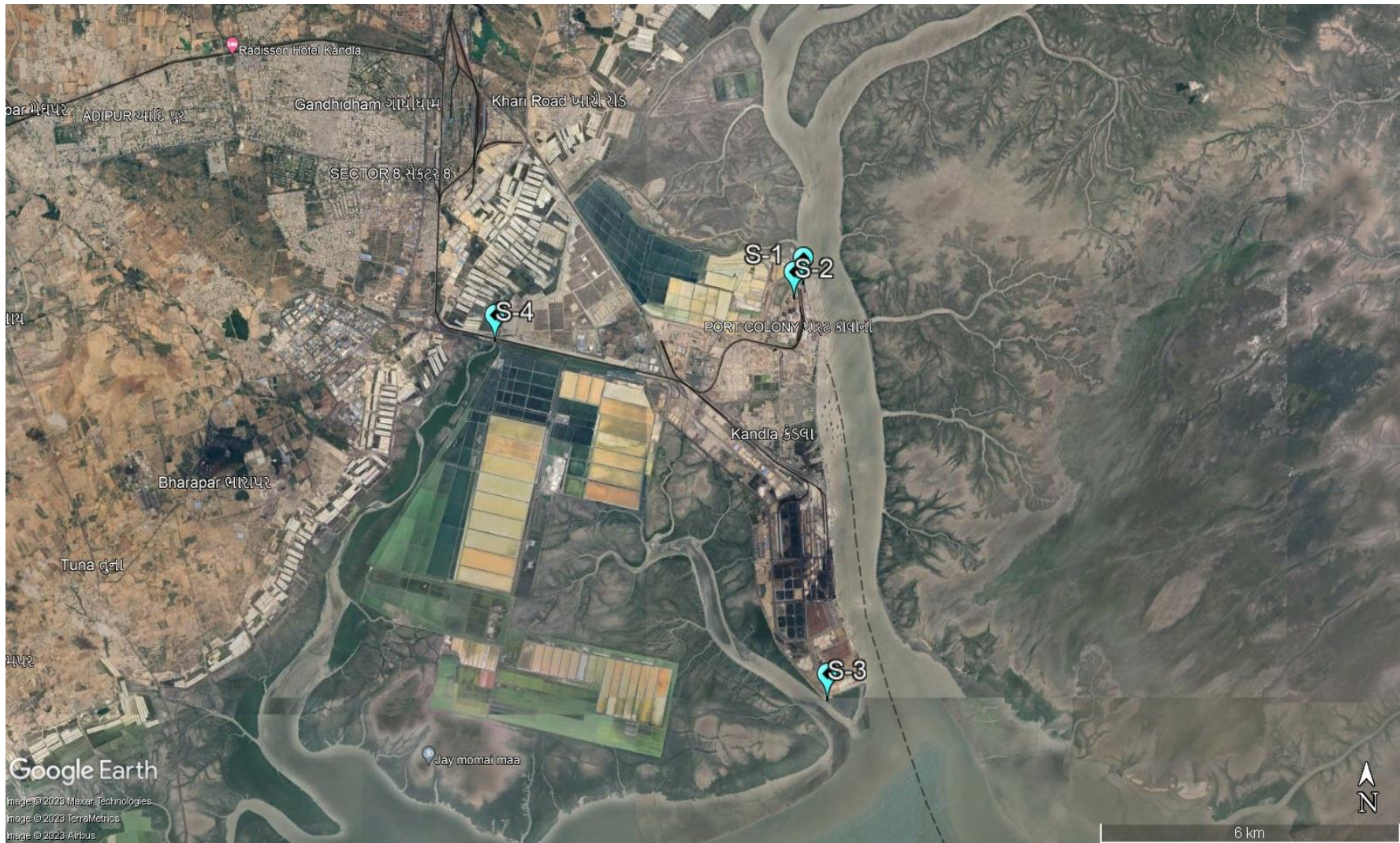
Monitoring is required to be carried out once a month for both the locations of Kandla and Vadinar. The monitoring was done from April 2023, to March, 2024.



**Table 18: Soil parameters**

Sr. No.	Parameters	Units	Reference method	Instruments
1.	TOC	%	Methods Manual Soil Testing in India January, 2011, 09. Volumetric method (Walkley and Black, 1934)	Titration Apparatus
2.	Organic Carbon	%		
3.	Inorganic Phosphate	Kg/Hectare	Practical Manual Chemical Analysis of Soil and Plant Samples, ICAR-Indian Institute of Pulses Research 2017 Determination of Available Phosphorus in Soil	UV-Visible Spectrophotometer
4.	Texture	-	Methods Manual Soil Testing in India January 2011,01	Hydrometer
5.	pH	-	IS 2720 (Part 26): 1987	pH Meter
6.	Conductivity	µS/cm	IS 14767: 2000	Conductivity Meter
7.	Particle size distribution & Silt content	-	Methods Manual Soil Testing in India January 2011	Sieves Apparatus
8.	SAR	meq/L	Procedures for Soil Analysis, International Soil Reference and Information Centre, 6 <sup>th</sup> Edition 2002 13-5.5.3 Sodium Absorption Ratio (SAR), Soluble cations	Flame Photometer
9.	Water Holding Capacity	%	NCERT, Chapter 9, 2022-23 and Water Resources Department Laboratory Testing Procedure for Soil & Water Sample Analysis	Muffle Furnace
10.	Aluminium	mg/Kg	EPA Method 3051A	ICP-OES
11.	Chromium	mg/Kg		
12.	Nickel	mg/Kg		
13.	Copper	mg/Kg	Methods Manual Soil Testing in India January, 2011, 17a	
14.	Zinc	mg/Kg	Methods Manual Soil Testing in India January, 2011, 17a	
15.	Cadmium	mg/Kg	EPA Method 3051A	
16.	Lead	mg/Kg		
17.	Arsenic	mg/Kg		
18.	Mercury	mg/Kg		

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



Map 10: Soil Quality Monitoring Locations at Kandla





Map 11: Soil Quality Monitoring Locations at Vadinar

## 7.2 Result and Discussion

The analysis results of physical analysis of the soil samples collected during environmental monitoring period during April 2023 to March 2024 mentioned in **Table 19** are shown below:

**Table 19: Soil Quality for the Monitoring period**

Sr. No	Location Parameters		Kandla				Vadinar	
			S-1 (Oil Jetty 7)	S-2 (IFFCO Plant)	S-3 (Khori Creek)	S-4 (Nakti Creek)	S-5 (Near SPM)	S-6 (Near Vadinar Jetty)
1	pH	Max	9.53	8.8	8.88	9.48	8.69	9.36
		Min	7.3	6.48	6.52	7.86	7.19	8.16
		Avg.	8.24	8.20	7.96	8.52	8.14	8.55
2	Conductivity ( $\mu\text{S}/\text{cm}$ )	Max	71500	36500	75700	17850	501	625
		Min	587	526	586	204	63	127
		Avg	26881.17	11442	20646.33	5470	177.13	281.54
3	Inorganic Phosphate (Kg/ha)	Max	13.32	619.89	20.31	15.87	5.64	8.67
		Min	0.39	0.43	1.24	0.32	0.35	0.26
		Avg	4.21	57.15	5.64	4.71	2.39	2.25
4	Organic Carbon (%)	Max	2.83	2.54	3.83	3.35	0.85	2.48
		Min	0.03	0.08	0.14	0.27	0.06	0.14
		Avg	0.91	0.79	1.06	0.92	0.33	0.59
5	Organic Matter (%)	Max	4.88	4.38	6.6	5.78	1.47	4.28
		Min	0.06	0.14	0.24	0.32	0.09	0.241
		Avg	1.57	1.36	1.82	1.48	0.57	1.01
6	SAR (meq/L)	Max	41.45	22.91	31.51	10.01	0.25	0.45
		Min	0.81	0.36	0.5	0.36	0.05	0.09
		Avg	13.24	6.56	11.71	2.57	0.10	0.17
7	Aluminium (mg/Kg)	Max	8643.04	9065.97	10298.7	9286.91	15921.7	14806.19
		Min	812.75	830.95	840.71	916.4	735.77	754.58
		Avg	2223.8	2322.3	2517.4	2470.4	2848.2	2762.2
8	Chromium (mg/Kg)	Max	92.23	90.7	86.18	87.07	106	91.88
		Min	28.213	28.91	31.57	24.7	71.68	60.93
		Avg	52.28	58.79	59.005	53.30	82.46	70.91
9	Nickel (mg/Kg)	Max	33.32	36.66	38.1	45.41	41.425	42.68
		Min	13.17	11.82	11.91	10.43	27.14	25.52
		Avg	19.17	19.22	22.72	21.72	33.29	32.353
10	Copper (mg/Kg)	Max	92.51	88.31	150.7	192.72	123.18	104.64
		Min	12.42	14.71	14.74	12.8	81.14	60.57
		Avg	49.94	61.10	84.93	56.708	103.06	82.37
11	Zinc (mg/Kg)	Max	210.35	1755.44	188.29	142.71	88.14	97.36
		Min	16.46	42.93	29.9	23.57	37.03	15.33
		Avg	73.75	283.57	99.49	81.77	62.53	49.70
12	Cadmium (mg/Kg)	Max	0.397	23.47	0.59	0	3	0
		Min	0.397	0.5	0.59	0	3	0
		Avg	0.397	6.608	0.59	0	3	0
13	Lead (mg/Kg)	Max	50.28	277.82	47.87	26.48	1.58	21.07
		Min	3.79	2.58	1.29	2.26	0.59	0.89
		Avg	12.09	32.75	15.59	8.88	1.08	6.66

Sr. No	Parameters	Location	Kandla				Vadinar	
			S-1 (Oil Jetty 7)	S-2 (IFFCO Plant)	S-3 (Khor Creek)	S-4 (Nakti Creek)	S-5 (Near SPM)	S-6 (Near Vadinar Jetty)
14	Arsenic (mg/Kg)	Max	4.87	8.4	5.28	6.62	0.4	5.05
		Min	0.1	0.29	0.88	0.3	0.099	0.59
		Avg	2.38	3.04	2.97	2.26	0.22	2.82
15	Mercury (mg/Kg)	Max	0	0	0	0	0	0
		Min	0	0	0	0	0	0
		Avg	0	0	0	0	0	0
16	Water Holding Capacity (%)	Max	54	77.92	61.99	75.84	60	66
		Min	35.8	34	23.74	15.9	39.85	44
		Avg	42.66	46.48	43.95	48.34	47.70	60.01
17	Sand (%)	Max	77.61	77.7	85.46	82.36	62.4	78.46
		Min	44.4	46.57	48.27	13.39	42.26	42.25
		Avg	59.26	65.74	62.96	65.03	51.61	60.59
18	Silt (%)	Max	53.28	47.28	41.25	57.98	49.27	53.27
		Min	9.77	9.28	9.93	9.28	12.24	12
		Avg	30.41	26.40	28.84	24.13	34.72	29.17
19	Clay (%)	Max	19.53	14.32	22.35	28.63	35.92	21.02
		Min	2.32	0.63	0.64	0.48	1.75	1.74
		Avg	10.29	7.86	8.19	10.83	13.66	10.23
20	Texture		Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Loam	Sandy Loam

### 7.3 Data Interpretation and Conclusion

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

#### 1) Kandla:

- The value of pH ranges from **6.48** to **9.53**, with the highest at location **S-1 (Oil Jetty 7)** and the lowest at **location S-2 (IFFCO plant)**, while the average pH for Kandla was observed to be **8.23**. The pH in Kandla varies from **Slightly alkaline to strongly alkaline**
- At all monitoring locations, the value of **Electrical Conductivity** ranges from **204 to 75,700  $\mu\text{s}/\text{cm}$** , with the highest at **location S-3 (Khor Creek)** and the lowest at **S-4 (Nakti Creek)**. The average Electrical Conductivity is **16,109.87  $\mu\text{s}/\text{cm}$** .
- The concentration of inorganic phosphate varied from **0.32 to 619.89 kg/ha**, with an average of **17.93 kg/ha**. The highest concentration of inorganic phosphate was found at **S-2 (IFFCO plant)** and the lowest concentration was found at **S-4 (Nakti Creek)**. The availability of phosphorus in the soil solution is influenced by several factors, such as organic matter, clay content, pH, temperature, and more.

- The concentration of **Total Organic Carbon** ranges from **0.03% to 3.86%**, with an average TOC of **0.92%** detected. The highest concentration was found at **location S-3 (Khorī Creek)**, and the minimum concentration was found at **S-1 (Oil Jetty 7)**.
- The **Sodium Adsorption Ratio** ranges from **0.36 to 41.45 meq/L**, with an average value of **8.25 meq/L** at Kandla. The highest concentration of SAR is found at **S-1 (Oil Jetty 7)** and the lowest concentration at **S-4 (Nakti Creek)**.
- The **Water Holding Capacity (WHC)** in the soil samples of Kandla varies from **15.9% to 77.92%**, with an average of **45.36%**. The highest concentration of WHC was observed at **S-2 (IFFCO plant)** and the lowest concentration at **S-4 (Nakti Creek)**.
- The Soil Texture was observed as “**Sandy loam**” to “**loamy sand**” at all the monitoring locations in Kandla.

### Heavy Metals

- During the sampling period, the concentration of **Aluminium** varied from **812.75 to 10,298.7 mg/kg**. The average **Aluminium** concentration was observed to be **2,383.475 mg/kg** at the Kandla monitoring station. The **highest concentration** was observed at **S-3 (Khorī Creek)**, and the **lowest concentration** was observed at **S-1 (Oil Jetty 7)**.
- The concentration of **Chromium** varied from **24.7 to 92.23 mg/kg**, with an average value of **55.848 mg/kg** observed at the Kandla monitoring station. The highest concentration was observed at **S-1 (Oil Jetty 7)**, and the lowest concentration was observed at **S-4 (Nakti Creek)**.
- The concentration of **Nickel** varied from **10.43 to 45.41 mg/kg** at Kandla, with an average value of **20.71 mg/kg** at the Kandla monitoring station. The highest concentration was observed at **S-4 (Nakti Creek)**, while the lowest concentration was also observed at **S-4 (Nakti Creek)**.
- The concentration of **Zinc** varied from **16.46 to 1755.4 mg/kg** at Kandla, with an average value of **134.64 mg/kg** at the Kandla monitoring station. The highest concentration was observed at **S-2 (IFFCO plant)**, which was the only spike observed during the entire monitoring period at Kandla. The lowest concentration was observed at **S-1 (Oil Jetty 7)**.
- The concentration of **Copper** varied from **12.42 to 192.72 mg/kg**, with an average value of **13.667 mg/kg** observed at the Kandla monitoring station. The highest concentration was observed at **S-4 (Nakti Creek)** and the lowest concentration was observed at **S-1 (Oil Jetty 7)**.
- The concentration of **Lead** varied from **1.29 to 277.82 mg/kg**, with an average value of **17.33 mg/kg**. The highest concentration was observed at **S-2 (IFFCO plant)**; this was the only spike observed during the entire monitoring period, while the lowest concentration was observed at **S-3 (Khorī creek)**.
- The concentration of **Arsenic** varied from **0.1 to 8.4 mg/kg**, with an average value of **2.67 mg/kg**. The highest concentration was observed at **S-1 (Oil Jetty 7)**, and the lowest concentration was observed at **S-3 (Khorī Creek)**.
- The concentration of **Cadmium** varied from **0 to 23.47 mg/kg**, with an average value of **1.89 mg/kg**. The highest concentration was observed at **S-2 (IFFCO plant)**. During the monitoring period, it was observed that cadmium was mostly found **Below**



**Quantification Limit (BQL)** at all locations, with only one spike observed at **S-2 (IFFCO plant)** throughout the entire monitoring period.

- During the monitoring period, it was observed that the concentration of **Mercury** was mostly found **below the quantification limit (BQL)** at all locations.

## 2) Vadinar:

- The value of **pH** ranges from **7.675** to **9.36**, with the highest at location **S-6 (Near Vadinar jetty)** and the lowest at **location S-5 (Near SPM)**, while the average pH for Vadinar was observed to be **8.34**. pH of Soil at Vadinar was found to be **moderately alkaline**.
- At all monitoring locations in Vadinar, the value of **Electrical Conductivity** ranges from **63** to **625**  $\mu\text{s}/\text{cm}$ , with the highest at **S-6 (Near Vadinar jetty)** and the lowest at **location S-5 (Near SPM)**. The average Electrical Conductivity is **229.33**  $\mu\text{s}/\text{cm}$ .
- The concentration of **inorganic phosphate** varied from **0.26** to **8.67** kg/ha, with an average of **2.32** kg/ha. The highest concentration of inorganic phosphate was found at **S-6 (Near Vadinar jetty)** and the lowest concentration was found at **location S-5 (Near SPM)**.
- The concentration of **Total Organic Carbon** ranges from **0.06%** to **2.48%**, with an average TOC of **0.46%** detected at Vadinar. The highest concentration was found at **S-6 (Near Vadinar jetty)**, and the minimum concentration was found at **S-5 (Near SPM)**.
- The **Sodium Adsorption Ratio** ranges from **0.05** to **0.45** meq/L, with an average value of **0.143** meq/L at Vadinar. The highest concentration of SAR is found at **6 (Near Vadinar jetty)** and the lowest concentration at **S-5 (Near SPM)**.
- The **Water Holding Capacity (WHC)** in the soil samples of Vadinar varies from **39.85%** to **66%**, with an average of **53.85%**. The highest concentration of WHC was observed at **S-6 (Near Vadinar jetty)** and the lowest concentration at **S-5 (Near SPM)**.
- The soil texture of Vadinar varies from “loam” to “slit loam”.

## Heavy Metals

- During the sampling period, the concentration of **Aluminium** varied from **735.77** to **15921.72** mg/kg. The average **Aluminium** concentration was observed to be **2,805.2** mg/kg at the Vadinar monitoring station. The **highest concentration** was observed at **S-5 (Near SPM)**, and the **lowest concentration** was observed at **S-5 (Near SPM)** but during different months.
- The concentration of **Chromium** varied from **60.93** to **106** mg/kg, with an average value of **76.69** mg/kg observed at the Vadinar monitoring station. The highest concentration was observed at **S-5 (Near SPM)**, and the lowest concentration was observed at **S-6 (Near Vadinar jetty)**.
- The concentration of **Nickel** varied from **25.62** to **42.68** mg/kg, with an average value of **32.825** mg/kg at the Vadinar monitoring station. The highest concentration was observed at **S-6 (Near Vadinar jetty)**, and the lowest concentration was also observed at **S-6 (Near Vadinar jetty)** but during different months.

- The concentration of **Zinc** varied from **15.33** to **97.36** mg/kg, with an average value of **56.118** mg/kg at the Vadinar monitoring station. The highest concentration was observed at **S-6 (Near Vadinar jetty)**, and the lowest concentration was also observed at **S-6 (Near Vadinar jetty)** but during different months.
- The concentration of **Copper** varied from **60.57** to **123.18** mg/kg, with an average value of **92.71** mg/kg observed at the Vadinar monitoring station. The highest concentration was observed at **S-5 (Near SPM)** and the lowest concentration was observed at **S-6 (Near Vadinar jetty)**.
- The concentration of **Lead** varied from **0.59** to **21.07** mg/kg, with an average value of **3.875** mg/kg. The highest concentration was observed at **S-6 (Near Vadinar jetty)**; this was the only spike observed during the entire monitoring period at Kandla, while the lowest concentration was observed at **S-5 (Near SPM)**.
- The concentration of **Arsenic** varied from **0.099** to **0.59** mg/kg, with an average value of **5.05** mg/kg. The highest concentration was observed at **S-6 (Near Vadinar jetty)**, and the lowest concentration was observed at **S-5 (Near SPM)**.
- The concentration of **Cadmium** varied from **0** to **3** mg/kg, with an average value of **3** mg/kg. The highest concentration was observed at **S-5 (Near SPM)**. During the monitoring period, it was observed that cadmium was mostly found **Below Quantification Limit (BQL)** at all locations.
- During the monitoring period, it was observed that the concentration of **Mercury** was mostly found **below the quantification limit (BQL)** at all locations.



## **CHAPTER 8: DRINKING WATER MONITORING**

## 8.1 Drinking Water Monitoring

It is necessary to check with the drinking water sources regularly so as to know whether water quality conforms to the prescribed standards for drinking. Monitoring the drinking water quality is essential to protect human health and the environment. With reference to the scope specified by DPA, a total of 20 locations (18 at Kandla and 2 at Vadinar) were monitored to assess the Drinking Water quality.

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

**Table 20: Details of Drinking Water Sampling Locations**

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





Map 12: Drinking Water Monitoring Locations at Kandla





Map 13: Drinking Water Monitoring Locations at Vadinar

## Methodology

The water samples were collected from the finalized sampling locations and analyzed for physico-chemical and microbiological parameter, for which the analysis was carried out as per APHA, 23<sup>rd</sup> 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<sup>(3)</sup>**

Sr. No.	Parameters	Units	Reference method	Instrument
1.	pH	-	APHA, 23 <sup>rd</sup> Edition (Section-4500-H <sup>+</sup> B):2017	pH Meter
2.	Colour	Hazen	APHA, 23 <sup>rd</sup> Edition, 2120 B:2017	Color Comparator
3.	EC	µS/cm	APHA, 23 <sup>rd</sup> Edition (Section-2510 B):2017	Conductivity Meter
4.	Turbidity	NTU	APHA, 23 <sup>rd</sup> Edition (Section -2130 B):2017	Nephlo Turbidity Meter
5.	TDS	mg/L	APHA, 23 <sup>rd</sup> Edition (Section-2540 C):2017	Vaccum Pump with filtration assembly and Oven
6.	TSS	mg/L	APHA, 23 <sup>rd</sup> Edition, 2540 D: 2017	
7.	Chloride	mg/L	APHA, 23 <sup>rd</sup> Edition (Section-4500-Cl-B):2017	Titration Apparatus
8.	Total Hardness	mg/L	APHA, 23 <sup>rd</sup> Edition (Section-2340 C):2017	
9.	Ca Hardness	mg/L	APHA, 23 <sup>rd</sup> Edition (Section-3500-Ca B):2017	
10.	Mg Hardness	mg/L	APHA, 23 <sup>rd</sup> Edition (Section-3500-Mg B):2017	
11.	Free Residual Chlorine	mg/L	APHA 23 <sup>rd</sup> Edition, 4500	
12.	Fluoride	mg/L	APHA, 23 <sup>rd</sup> Edition (Section-4500-F-D):2017	UV- Visible Spectrophotometer
13.	Sulphate	mg/L	APHA, 23 <sup>rd</sup> Edition (Section 4500-SO4-2-E):2017	
14.	Sodium	mg/L	APHA, 23 <sup>rd</sup> Edition (Section-3500-Na-B):2017	Flame Photometer
15.	Potassium	mg/L	APHA,23 <sup>rd</sup> Edition, 3500 K-B: 2017	
16.	Salinity	mg/L	APHA, 23 <sup>rd</sup> Edition (section 2520 B, E.C. Method)	Salinity /TDS Meter
17.	Nitrate	mg/L	APHA, 23 <sup>rd</sup> Edition, 4500 NO3- B: 2017	UV- Visible Spectrophotometer
18.	Nitrite	mg/L	APHA, 23 <sup>rd</sup> Edition, 4500 NO2-B: 2017	
19.	Hexavalent Chromium	mg/L	APHA, 23 <sup>rd</sup> Edition, 3500 Cr B: 2017	
20.	Manganese	mg/L	APHA,23 <sup>rd</sup> Edition, ICP Method 3120 B: 2017	ICP-OES



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

### Monitoring Frequency

Monitoring is required to be carried out once a month for both the locations of Kandla and Vadinar. Sample Collected from this location during the monitoring period April/2023 to March/2024.



## 8.2 Result and Discussion

The drinking water quality of the locations at Kandla and Vadinar and its comparison with the to the stipulated standard (Drinking Water Specifications i.e., IS: 10500:2012) <sup>(4)</sup> have been summarized in **Table 22A, 22B, 22C** as follows:

**Table 22A: Drinking Water Quality for the Monitoring period**

Parameters	Standard values as per IS-		DW-1 (Oil Jetty 7)			DW-2 (Port & Custom Building)			DW-3 (North Gate)			DW-4 (Workshop)			DW-5 (Canteen Area)			DW-6 (West Gate 1)			DW-7 (Sewa Sadan -3)		
	A	P	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
pH	6.5-8.5		7.9	6.6	7.4	8.4	6.8	7.3	8.0	6.8	7.3	8.1	7.1	7.4	8.2	7.3	7.7	8.4	7.2	7.7	8.2	7.2	7.5
Colour (Hazen)	5	15	5.0	1.0	1.7	5.0	1.0	1.3	5.0	1.0	1.3	5.0	1.0	1.3	5.0	1.0	3.3	5.0	1.0	1.7	5.0	1.0	1.3
EC (µS/ cm)			370	19.4	195.6	600.	36.0	153.8	1653	27.0	259.7	401	12.8	85.6	2200	42.0	1056	1470	28.0	336.3	150	22	57.8
Salinity (PSU)			1.0	0.0	0.2	0.3	0.0	0.1	0.8	0.0	0.1	0.2	0.0	0.0	1.1	0.0	0.5	0.7	0.0	0.2	0.1	0	0.0
Turbidity (NTU)	1	5	1.2	1.1	1.1	2.0	1.5	1.8	1.9	0.7	1.2	3.7	0.9	2.3	3.1	0.9	1.9	1.5	1.0	1.2	5.9	1.1	3.5
Chloride (mg/L)	250	1000	81	5.8	41.6	92	7.5	34.1	354.9	8.0	56.9	110	3	22.9	437.4	10.3	192.0	329.9	9.0	78	42.5	6.5	15.7
Total Hardness (mg/L)	200	600	42	3	13.3	148	3	24.8	320	2.0	33.4	20.0	2	7.5	310	10	181	230	5.0	53.2	10	2	4.1
Ca Hardness (mg/L)			27	2	6.3	92	2	13.9	200	1.0	20.3	8.0	1	3.3	210.0	5	103.9	120.0	2.5	28.9	5.0	1	2.2
Mg Hardness (mg/L)			15	1	6.8	56	1	10.1	120	1.0	13.1	12	1	3.9	120.0	5	76.6	110.0	2.0	24.4	5.0	1	2
Free Residual Chlorine (mg/L)	0.2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TDS (mg/L)	500	2000	184	10	101.7	306	20	81.8	840	14	132.7	204	8.0	44.7	928	22	452.4	752	20.0	171.6	78	14	30.8
TSS (mg/L)			0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	0	0	0	0	0	0
Fluoride (mg/L)	1	1.5	0.4	0.4	0.4	0.5	0.4	0.5	0.7	0.3	0.4	0.0	0.0	0.0	0.9	0.3	0.5	0.9	0.7	0.8	0.4	0.4	0.4
Sulphate (mg/L)	200	400	15.7	15.7	15.7	35.7	35.7	35.7	73.9	73.9	73.9	0.0	0.0	0.0	113.3	2.2	64.0	97.3	2	55.3	0	0	0



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Parameters	Standard values as per IS-		DW-1 (Oil Jetty 7)			DW-2 (Port & Custom Building)			DW-3 (North Gate)			DW-4 (Workshop)			DW-5 (Canteen Area)			DW-6 (West Gate 1)			DW-7 (Sewa Sadan -3)		
	A	P	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
Nitrate (mg/L)	45		26	3.7	12.5	4.2	0.5	1.8	7.5	1.3	4.6	2.4	2.4	2.4	8.8	3.4	5.8	5.7	1.3	2.8	2.1	2.1	2.1
Nitrite (mg/L)			0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.1	0.1	0.2	0.2	0.2	0	0	0
Sodium (mg/L)			86	5	34.5	38.5	7	21.2	178.6	9.7	38.0	42.6	5.7	18.0	319.6	12.0	118.4	197.5	8.8	44.1	15.1	5.5	9.6
Potassium (mg/L)			0	0	0	0	0	0	0	0	0	0	0	0	5.8	5.8	5.8	0	0	0	0	0	0
Hexavalent Chromium (mg/L)			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odour (TON)	Agreeable			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Arsenic (mg/L)	0.01	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cadmium (mg/L)	0.003		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper (mg/L)	0.05	1.5	17.3	0	5.8	8.4	0.0	2.8	6.2	0.0	3.1	11.1	0.0	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Iron (mg/L)	0.3		0.6	0	0.3	0.2	0.2	0.2	0.2	0.0	0.1	0.2	0.2	0.2	0.2	0.0	0.1	0.2	0.0	0.1	0.1	0.1	0.1
Lead (mg/L)	0.01		3.1	0	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manganese (mg/L)	0.1	0.3	0.1	0	0.1	0	0	0	0.5	0.5	0.5	0.1	0.1	0.1	0	0	0	0.5	0	0.2	0	0	0
Mercury (mg/L)	0.001		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Chromium (mg/L)	0.05		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zinc (mg/L)	5	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Coliform* (MPN/ 100ml)	Shall not be detected		630.0	5.0	118.0	12500.0	5.0	1629.3	250.0	10.0	100.7	50.0	5.0	24.0	144500	5.0	17137	4350	5.0	1407	23500	2.0	3963.3





**Table 22B: Drinking Water Quality for the Monitoring period**

Parameters	Standard values as per IS		DW-8 (Nirman Building)			DW-9 (Custom Building)			DW-10 (Port Colony Kandla)			DW-11 (Wharf Area/ Jetty)			DW-12 (Hospital Kandla)			DW-13 (A.O. Building)			DW-14 (School Gopalpuri)		
	A	P	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
pH	6.5-8.5		8	7	7.5	8	6.2	7.3	7.9	6.82	7.31	8.3	6.85	7.71	7.75	6.62	7.224	8.5	7.2	7.61	8.2	7.08	7.56
Colour (Hazen)	5	15	5.0	1.0	2.3	5.0	1.0	2.0	5.0	1	2	10	1	3.083	5	1	1.67	5	1	1.33	10	1	3.28
EC (µS/ cm)			2000	40.0	403.8	2900.0	48.0	492.9	3100	105.4	554.9	2460	55	980.1	269	47	141.2	1412	23.2	187.2	1467	43.3	412.15
Salinity (PSU)			1.0	0.0	0.2	1.5	0.0	0.2	1.6	0.05	0.283	1.2	0.02	0.42	0.13	0.03	0.072	0.71	0.02	0.151	0.73	0.03	0.22
Turbidity (NTU)	1	5	3.6	1.1	1.8	4.7	1.0	2.8	2.2	0.95	1.575	3.79	1	2.09	2	1.02	1.57	9.9	0.9	3.67	13.9	0.5	5.48
Chloride (mg/L)	250	1000	499.9	10.0	93.1	689.8	12.5	108.7	504.8	21.99	75.52	404.8	13.54	173.9	67.98	12.5	31.79	307.4	7.5	44.28	332.4	11.5	93.83
Total Hardness (mg/L)	200	600	280.0	4.0	61.8	480	6.0	80.2	340.0	3	62.83	320	15	176.4	30	3	17.84	240	1.5	70.3	270	2	82.64
Ca Hardness (mg/L)			140.0	2.0	31.8	240	3.0	38.7	190.0	2	33.5	170	5	91.30	17	2	9.67	120	1	31.12	140	1.5	42.96
Mg Hardness (mg/L)			140.0	2.0	30.1	190	3.0	37.5	150.0	1	29.32	150	10	84.76	14	1	8.167	120	0.5	33.15	130	2	43.6
Free Residual Chlorine (mg/L)	0.2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TDS (mg/L)	500	2000	1012	22.0	205.2	1522	24.0	255.8	1064	54	165.4	872	29	403.8	138	24	73.17	718	14	101.9	742	22	218
TSS (mg/L)			2.0	2.0	2.0	12.0	2.0	7.0	2.0	2	2	2	2	2	0	0	0	0	0	0	12	8	10
Fluoride (mg/L)	1	1.5	0.0	0.0	0.0	1.5	0.6	1.1	0.5	0.416	0.433	1.06	0.367	0.57	1.108	1.108	1.108	0	0	0	0.35	0.15	0.25
Sulphate (mg/L)	200	400	100.8	45.5	73.2	142.0	41.5	80.0	115.6	3.17	59.39	134.7	1.97	59.51	0	0	0	108.7	108.77	108.7	113.4	11.55	56.304
Nitrate (mg/L)	45		4.5	1.1	2.6	5.6	2.4	3.8	7.5	1.04	3.68	8.49	3.78	5.929	2.023	1.42	1.752	3.392	1.524	2.585	4.48	1.382	2.38



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Parameters	Standard values as per IS		DW-8 (Nirman Building)			DW-9 (Custom Building)			DW-10 (Port Colony Kandla)			DW-11 (Wharf Area/ Jetty)			DW-12 (Hospital Kandla)			DW-13 (A.O. Building)			DW-14 (School Gopalpuri)		
	A	P	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
Nitrite (mg/L)			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0.201	0.11	0.147	0	0	0	0	0	0	0	0	0
Sodium (mg/L)			109.5	9.2	39.4	396.2	8.0	75.4	105.8	11.98	37.65	356.5	12.8	106.5	31.35	11.59	20.22	83.91	8.66	21.44	173.5	6.24	46.666
Potassium (mg/L)			0	0	0	13.6	13.6	13.6	7.0	2.6	4.8	0	0	0	0	0	0	0	0	0	0	0	0
Hexavalent Chromium (mg/L)			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odour (TON)	Agreeable			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Arsenic (mg/L)	0.01	0.05	0	0	0	0	0	0	0	0.007	0.007	0.005	0.0039	0.004	0	0	0	0	0	0	0.015	0.015	0.015
Cadmium (mg/L)	0.003		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.005	0.005	0.005	0.006	0.006	0.006
Copper (mg/L)	0.05	1.5	6.8	0	3.4	0	0	0	10.2	0.005	2.049	0	0	0	9.257	0.005	3.57	0.008	0.0079	0.008	0	0	0
Iron (mg/L)	0.3		0.1	0.1	0.1	0	0	0	0.3	0.0001	0.16	0.17	0.0001	0.092	0	0	0	0.13	0.13	0.13	0.0001	0.0001	0.0001
Lead (mg/L)	0.01		0.2	0	0.1	0	0	0	0	0.0033	0.003	0.004	0.0038	0.004	0.0028	0.003	0.003	0.002	0.002	0.002	4.27	4.27	4.27
Manganese (mg/L)	0.1	0.3	0.2	0.2	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0.05	0.05	0.05	0	0	0
Mercury (mg/L)	0.001		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Chromium (mg/L)	0.05		0	0	0	0	0	0	0	0	0	0	0	0	0.0122	0.012	0.012	0.006	0.006	0.006	0	0	0
Zinc (mg/L)	5	15	0	0	0	0.6	0.6	0.6	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Coliform* (MPN/ 100ml)	Shall not be detected		240.0	2.0	114.7	12050	4.0	1826	37080	35	5374	25550	5	3329	140	4	47.2	685	20	166.7	4900	15	636.4



**Table 22C: Drinking Water Quality for the Monitoring period**

Parameters	Standard values as per IS		DW-15 (Guest House)			DW-16 (E- Type Quarter)			DW-17 (F- Type Quarter)			DW-18 (Hospital Gopalpuri)			DW-19 (Near Vadinar Jetty)			DW-20 (Near Port Colony)		
	A	P	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
pH	6.5-8.5		7.99	6.87	7.35	7.68	6.93	7.28	8.19	6.78	7.46	8.27	7.12	7.6	8.38	7.21	7.685	8.07	7.05	7.435
Colour (Hazen)	5	15	5	1	1.67	5	1	1.67	5	1	1.67	10	1	3.5	5	1	2.333	20	1	6
EC (µS/ cm)			264	34.3	120.22	746	17.79	116.84	1337	15.93	298.6	7930	30.2	1037	537	30	199.7	1736	88.4	427.7
Salinity (PSU)			0.7	0.02	0.113	0.38	0.02	0.06	0.67	0.02	0.16	4.39	0.02	0.55	0.26	0.02	0.100	0.87	0.05	0.235
Turbidity (NTU)	1	5	2.29	0.63	1.27	2.8	0.52	1.50	1.97	1.1	1.66	3.98	0.7	2.03	1.5	1.2	1.35	5.3	0.7	3.25
Chloride (mg/L)	250	1000	60.98	10.5	26.98	124.96	4	24.58	287.41	4	61.99	163.9	9	75.28	66.98	9	27.20	407.37	13	73.15
Total Hardness (mg/L)	200	600	20	2	11.97	180	1.5	22.86	230	2	52.6	195	4	96.25	160	2	44.58	240	20	88.5
Ca Hardness (mg/L)			10	1.5	6.25	80	1	10.77	120	1	28.5	102	2	49.43	80	1.5	21.54	140	10	44.08
Mg Hardness (mg/L)			12.5	1	6.136	100	0.5	13.25	110	1	24.1	100	1	46.79	80	1	25.09	100	8	44.41
Free Residual Chlorine (mg/L)	0.2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TDS (mg/L)	500	2000	138	18	62.75	382	10	60.5	682	8	157.5	448	16	198.8	272	15	100.9	882	46	218.5
TSS (mg/L)			0	0	0	0	0	0	0	0	0	2	2	2	2	2	2	12	4	8
Fluoride (mg/L)	1	1.5	0.34	0.34	0.34	0	0	0	0.5	0.37	0.43	0.51	0.38	0.44	0.35	0.35	0.35	1.06	1.06	1.06
Sulphate (mg/L)	200	400	10.62	10.3	10.46	34.35	34.35	34.35	104.64	8.37	41.20	59.94	1.81	40.82	42.2	13.07	31.87	102.92	25.4	48.22
Nitrate (mg/L)	45		5.63	1.12	2.53	1.97	1.97	1.97	6.06	1.19	3.20	16.51	1.17	5.1	15.79	1.82	5.55	18.54	1.06	6.45
Nitrite (mg/L)			0	0	0	0	0	0	0	0	0	0.20	0.11	0.16	0	0	0	1.89	1.89	1.89



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Parameters	Standard values as per IS		DW-15 (Guest House)			DW-16 (E- Type Quarter)			DW-17 (F- Type Quarter)			DW-18 (Hospital Gopalpuri)			DW-19 (Near Vadinar Jetty)			DW-20 (Near Port Colony)		
	A	P	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
Sodium (mg/L)			40.46	14.3	19.38	74.46	7.06	24.85	82.61	5.75	35.30	185.2	7.08	55.81	58.37	6.08	20.49	204.04	7.18	46.23
Potassium (mg/L)			0	0	0	0	0	0	0	0	0	3.2	3.2	3.2	0	0	0	5.85	5.85	5.85
Hexavalent Chromium (mg/L)			0	0	0	0	0	0	0	0	0	0	0	0	0.041	0.041	0.041	0.01	0.01	0.01
Odour (TON)	Agreeable			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Arsenic (mg/L)	0.01	0.05	0.007	0.007	0.007	0	0	0	0.008	0.008	0.008	0.015	0.01	0.012	0.08	0.08	0.08	0	0	0
Cadmium (mg/L)	0.003		0.007	0.007	0.007	0.006	0.006	0.006	0.007	0.007	0.007	0.008	0.008	0.008	0	0	0	0	0	0
Copper (mg/L)	0.05	1.5	7.24	0.006	2.42	0	0	0	0.012	0.012	0.012	7.3	0.006	3.65	16.25	0.006	7.99	15.403	0.01	3.09
Iron (mg/L)	0.3		0.25	0.0002	0.13	0	0	0	0.52	0.0001	0.213	0.11	0.0003	0.055	1.47	1.47	1.47	0	0	0
Lead (mg/L)	0.01		2.21	0.002	1.10	0	0	0	0	0	0	0	0	0	10.53	0.003	5.26	0.002	0.002	0.002
Manganese (mg/L)	0.1	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.13	0	0.08
Mercury (mg/L)	0.001		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Chromium (mg/L)	0.05		0	0	0	0	0	0	0	0	0	0.006	0.006	0.006	0	0	0	0	0	0
Zinc (mg/L)	5	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Coliform* (MPN/100ml)	Shall not be detected		200	5	57.75	7650	5	1669	57000	9	6635	310	5	131	2850	120	1485	130000	10	16647

A: Acceptable, P:Permissible, BQL: Below Quantification limit Turbidity (QL=0.5 NTU), Free Residual Chlorine (QL=2 mg/L), Total Suspended Solids (QL=2 mg/L), Fluoride (QL=0.3 mg/L), Sulphate (QL=10 mg/L), Nitrate as NO<sub>3</sub> (QL=1 mg/L), Nitrite as NO<sub>2</sub> (QL=0.1mg/L), Sodium as Na (QL=5mg/L), Potassium as K (QL=5mg/L), Hexavalent Chromium (QL=0.01 mg/L), Arsenic (QL=0.005 mg/L), Cadmium (QL=0.002 mg/L), Copper (QL=0.005 mg/L), Iron (QL=0.1mg/L), Lead (QL=0.002 mg/L), Manganese (QL=0.04 mg/L), Mercury (QL=0.0005 mg/L), Total Chromium (QL=0.005 mg/L), Zinc (QL=0.5 mg/L), Total Coliforms (QL=1 MPN/ 100ml)

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

### 8.3 Data Interpretation and Conclusion

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

#### Physico-Chemical Parameters:

- **pH:** The pH values of drinking water samples in Kandla were reported to be in the range of **6.24 to 8.5**, with an average pH of **7.5**. In Vadinar, its values ranged from **7.05 to 8.38**, with an average pH of **7.36**. Notably, the pH levels at both project sites fall within the acceptable range of 6.5 to 8.5, as specified under IS:10500:2012.
- **Colour:** The colour varies from 1 to 10 at the monitoring locations in Kandla. Locations DW-11, DW-14 and DW-10 showed the value of 10 Hazen at Kandla. At Vadinar, the color was observed within the range of 1 to 20 Hazen. the Colour levels at both project sites fall within the acceptable range of 1 to 15, as specified under IS:10500:2012, except of one location DW-20 within the monitoring period of April to May 2023
- **Electrical Conductivity (EC):** It is a measure of the ability of a solution to conduct electric current, and it is often used as an indicator of the concentration of dissolved solids in water. During the monitoring period, the EC values for samples collected in Kandla were observed to range from **12.83 to 7930  $\mu\text{S}/\text{cm}$** , with an average value of **708.65  $\mu\text{S}/\text{cm}$** . In Vadinar, the EC values showed variation from **30 to 1736  $\mu\text{S}/\text{cm}$** , with an average value of **503.14  $\mu\text{S}/\text{cm}$** . It's important to regularly monitor EC levels in drinking water as it can provide valuable information about water quality and presence of dissolved substances.
- **Salinity:** Salinity at Kandla varies from **0.02 to 4.39 PSU** with an average of **0.396 PSU**, while at Vadinar, salinity was observed within the range of **0.02 to 0.87 PSU**.
- **Turbidity:** The Turbidity values of drinking water samples in Kandla were reported to be in the range of **0.5 to 13.9 NTU**, with an average of **2.32**. In Vadinar, its values ranged from **0 to 5.3**, with an average **2.21**. Notably, the Turbidity levels at both project sites fall within the acceptable range of 1 to 5 NTU, as specified under IS:10500:2012, except DW-7, in the monitoring period of July to August 2023, DW-13 in the monitoring period of May to June 2023 and DW-14 in the monitoring period of September to October and October to November 2023. On all this location most of the time Turbidity observed Below Quantification Limit
- **Chlorides:** The chloride concentrations in Kandla varied from **3 to 689.78 mg/L**, with an average value of **116.85 mg/L**. At Vadinar the chloride concentration was observed within the range of **9 mg/L to 407.37 mg/L**, with an average value of **99.45 mg/L**. Thus, the chloride levels at both project sites fall within the Permissible limit of 1000 mg/L, as specified under IS:10500:2012.
- **Total Hardness (TH):** The concentration of Total Hardness varies from **1.5 to 480 mg/L**, with an average concentration of **88.68 mg/L**. While at Vadinar, the observed values were within range of **2 to 240 mg/L**. at both study areas Total Hardness found



to be within the Permissible limit norm of 600 mg/L as specified by IS:10500:2012 and is not harmful for local inhabitants.

- **Total Dissolved Solids (TDS):** Monitoring TDS is crucial because it provides an indication of overall quality of the water. During the monitoring period, the TDS concentrations in Kandla were observed to vary in a wide range i.e., between 8 to **1522** mg/L, with an average concentration of **264.4** mg/L. which is within the permissible limit. while in Vadinar, it ranged from 6 to **882** mg/L, with an average of **255.75** mg/L. It is important to note that the TDS concentrations in both Kandla and Vadinar fall well within the Permissible limit of 2000 mg/L.
- **Fluoride:** The concentration Fluoride varies from 0 to **1.477** mg/L, with an average concentration of **0.44** mg/L. While at Vadinar Fluoride concentration was varies within range of 0 to **1.06** mg/L, with an average concentration of **0.708** mg/L. The Fluoride concentration was found to be **BQL** in majority of the monitoring location at Kandla and Vadinar. at both study areas Fluoride found to be within the Permissible limit norm of 1.5 mg/L as specified by IS:10500:2012
- **Sulphate:** The concentration Sulphate varies from 0 to **141.99** mg/L, with an average concentration of **45.67** mg/L. While at Vadinar Sulphate concentration was varies within range of **13.07** to **102.92** mg/L, with an average concentration of **43.94** mg/L. During monitoring period in Kandla and Vadinar, the sulphate concentrations were found to be within the acceptable limits i.e., 200 mg/L as per the specified norms.
- **Nitrate:** The concentration Nitrate varies from 0 to **25.96** mg/L, with an average concentration of **4.08** mg/L. While at Vadinar Nitrate concentration was varies within range of 0 to **18.54** mg/L, with an average concentration of **8.20** mg/L. The Nitrate concentration was found to be **BQL** in majority of the monitoring location at Kandla and Vadinar. at both study areas Nitrate found to be within the Acceptable limit norm of 45 mg/L as specified by IS: 10500:2012.
- **Nitrite:** The concentration Nitrite varies from 0 to **0.2** mg/L. While at Vadinar Nitrite concentration was varies within range of 0 to **1.89** mg/L, with an average concentration of **0.945** mg/L. The Nitrite concentration was found to be **BQL** in majority of the monitoring location at Kandla and Vadinar.
- **Sodium:** During the monitoring period, at Kandla variation in the concentration of Sodium was observed to be in the range of **5.01** to **396.2** mg/L, with the average concentration of **63.71** mg/L. While at Vadinar, the concentration recorded between **6.08** to **204.4** mg/L, with the average concentration of **57.067** mg/L.
- **Odour:** Odour values recorded 1 TON at all monitoring locations of Kandla and Vadinar.

#### Metals:

- **Arsenic:** The Arsenic concentrations in Kandla varied from 0 to **0.042** mg/L. At Vadinar the Arsenic concentration was observed within the range of 0 mg/L to **0.08** mg/L. Thus, the Arsenic levels at both project sites fall within the Permissible limit of 0.05 mg/L, as specified under IS:10500:2012, except on one location at Vadinar DW-19 where Arsenic Concentration found 0.08 mg/L in the monitoring period of November to December 2023. In Kandla and Vadinar, the Arsenic concentrations were recorded

BQL for majority of the locations except the locations DW-2, DW-12, and DW-18 in Kandla and DW-20 In Vadinar.

- **Copper:** The Copper concentrations in Kandla varied from **0 to 17.3 mg/L**. At Vadinar the Copper concentration was observed within the range of **0 mg/L to 16.25 mg/L**. Thus, the Copper levels at both project sites fall within the Permissible limit of 1.5 mg/L, as specified under IS:10500:2012, except for locations DW-1, DW-2, DW-4, DW-8, DW-10, DW-12, DW-15, DW-18 in Kandla and on both Locations DW-19 and DW-20 of Vadinar for some samples taken during whole monitoring period. The Copper concentrations were recorded BQL for majority of the locations in Kandla and Vadinar.
- **Iron:** The Iron concentrations in Kandla varied from **0 to 0.64 mg/L**, with an average concentration of **0.10 mg/L**. At Vadinar the Iron concentration was observed within the range of **0 mg/L to 1.478 mg/L**. Thus, the Iron levels at both project sites fall within the Acceptable limit of 0.3 mg/L, as specified under IS:10500:2012, except for locations DW-1, DW-10, and DW-17 in Kandla and on Location DW-19 of Vadinar for some samples taken during the whole monitoring period. The Iron concentrations were recorded by BQL for the majority of the locations in Kandla and Vadinar.
- **Lead:** The Lead concentrations in Kandla varied from **0 to 4.279 mg/L**, with an average concentration of **0.37 mg/L**. While at Vadinar the Lead concentration was observed within the range of **0 mg/L to 10.53 mg/L**, with an average concentration of **2.6344**. Thus, the Lead levels at both project sites fall within the Acceptable limit of 0.01 mg/L, as specified under IS:10500:2012, except for locations DW-1, DW-8, DW-14 and DW-15 in Kandla and on Location DW-19 of Vadinar for some samples taken during the whole monitoring period. The Lead concentrations were recorded in BQL for the majority of the locations in Kandla and Vadinar.
- **Manganese:** The Manganese concentrations in Kandla varied from **0 to 0.51 mg/L**, with an average concentration of **0.1 mg/L**. While at Vadinar, the Manganese concentration was observed within the range of **0 mg/L to 0.13 mg/L**. Thus, the Manganese levels at both project sites fall within the Acceptable limit of 0.3 mg/L, as specified under IS:10500:2012, except for locations DW-3, and DW-6 in Kandla and on Location DW-20 of Vadinar for some samples taken during the whole monitoring period. The Manganese concentrations were recorded BQL for the majority of the locations in Kandla and Vadinar.
- The concentrations of parameters such as **Free Residual Chlorine, Total Suspended Solid, Potassium Hexavalent Chromium and the metals (Cadmium, Mercury, Total Chromium and Zinc)** were observed to fall within the Permissible limit at both project sites. Observed “Below the Quantification Limit (BQL)” at majority of the locations during the monitoring period.
- Bacteriological Analysis of the drinking water reveals that **Total Coliforms (TC)** were detected in the range of **0 to 144500 MPN/100ml**, with the average of **6964.8 MPN/100ml**. While at Vadinar the observed within the range of **0 MPN/100ml to 1,30,000 MPN/100ml**, with the average concentration of **25,185 MPN/100ml**. And for the rest of the monitoring locations of Kandla and Vadinar were detected “Below the Quantification Limit (BQL)”. Reporting such concentration of Coliforms indicates

certain external influx may contaminate the source. Hence, it should be checked at every distribution point. The higher concentration of total coliforms were observed on locations DW-2, DW-5, DW-7, DW-10, DW-11, and DW-17 in Kandla and DW-20 location in Vadinar.

#### 8.4 Remedial Measures

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

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

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



## **CHAPTER 9: SEWAGE TREATMENT PLANT MONITORING**

### 9.1 Sewage Treatment Plant (STP) Monitoring:

The principal objective of STP is to remove contaminants from sewage to produce an effluent that is suitable to discharge to the surrounding environment or an intended reuse application, thereby preventing water pollution from raw sewage discharges. As defined in the scope by Deendayal Port Authority (DPA), Kandla, the STP Monitoring is to be carried out weekly at three locations, one at Kandla, one at Gopalpuri and one STP at Vadinar. The samples from the inlet and outlet of the STP have been collected weekly. The details of the locations of STP to be monitored for Kandla and Vadinar have been mentioned in **Table 23A** as follows:

**Frequency of monitoring: weekly**

**Table 23A: Details of the monitoring locations of STP**

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

The Consolidated Consent and Authorization (CC&A) issued by the GPCB were referred for the details of the STP for Kandla and Gopalpuri. The CC&A of Kandla and Gopalpuri entails that the treated domestic sewage should conform to the norms specified in **Table 23B**. The treated effluent conforming to the norms shall be discharged on the land within the premises strictly for the gardening and plantation purpose. Whereas, no sewage shall be disposed outside the premises in any manner.

**Table 22B: Discharge norms (as per CC&A of Kandla STP)**

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

The detailed process flow diagram of the Kandla and Gopalpuri STP have been mentioned in **Figure 3 and 4** as follows:



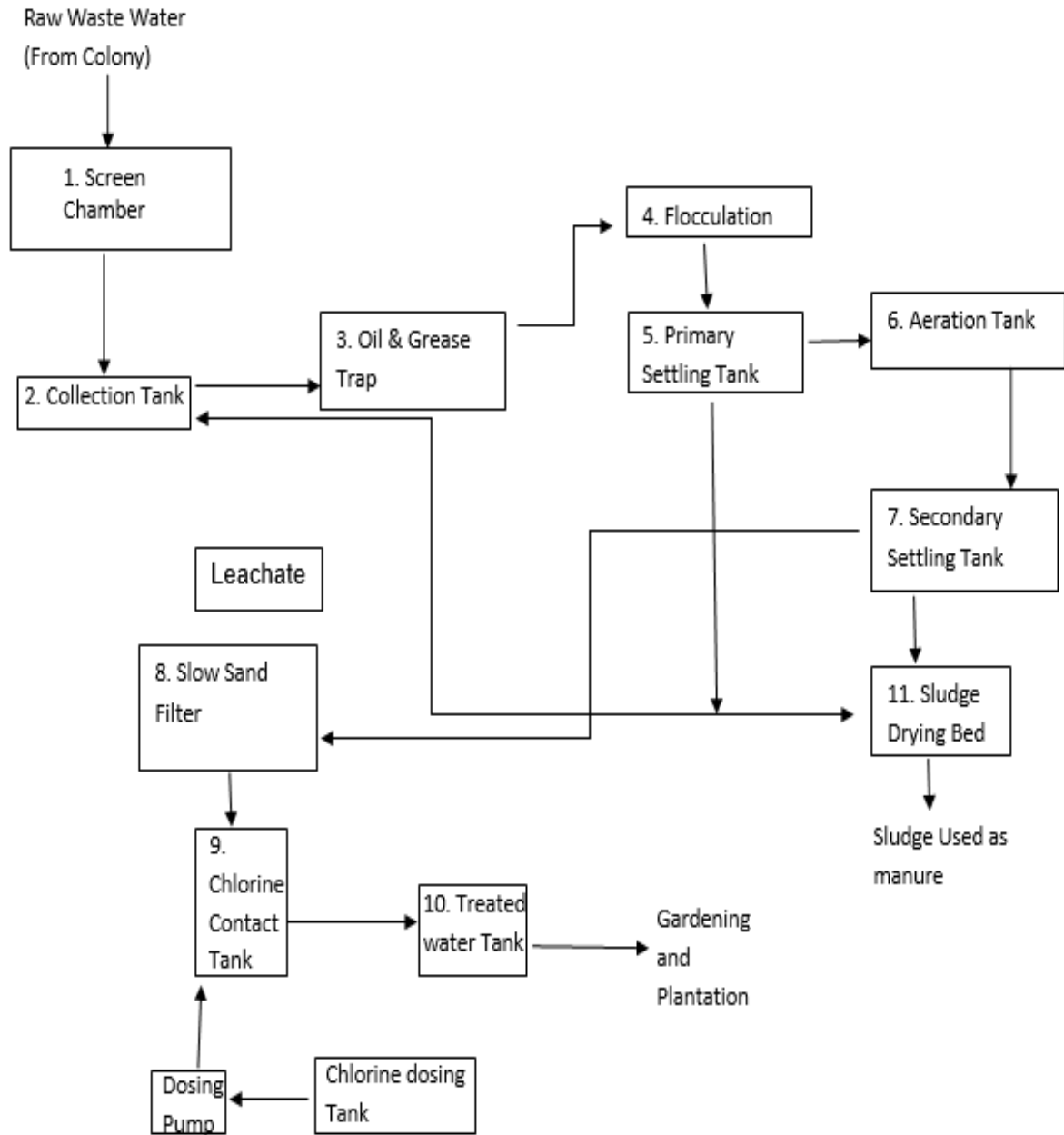


Figure 3: Process flow diagram of STP at Kandla

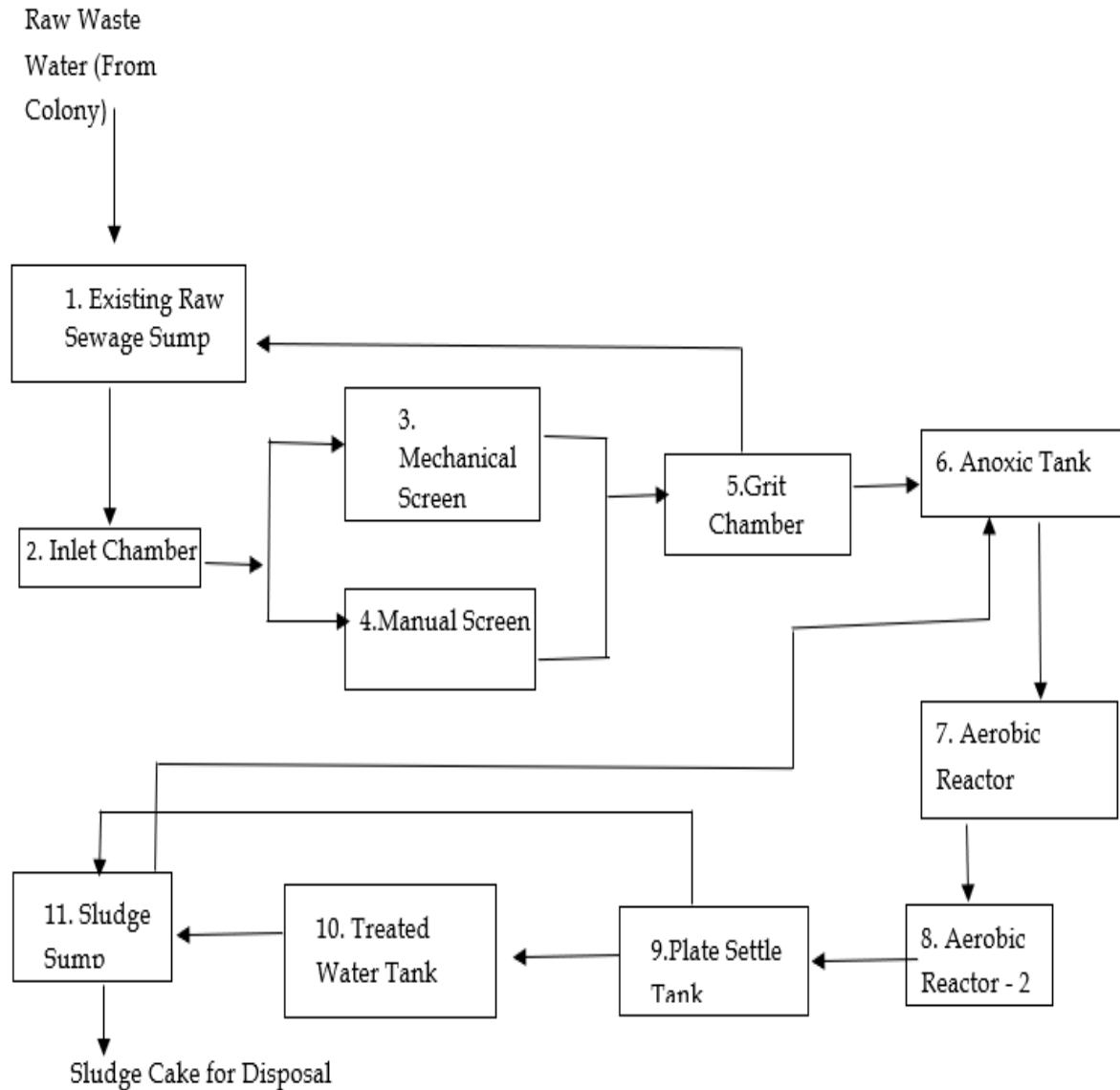


Figure 4: Process flow diagram of STP at Gopalpuri, Kandla

**STP at Vadinar**

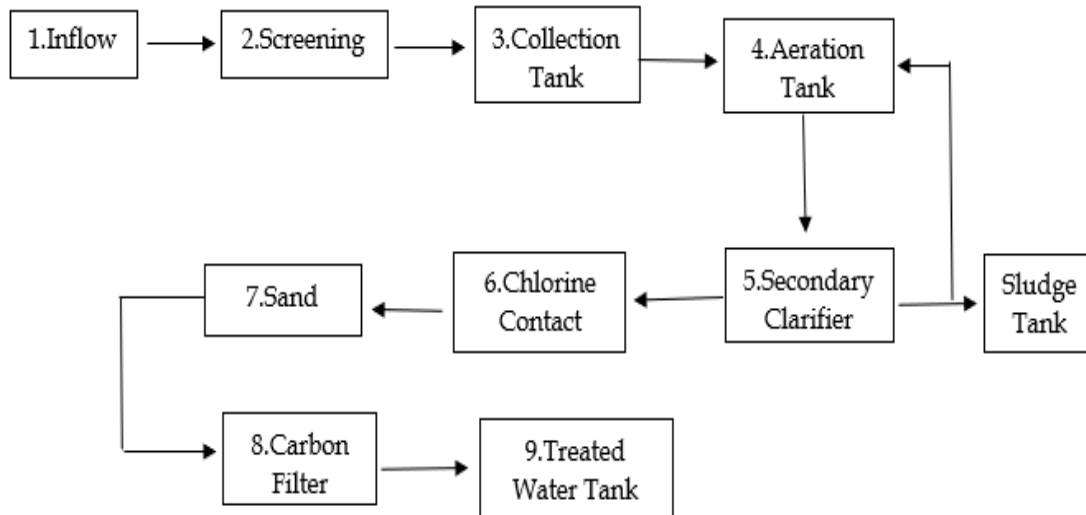
The STP at Vadinar has been built with a treatment capacity of 450 KLD/day. The Consolidated Consent and Authorization (CC&A) issued by the GPCB has been referred for the details of the said STP. The CC&A of the Vadinar STP suggests that the domestic effluent generated shall be treated as per the norms specified in **Table 24**. The treated effluent conforming to the norms shall be discharged on the land within the premises strictly for the gardening and plantation purpose. Whereas, no sewage shall be disposed outside the premises in any manner.

Table 23: Norms of treated effluent as per CC&A of Vadinar STP

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

Sr. No.	Parameters	Prescribed limits
5.	COD	50 mg/L

The detailed process flow diagram of the Vadinar STP have been mentioned in **Figure 5** as follows:



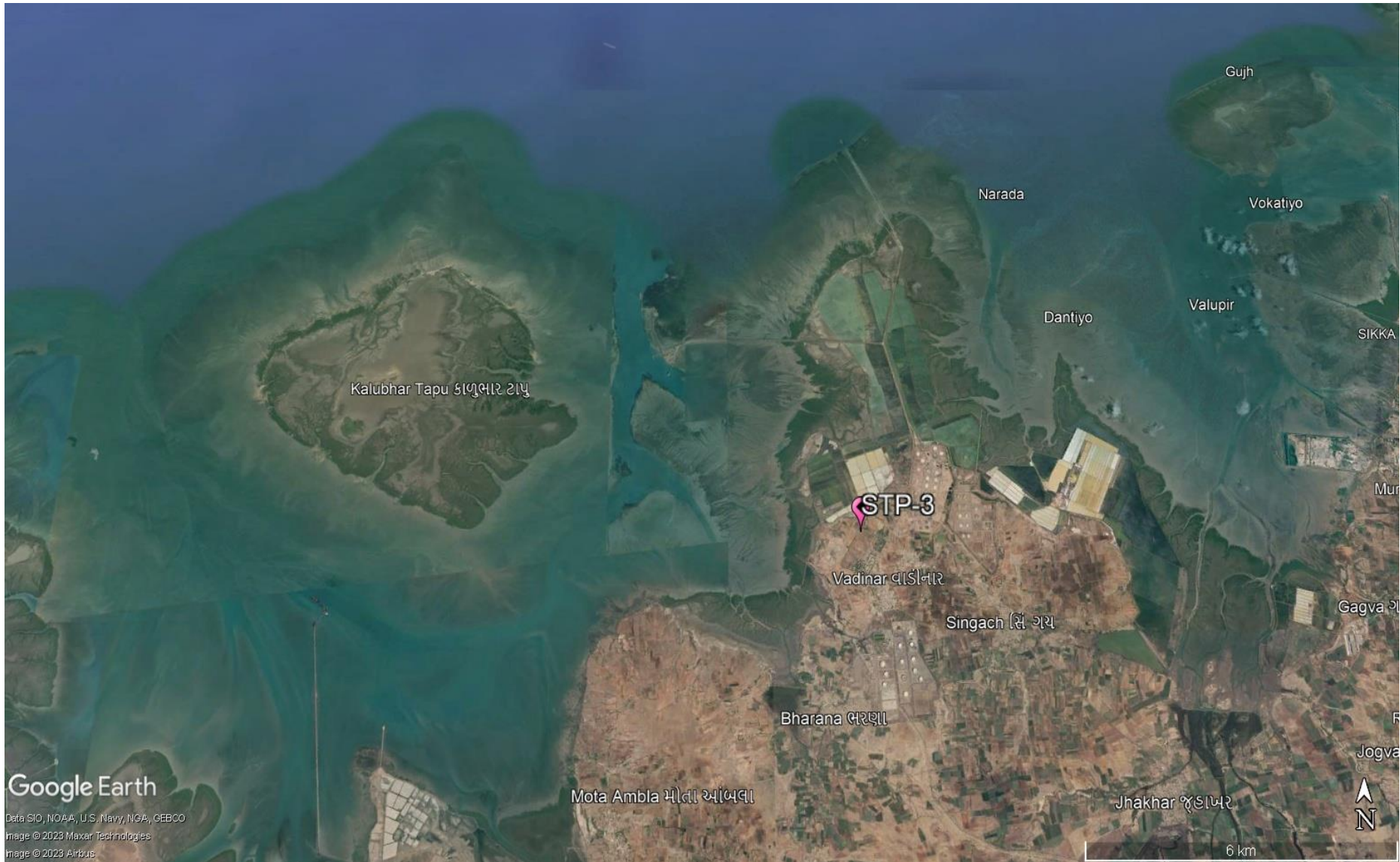
**Figure 5: Process flowchart for the STP at Vadinar**

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



Map 14: STP Monitoring Locations at Kandla





Map 15: STP Monitoring Locations 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:

## Monitoring Frequency

Monitoring is required to be carried out once a week for monitoring location of Kandla and Vadinar i.e., two STP station at Kandla and one STP station at Vadinar. Sample Collected from this location during the monitoring period April 2023 to March 2024.

**Table 24: List of parameters monitored for STP's at Kandla and Vadinar**

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

## 9.2 Result and Discussion

Analytical results of the STP samples collected from the inlet and the outlet of the STP's of Kandla and Vadinar have been summarized in **Table 26**. Further it was compared with the standard norms specified in the CC&A of the respective STPs.

**Table 25: Water Quality of inlet and outlet of STP of Kandla**

Sr No.	Parameter	Units	Kandla							Vadinar			
			GPCB Norms (Kandla)	STP-1			STP-2			GPCB Norms (Vadinar)	STP-3		
				Inlet	Outlet		Inlet	Outlet			Inlet	Outlet	
					Avg	Avg		Max	Avg			Avg	Max
1.	pH	-	6.5-8.5	7.17	7.302	7.65	6.99	7.48	8.88	5.5-9	7.19	7.41	8.46
2.	TDS	mg/L	-	3065.7	2069.28	6228	1099.40	1003.3	1814	-	471.61	402.67	482
3.	TSS	mg/L	100	183.4	20.97	88	115.17	16.45	46	20	38.78	8.42	36
4.	COD	mg/L	-	184.7	32.57	133.1	213.54	25.98	88.4	50	138.27	16.18	40.2
5.	DO	mg/L	-	145.91	37.780	277.09	162.29	21.98	76.92	-	115.12	18.69	54.5
6.	BOD	mg/L	30	56.82	11.937	52.4	61.75	8.40	18.45	10	44.62	6.053	11
7.	SAR	meq/L	-	12.06	9.318	21.04	5.75	5.43	13.1	-	2.71	2.12	3.2
8.	Total Coliforms	MPN/100ml	<1000	1565.95	1530.66	1600	1537.02	1500.51	1600	100-230	1551	1492.3	1600

BQL: Below Quantification limit; Total Suspended Solids (QL=2), Dissolved Oxygen (QL=0.5), Biochemical Oxygen Demand (QL=3 mg/L)

### 9.3 Data Interpretation and Conclusion

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

- The average pH at the inlet of STP-1, STP-2, and STP-3 is, respectively, **7.17, 6.99, and 7.19**. After treatment, the treated effluent from STPs at Kandla (STP-1 and STP-2) and Vadinar (STP-3) had a maximum pH of **7.65, 8.88, and 8.46** and an average pH of **7.302, 7.48, and 7.41**, respectively. Which conform to their respective stipulated norms of 6.5–8.5 at Kandla and 5.5–9 at Vadinar, respectively.
- The average TDS concentrations at the inlet of STP-1, STP-2, and STP-3 are, respectively, **3065.8, 1099.4, and 471.33** mg/L. After treatment, the treated effluent from STPs at Kandla (STP-1 and STP-2) and Vadinar (STP-3) had a maximum TDS concentration of **6228, 1814, and 482** mg/L, and an average TDS concentration of **2069.3, 1003.3, and 402.67** mg/L, respectively.
- The average TSS at the inlet of STP-1, STP-2, and STP-3 is respectively **183.43, 115.17, and 38.78** mg/L. After treatment, the treated effluent from STPs at Kandla (STP-1 and STP-2) and Vadinar (STP-3) had a maximum TSS of **88, 46, and 36** mg/L, and an average TSS of **20.974, 16.452, and 8.41** mg/L, respectively. Which conform to their respective stipulated norms of 100 mg/L at Kandla and 20 mg/L at Vadinar, respectively, as mentioned in their respective CCA, except in STP-3 at Vadinar, which exceeds norms in the 3rd and 4th weeks of April 2023.
- The average COD at the inlet of STP-1, STP-2, and STP-3 is respectively **184.7, 213.54, and 138.27** mg/L. After treatment, the treated effluent from STPs at Kandla (STP-1 and STP-2) and Vadinar (STP-3) had maximum COD concentrations of **133.1, 88.4, and 40.2** mg/L, and average COD concentrations of **32.576, 25.97, and 16.18** mg/L, respectively. There are no discharge norms for the COD parameter in STP-1 and STP-2 at Kandla, and they conform to their respective stipulated norms of 50 mg/L at Vadinar as mentioned in their respective CCA.
- The average DO concentrations at the inlet of STP-1, STP-2, and STP-3 are, respectively, **145.91, 162.29, and 115.12** mg/L. After treatment, the treated effluent from STPs at Kandla (STP-1 and STP-2) and Vadinar (STP-3) had a maximum DO concentration of **277.09, 76.92, and 54.5** mg/L, and an average DO concentration of **37.78, 21.98, and 18.68**, mg/L respectively.
- The average BOD at the inlet of STP-1, STP-2, and STP-3 is respectively **56.82, 61.76, and 44.62** mg/L. After treatment, the treated effluent from STPs at Kandla (STP-1 and STP-2) and Vadinar (STP-3) had a maximum BOD of **52.4, 18.45, and 11** mg/L, and an average BOD of **11.93, 8.40, and 6.05** mg/L, respectively. Which conform to their respective stipulated norms of 30 mg/L at Kandla and 10 mg/L at Vadinar, respectively, as mentioned in their respective CCA, except in STP-3 at Vadinar, which exceeds norms in the 3rd and 4th weeks of April 2023.
- The average SAR concentrations at the inlet of STP-1, STP-2 and STP-3 are respectively **12.068, 5.75 and 2.71** meq/L. After treatment, the treated effluent from

STPs at Kandla (STP-1 and STP-2) and Vadinar (STP-3) having maximum SAR concentration **21.04**, **13.1** and **3.2** meq/L, and having Average SAR concentration **9.31**, **5.46** and **2.12** meq/L respectively.

- The **Total Coliforms** was observed to exceed the norms at the locations of the STP-1 & STP-2 for the treated effluent at Kandla and STP-3 at Vadinar.

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

#### 9.4 Remedial Measures:

- The quantum of raw sewage (influent) entering the STP should be monitored by installation of the flow meter. If the quantity of the sewage exceeds the treatment capacity of the treatment plant, then provision of additional capacity of collection sump should be provided.
- The adequacy and efficacy of the stages of Sewage treatment units shall be conducted.
- The results show the presence of total coliforms; hence the method of disinfection (Chlorination) sodium or calcium Hypochlorite can be used.
- Effectiveness of any technology depends on factors such as the specific pollutants in the wastewater, plant size, local regulations, and available resources. There are several processes that may be implemented such as - Advanced oxidation process involve using strong oxidants to break down complex organic compounds. Methods like Fenton's reagent (hydrogen peroxide and iron catalyst) and UV/H<sub>2</sub>O<sub>2</sub> treatment can help in reducing COD through oxidation.
- Electrochemical processes like Electrocoagulation (EC) and Electrooxidation (EO) that involve the application of an electric current to facilitate the removal of pollutants through coagulation, flocculation, and oxidation. These methods can be useful for treating sewage containing various pollutants.



## **CHAPTER 10: MARINE WATER QUALITY MONITORING**



### 10.1 Marine Water

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

Major water quality concerns at ports include wastewater and leakage of toxic substances from ships, stormwater runoff, etc. This discharge of wastewater, combined with other ship wastes which includes sewage and wastewater from other on-board uses, is a serious threat to the water quality as well as to the marine life. As defined in the scope by DPA, the Marine Water sampling and analysis has to be carried out at a total of eight locations, six at Kandla and two at Vadinar. The marine water sampling has been carried out with the help of Niskin Sampler with a capacity of 5L. The Niskin Sampler is a device used to take water samples at a desired depth without the danger of mixing with water from other depths. Details of the locations to be monitored have been mentioned in **Table 27**:

**Table 26: Details of the sampling locations for Marine water**

Sr. No.	Location Code	Location Name	Latitude Longitude
1.	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.	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: Marine Water Monitoring Locations at Kandla





Map 17: Marine Water Monitoring Locations at Vadinar

## Methodology

The methodology adopted for the sampling and monitoring of Marine Water was carried out as per the ‘**Sampling Protocol for Water & Wastewater**’ developed by GEMI. The water samples collected through the Niskin Sampler are collected in a clean bucket to reduce the heterogeneity. The list of parameters to be monitored under the project for the Marine Water quality have been mentioned in **Table 28** along with the analysis method and instrument.

## Monitoring Frequency

As defined in the scope by DPA, the sampling and analysis of Marine Water has to be carried out once in a month at the eight locations (i.e., six at Kandla and two at Vadinar). For the period April 2023 to March 2024.

**Table 27: List of parameters monitored for Marine Water**

Sr. No	Parameters	Units	Reference method	Instrument
1.	Electrical Conductivity	µS/cm	APHA, 23 <sup>rd</sup> Edition (Section-2510 B):2017	Conductivity Meter
2.	Dissolved Oxygen (DO)	mg/L	APHA, 23 <sup>rd</sup> Edition, 4500 O C, 2017	Titration Apparatus
3.	pH	-	APHA, 23 <sup>rd</sup> Edition (Section-4500-H+B):2017	pH meter
4.	Color	Hazen	APHA, 23 <sup>rd</sup> Edition, 2120 B: 2017	Color comparator
5.	Odour	-	IS 3025 Part 5: 2018	Heating mantle & odour bottle
6.	Turbidity	NTU	IS 3025 Part 10: 1984	Nephlo Turbidity Meter
7.	Total Dissolved Solids (TDS)	mg/L	APHA, 23 <sup>rd</sup> Edition (Section-2540 C):2017	Vaccum Pump with Filtration Assembly and Oven
8.	Total Suspended Solids (TSS)	mg/L	APHA, 23 <sup>rd</sup> Edition, 2540 D: 2017	
9.	Particulate Organic Carbon	mg/L	APHA, 23 <sup>rd</sup> Edition, 2540 D and E	TOC analyser
10.	Chemical Oxygen Demand (COD)	mg/L	IS-3025, Part- 58: 2006	Titration Apparatus plus Digester
11.	Biochemical Oxygen Demand (BOD)	mg/L	IS-3025, Part 44,1993,	BOD Incubator plus Titration apparatus
12.	Silica	mg/L	APHA, 23 <sup>rd</sup> Edition, 4500 C, 2017	UV- Visible Spectrophotometer
13.	Phosphate	mg/L	APHA, 23 <sup>rd</sup> Edition, 4500 P-D: 2017	
14.	Sulphate	mg/L	APHA, 23 <sup>rd</sup> Edition, 4500 SO4-2 E: 2017	
15.	Nitrate	mg/L	APHA, 23 <sup>rd</sup> Edition, 4500 NO3-B: 2017	
16.	Nitrite	mg/L	APHA, 23 <sup>rd</sup> Edition, 4500 NO2- B: 2017	
17.	Sodium	mg/L	APHA, 23 <sup>rd</sup> Edition, 3500 Na-B: 2017	Flame photometer

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

## 10.2 Result and Discussion

The quality of the Marine water samples collected from the locations of Kandla and Vadinar during the monitoring period has been summarized in the **Table 29**. The said water quality has been represented in comparison with the standard values as stipulated by CPCB for Class SW-IV Waters.





Table 28: Results of Analysis of Marine Water Sample for the sampling period

Parameters	Primary Water Quality Criteria for Class SW-IV Waters	Kandla																		Vadinar					
		MW-1			MW-2			MW-3			MW-4			MW-5			MW-6			MW-7			MW-8		
		Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Density (kg/m <sup>3</sup> )	-	1.02	1.03	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02
pH	6.5-9.0	6.12	8.32	7.89	7.04	8.36	7.99	7.83	8.33	8.11	7.69	8.31	8.05	7.19	8.48	8.03	6.01	8.31	7.94	7.98	8.2	8.11	7.07	8.22	8.06
Colour (Hazen)	No Noticeable	1	10	5.41	1	20	7.83	1	15	7.16	5	20	9	5	15	7.41	5	20	8.27	1	10	5.66	1	10	5.08
EC (µS/cm)	-	49700	63600	54282.5	49800	61700	54490.91	50200	60600	53767.75	50400	75300	55689.91	50100	65100	55115.58	15950	61528	50873.17	52200	56900	54239.2	52.119	57500	50312.6
Turbidity (NTU)	-	56.4	310	188.26	33.9	314	206.76	61.8	317	203.81	69	300	216.66	94.5	379	202.5	70.1	346	209.23	3.15	12.5	5.36	3.42	13.8	6.39
TDS (mg/L)	-	24800	44466	36356.3	24900	41922	36679.5	25100	41624	35690.92	25200	64721	38189.5	25000	47159	36938.58	9970	41436	32927.91	25784	38620	35400.16	26882	41790	35965.75
TSS (mg/L)	-	44	436	342.42	26	563	374.58	52	478	340.75	58	924	402.33	80	682	427.66	58	852	387.72	78	341	255.08	151	346	282.33
COD (mg/L)	-	29.2	79.37	49.62	11.98	79.37	47.81	25.41	81	47.68	22.65	81	52.12	31.56	79.37	53.76	22.97	88.8	49.34	21.28	75	50.98	17.92	75	47.63
DO (mg/L)	3.0 mg/L	4.7	6.4	5.76	5.3	6.4	6.07	4.5	6.7	5.87	3.4	6.5	5.85	5	6.6	6.07	5.6	8.4	6.49	4.3	7.6	6.25	4.4	7.9	6.48
BOD (mg/L)	5.0 mg/L	5.24	8.54	7.56	8.4	8.9	8.57	3.74	8.45	6.81	5	8.78	7.755	9.32	9.87	9.57	3.6	11.1	8.64	3.91	7.5	6.51	4.2	7.16	6.16
Oil & Grease (mg/L)	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulphate (mg/L)	-	2056	2937.5	2529.7	2156.32	2897.7	2544.18	2083.7	2925.2	2530.85	2239	3704.9	2879.88	2334.9	2916.8	2652.42	632.62	3612.8	2561.07	1846.3	3225.8	2472.195	2039.9	3236.8	2664.27
Nitrate (mg/L)	-	1.89	5.40	4.28	1.12	5.16	3.75	3.21	5.68	4.17	3.41	5.85	4.64	3.17	6.92	4.21	3.06	6.84	4.06	2.225	5.17	3.56	1.759	5.1	3.39
Nitrite (mg/L)	-	0.12	0.12	0.12	0	0	0	0	0	0	0	0	0	0.11	0.11	0.11	0.13	0.16	0.14	0	0	0	0	0	0!
Phosphate (mg/L)	-	0.25	1.59	0.82	0.09	1.34	0.69	0.57	1.46	0.96	0.61	2.01	0.92	0.29	1.34	0.76	0.54	1.61	0.81	0.64	0.94	0.79	1.43	1.43	1.43
Silica (mg/L)	-	0.29	3.24	2.12	0.22	4.04	2.24	0.2	3.73	2.19	1.12	3.69	2.54	1.26	4	2.64	0.33	3.74	1.92	0.11	0.96	0.56	0.09	1.86	0.76
Sodium (mg/L)	-	7686	10625	9475.57	7811	10341	9242.42	7763	10308	9347.33	9101	10323	9724.14	8789	10278	9403.67	2086	10722	8042.71	2149.6	9485	6743.97	2349.4	9542	7244.66
Potassium (mg/L)	-	68.35	451.9	318.57	69.27	446.5	303.94	68.57	421	290.60	71.73	543.96	342.71	69.63	423.34	324.92	68.34	442.63	272.9	10.86	421.7	259.6	76.31	518	327.43
Hexavalent Chromium (mg/L)	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	321	321	321	333	333	333
Odour	-	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Arsenic (mg/L)	-	5.13	5.13	5.13	5.25	5.25	5.25	5.4	5.4	5.4	0	0	0	0	0	0	9.44	12.94	11.19	0.11	1	0.41	0.08	1	0.38
Cadmium (mg/L)	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper (mg/L)	-	5.1	6.99	5.8175	0.006	10.9	5.79	0.005	7.7	3.85	5.34	12.01	8.224	0.0067	7.6	5.13	8.07	10.2	9.49	3.4	3.4	3.4	0	0	0
Iron (mg/L)	-	0.69	4.11	1.38	0.21	4.07	1.76	0.37	3.92	1.79	1.02	7.93	2.49	0.98	5.45	2.09	0.43	5.3	2.005	0.01	0.25	0.145	0.08	0.66	0.21
Lead (mg/L)	-	0.002	3.44	2.067	0.0029	3.44	2.29	0.0026	3.06	1.98	0.002	9.68	4.32	0.002	4.65	2.39	0.0029	3.65	2.47	0.0023	2.26	1.035	0.002	2.75	0.96
Manganese (mg/L)	-	0.082	129.91	71.47	0.12	159.78	83.88	0.1085	125.66	74.0	0.096	294.91	93.56	0.074	213.14	74.7	0.11	156.41	80.27	2.39	113.93	39.62	1.97	98.8	34.64
Total Chromium (mg/L)	-	0	0	0	5.62	7.8	6.71	5.67	5.67	5.67	5.14	15.99	12.28	5.11	9.65	7.207	0	0	0	0	0	0	45.75	45.75	45.75
Zinc (mg/L)	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mercury (mg/L)	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Particulate Organic	-	0.51	900	76.22	0.51	35	3.98	0.42	10	1.94	0.58	55	6.03	0.92	30	3.89	0.85	44	5.01	0.47	4.67	1.62	0.32	4.76	1.51



- TSS values in the studied area varied between **26 to 924 mg/L** at Kandla and **78 to 346 mg/L** at Vadinar, with the average value of **362.69 mg/L** and **242.23 mg/L** respectively for Kandla and Vadinar.
- COD varied between **11.98 to 88.8 mg/L** at Kandla and **17.92 to 75 mg/L** at Vadinar, with the average value as **51.83 mg/L** and **47.86 mg/L** respectively for Kandla and Vadinar.
- DO level in the studied area varied between **3.4 to 8.4 mg/L** at Kandla and **4.3 to 7.9 mg/L** at Vadinar, with the average value of **5.86 mg/L** and **6.15 mg/L** respectively for Kandla and Vadinar. Which represents that the marine water is suitable for marine life.
- BOD observed was observed in the range of **3.6 to 11.1 mg/L**, with average of **7.76 mg/L** for the location of Kandla and for the locations of Vadinar, it was observed in the range of **3.91 to 7.5 mg/L**, with an average value of **5.9 mg/L**.
- Sulphate concentration in the studied area varied between **632.92 to 3704.9 mg/L** at Kandla and **1846.3 to 3236.8 mg/L** at Vadinar. The average value observed at Kandla was **2566.45 mg/L**, whereas **2580.87 mg/L** was the average value of Vadinar. Sulphate is naturally formed in inland waters by mineral weathering or the decomposition and combustion of organic matter.
- Nitrate in the study area was observed in the range of **1.12 to 6.92 mg/L**, with the average of **4.26 mg/L**. Whereas for the Vadinar the concentration of Nitrate was observed in the range of **1.759 to 5.17 mg/L**, with the average **3.53 mg/L**.
- Nitrite in the study area was observed in the range of **0 to 0.16 mg/L**, with the average of **0.625 mg/L**. Whereas for the Vadinar the concentration of Nitrite was observed Below Quantification Limit During whole monitoring period.
- Phosphate in the study area was observed in the range of **0.09 to 2.01 mg/L**, with the average of **0.92 mg/L**. Whereas for the Vadinar the concentration of Phosphate was observed in the range of **0.64 to 1.43 mg/L**, with the average **1.11 mg/L**.
- Silica in the study area was observed in the range of **0.2 to 4.04 mg/L**, with the average of **2.19 mg/L**. Whereas for the Vadinar the concentration of silica was observed in the range of **0.09 to 1.86 mg/L**, with the average **0.724 mg/L**.
- In the study area of Kandla the concentration of Potassium varied between **68.34 to 543.68 mg/L** and **10.86 to 518 mg/L** at Vadinar, with the average value as **277.71 mg/L** and **268.99 mg/L** respectively for Kandla and Vadinar.
- Sodium in the study area varied between **2,086 to 10,722 mg/L**, with average of **8948.26 mg/L**, at Kandla whereas at Vadinar its value recorded within range of **2149.6 to 9542 mg/L**, with the average of **6252.43 mg/L**.
- Odour was observed 1 for all locations of Kandla and Vadinar.
- Arsenic concentration observed to be BQL for majority of location for Kandla and Vadinar except locations MW-1, MW-2, MW-3, MW-6, MA-7 and MW-8 for some instant of time during whole monitoring period.
- Copper in the study area varied between **0.005 to 12.01 mg/L**, with average of **6.23 mg/L**, at Kandla whereas at Vadinar its value recorded within range of **0 to 3.4 mg/L**,

with the average of **2.04 mg/L**, on both project sites during monitoring majority of time Copper found Below Quantification Limit.

- **Iron** in the studied area varied between **0.21 to 7.93 mg/L**, with the average of **2.55 mg/L**, at Kandla, and for Vadinar value were recorded within range of **0.01 to 0.66 mg/L**, with average value of **0.22 mg/L**.
- **Lead** concentration varied **0.002 to 9.68 mg/L**, with an average of **2.41 mg/L** at Kandla. At Vadinar location within range of **0.002 to 2.753 mg/L** with an average **1.17 mg/L**
- **Manganese** in the studied area varied between **0.0748 to 294.91 mg/L**, with the average of **86.57 mg/L**, at Kandla and for Vadinar, recorded value were observed within the range of **1.97 to 113.93 mg/L**, with the average of **48.56 mg/L**.
- **Total Chromium** in the study area varied between **0 to 15.99 mg/L**, with average of **5.13 mg/L**, at Kandla whereas at Vadinar its value recorded **45.76 mg/L** at MW-8 in the monitoring period of January to February 2024, While on both project sites during monitoring majority of time Total Chromium found Below Quantification Limit
- **Particulate Organic Carbon** in the study area was observed in the range of **0.42 to 900**, with the average value of **65.27**. the maximum spike of 900 is only observed once in the period of April to May 2023 during whole monitoring period. Whereas for the Vadinar, the value observed was Within the range of **0.32 to 4.76**, with the average of **2.22**.
- **Oil & Grease, Nitrite, Phosphate, Hexavalent Chromium, Arsenic, Cadmium, Total Chromium, Zinc, Mercury and Floating Material (Oil grease scum, petroleum products)** were observed to have concentrations “**Below the Quantification Limits (BQL)**” for most of the locations of Kandla and Vadinar, majority of time during whole monitoring period.
- **Total Coliforms** were detected complying with the specified norm of 500 MPN/100ml for all the locations of Kandla and Vadinar, except on location MW-1 in the month of May to June 2023.

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

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



## **CHAPTER 11: MARINE SEDIMENT QUALITY MONITORING**



## 11.1 Marine Sediment Monitoring

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

The materials or part of materials spilled over the water during loading and unloading operations lead to the deposition in the harbour water along with sediment and thus collected as harbour sediment sample. These materials, serve as receptor of many trace elements, which are prone to environment impact. In this connection it is pertinent to study the concentration and distribution of environmentally sensitive elements in the harbour sediment. However, human activities result in accumulation of toxic substances such as heavy metals in marine sediments. Heavy metals are well-known environmental pollutants due to their toxicity, persistence in the environment, and bioaccumulation. Metals affect the ecosystem because they are not removed from water by self-purification, but accumulate in sediments and enter the food chain.

### Methodology

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

**Table 29: Details of the sampling locations for Marine Sediment**

Sr. No	Location Code	Location Name	Latitude Longitude	
1.	Kandla	MS-1	Near Passenger Jetty One	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: Marine Sediment Monitoring Location at Kandla





Map 19: Marine Sediment Monitoring Locations at Vadinar

The list of parameters to be monitored under the projects for the Marine Sediment sampling been mentioned in **Table 31** as follows:

**Table 30: List of parameters to be monitored for Sediments at Kandla and Vadinar**

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

## 11.2 Result and Discussion

The quality of Marine Sediment samples collected from the locations of Kandla and Vadinar during the monitoring period of April 2023 to March 2024 has been summarized in the **Table 32**.



**Table 31: Summarized result of Marine Sediment Quality**

Parameters	Kandla																		Vadinar					
	MS-1			MS-2			MS-3			MS-4			MS-5			MS-6			MS-7			MS-8		
	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
<b>Inorganic Phosphate (kg/ha)</b>	16.85	0.86	6.6042	14.37	0.67	8.81	41.2	0.8	16.98	19.44	0.81	9.532	45.1	0.72	14.48	34.6	0.66	15.24	14.5	1.24	5.65	18.51	0.82	5.7325
<b>Phosphate (mg/Kg)</b>	3247.8	290.8	1280.63	2514.7	258.3	1304	3736	226.6	1515	3871	353.7	1287	3741	306.8	1442	14076	578.3	2793.9	3002	152.5	770.24	3477.29	167.93	940.70
<b>Organic Matter (%)</b>	1.42	0.21	0.7875	2.17	0.29	1.13	1.01	0.17	0.593	2.1	0.33	0.975	1.24	0.67	0.911	2.06	0.21	0.915	2.29	0.15	1.04	1.65	0.17	0.89
<b>Sulphate as SO<sup>4-</sup> (mg/Kg)</b>	905.25	110.2	366.8	1022.25	98.2	370.03	571.64	95.33	275.09	650.25	97.45	268.51	768	87.28	294.27	732	96.38	249.1	296	74.07	126.31	213.4	80.06	132.03
<b>Calcium as Ca (mg/Kg)</b>	13800	1612	3464.3	5800	1259	2836	4200	962	2163	4200	1102	2669	10500	1089	3102	3800	1047	2274.6	3700	2200	2930.9	3974.2	2100	2805.45
<b>Magnesium as Mg (mg/Kg)</b>	1952	1225	1538.53	3050	826.46	1810.84	2136	764	1592.59	3172	866.94	1810.6	2440	1032	1622.80	2745	906.98	1581.95	1952	854	1385.18	14640	1167	2920.83
<b>Silica (g/Kg)</b>	671.25	261.3	479.11	612.51	289.4	481.7	571.5	329.1	444.8	555.2	245.7	392.1	597.1	179.2	418.6	580.4	245.3	436.12	529.8	220.9	377.71	546.08	264.92	426.66
<b>Nitrite (mg/Kg)</b>	0.75	0.12	0.41	0.92	0.13	0.50	0.81	0.08	0.41	0.91	0.01	0.43	0.71	0.11	0.375	0.89	0.07	0.489	0.22	0.07	0.159	0.37	0.04	0.23
<b>Nitrate (mg/Kg)</b>	22.34	5.86	16.58	37.12	7.59	18.29	36.47	4.51	15.50	25.94	4.31	13.99	10.34	5.24	13.17	20.38	6.34	14.52	25.33	9.54	15.36	25.21	4.75	10.52
<b>Sodium (mg/Kg)</b>	7860	3194	4512.43	14688	2453	5318	8612	2072	4550	18308	2612	6435	10520	2063	4665	14076	2072	5639.6	11944	3971	7904.6	13660	2719.42	9536.63
<b>Potassium (mg/Kg)</b>	2610.7	241	1525.98	11580	276	2320	3479	260.7	2126	4208	294	2424	3152	205	1790	3479	236.9	2233.4	3372	699	1876.1	4377	1028	2025.66
<b>Aluminium (mg/Kg)</b>	8371.7	2116	3827.74	10641	1237.1	4465.9	10363.1	1278.5	4370.2	12008.4	1971.2	5025.2	10361.1	1264.58	3891.23	12314.1	1273.22	4384.20	14179.7	358.3	4028.56	19356.55	479.16	4883.52
<b>Mercury (mg/Kg)</b>	4.71	4.71	4.71	10.74	10.74	10.74	41.29	41.29	41.29	6.44	6.44	6.44	15.21	15.21	15.21	34.69	34.69	34.69	0	0	0	0	0	0
<b>Texture</b>	Sandy loam	Sandy loam	Silt loam	Sandy loam	Silt loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Loam	Loam	Loam



### 11.3 Data Interpretation and Conclusion

The Marine sediment quality at Kandla and Vadinar has been monitored for various physico-chemical parameters during the monitoring April 2023 to March 2024. The detailed interpretation of the parameters is given below:

- **Inorganic Phosphate** for the sampling period was observed in range of **0.66 to 45.12** Kg/ha for Kandla. Whereas for Vadinar the value observed Within range of **0.82 to 18.51** Kg/ha. For Kandla and Vadinar the average value of Inorganic Phosphate was observed **13.77** and **7.74** Kg/ha respectively.
- The concentration of **Phosphate** was observed in range of **226.6 to 3871.15 mg/Kg** for Kandla and for Vadinar the value observed within the range of **152.53 to 3477.29** mg/Kg. For Kandla and Vadinar the average concentration of Phosphate was observed **1616.78** and **1418.5** mg/Kg respectively.
- The **Organic Matter** for the sampling period was observed in the range of **0.17 to 2.17** % for Kandla with the average value of **0.95%** and for Vadinar the value recorded Within range of **0.15 to 2.29%**, with average concentration as **1.03** %.
- The concentration of **Sulphate** was observed in the range of **87.28 to 1022 mg/Kg** for Kandla and for Vadinar the value observed Within range of **74.07 to 296** mg/Kg. For Kandla and Vadinar the average value of Sulphate was observed **392.10** and **153.64** mg/Kg respectively.
- The value of **Calcium** was observed in the range of **962 to 13800 mg/Kg** for Kandla and for Vadinar the value observed within the range of **2100 to 3974.5** mg/Kg. The average value of Calcium for the monitoring period was observed **3660.21** mg/Kg and **2951.76** mg/Kg at Kandla and Vadinar, respectively.
- The value of **Magnesium** for the sampling period was observed in the range of **764 to 3172 mg/Kg** for Kandla and for Vadinar the value observed Within the range of **854 to 1952** mg/Kg. For Kandla and Vadinar the average value of Magnesium was observed **1726.35** mg/Kg and **1440.69** mg/Kg respectively.
- For the sampling period **Silica** was observed in the range of **179.25 to 671.25 mg/Kg** for Kandla with average value **432.83** mg/Kg and for Vadinar the value observed within the range of **220.98** and **546.5** mg/Kg with average **394.35** mg/Kg.
- The value of **Nitrate** was observed in the range of **4.31 to 37.12 mg/Kg** for Kandla with average value **15.47** mg/Kg and for Vadinar the value observed within the range of **4.75 to 25.33** mg/Kg. with average **15.12** mg/Kg.
- The value of **Nitrite** was observed in the range of **0.01 to 0.92 mg/Kg** for Kandla with average value **0.45** mg/Kg and for Vadinar the value observed to be within the range of **0.04 to 0.37** mg/Kg, with average **0.1828** mg/Kg.
- The value of **Sodium** was observed in the range of **2063.3 to 18308 mg/Kg** for Kandla with average value **6647.43** mg/Kg and for Vadinar the value observed within the range of **2719.42** and **13660** mg/Kg, with average **8289** mg/Kg.
- The value of **Potassium** was observed in the range of **205.08 to 11580 mg/Kg** for Kandla with average value **2357.95** mg/Kg and for Vadinar the value observed within range of **699.09 to 4377** mg/Kg, with average **2229.65** mg/Kg.

- The value of **Aluminium**, was observed in the range of **1237.13 to 12314.13 mg/Kg** for Kandla with average value **5509.23 mg/Kg** and for Vadinar the value observed within the range of **358.3 to 19356 mg/Kg**, with average **7214.30 mg/Kg**.
- The value of **Mercury**, was observed in the range of **4.71 to 41.29 mg/Kg** for Kandla with average value **18.84 mg/Kg** and for Vadinar the value of **Mercury** was observed “Below the Quantification Limit” at both two locations. During monitoring period majority of time Mercury was observed Below Quantification limit.
- Texture was observed to be “**Sandy Loam**” at location MS-1, MS-2, MS-4 and MS-6 “**Silt loam**” at location MS-3 & MS-5 in Kandla. “**Sandy Loam**” at location MS-7 & “**Silt loam**” at location MS-8 in Vadinar during sampling period.

### Heavy Metals

The sediment quality of Kandla and Vadinar has been compared with respect to the Average Standard guideline applicable for heavy metals in marine sediment specified by EPA have been mentioned in **Table 33**.

**Table 32: Standard Guidelines applicable for heavy metals in sediments**

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

ND = Not Detected

(Source: G Perin et al. 1997)

**Table 33: Comparison of Heavy metals with Standard value in Marine Sediment**

Parameters	Kandla																		Vadinar					
	MS-1			MS-2			MS-3			MS-4			MS-5			MS-6			MS-7			MS-8		
	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
<b>Arsenic (mg/Kg)</b>	5.13	1.09	3.527	4.43	2.11	3.264	6.17	2.06	3.92	5.86	1.28	3.75	5.2	1.75	3.458	5.78	1.98	3.67	5.36	2.04	2.84	5.17	2.5	3.69
<b>Copper (mg/Kg)</b>	5.6	2.13	3.282	11.4	2.14	5.013	8.1	2.08	4.49	9.8	3.48	5.71	12	2.14	5.97	8.9	2.98	4.97	6.13	2.19	4.567	412	2.1	39.05
<b>Chromium (mg/Kg)</b>	64.1	42.12	53.94	67.45	32.74	47.04	73.02	32.41	48.31	83.23	41.08	55.17	59.95	41.87	51.50	104.2	36.71	59.71	59.27	23.18	44.01	104.1	29.7	61.12
<b>Nickel (mg/Kg)</b>	51.4	16.8	31.76	38.9	10.21	23.87	36.41	4.54	22.77	40.87	7.61	27.45	31.86	21.72	25.881	50.78	4.54	25.058	36.21	12.23	22.84	43.66	12.47	29.282
<b>Lead (mg/Kg)</b>	7.05	1.25	5.3	7.45	4.21	5.76	28.73	2.36	6.683	8.25	3.46	5.9	14.22	1.21	6.055	5.01	2.81	7.88	7.94	2.85	4.90	10.58	2.97	5.65
<b>Zinc (mg/Kg)</b>	63.2	35.88	54.63	65.69	32.11	50.455	301.32	23.63	69.545	82.9	18.15	50.86	159.42	19.54	60.65	157.82	23.63	57.7	52.13	11.47	34.6	104.87	13.65	53.8595
<b>Cadmium (mg/Kg)</b>	1.08	0.88	0.98	0.6	0.6	0.6	1.25	0.87	1.1	1.12	0.78	1.022	1.08	0.91	0.995	7.53	0.15	2.302	0	0	0	0	0	0

- Arsenic** was observed in the range of **1.09 to 6.17 mg/Kg** for Kandla with average value **3.58 mg/Kg** and for Vadinar the value observed within range of **2.04 to 5.36 mg/Kg**, with average of **3.6 mg/Kg**. during monitoring period majority of time arsenic concentration found within moderately polluted class on both study area.
- Copper** was observed in the range of **2.08 to 12 mg/Kg** for Kandla with average value **5.6 mg/Kg** and for Vadinar the value observed within the range of be **2.1 to 8.33 mg/Kg**, with average **4.72 mg/Kg**. With reference to the guidelines mentioned in table 35, the sediment quality with respect to copper falls in non-polluted class.
- Chromium** was observed in the range of **32.41 to 104.24 mg/Kg** for Kandla with average value **55.25 mg/Kg** and for Vadinar the value observed within the range of **23.18 to 104.16 mg/Kg**, with average **53.57 mg/Kg**. With reference to the guidelines mentioned in table 35, the sediment quality with respect to chromium falls majority of time in moderately polluted and for some instance it location MS-4, MS-6, and MS-8 fall in Heavily polluted class.
- Nickel** was observed in the range of **4.54 to 51.47 mg/Kg** for Kandla with average value **26.25 mg/Kg** and for Vadinar the value observed within range of **12.23 to 43.66 mg/Kg**, with average **26.115 mg/Kg**. With reference to the guidelines mentioned in table 35, the sediment quality with respect to nickel falls in moderately polluted class and for some instance it location MS-1, and MS-6 fall in heavily polluted class.

- **Lead** was observed in the range of **1.21 to 28.73 mg/Kg** for Kandla with average value **5.63 mg/Kg** and for Vadinar the value observed within the range of **2.85 and 10.58 mg/Kg**, with average **5.81 mg/Kg**. With reference to the guidelines mentioned in table 35, the sediment quality with respect to lead falls in not polluted class.
- **Zinc** was observed in the range of **18.15 to 301.32 mg/Kg** for Kandla with average value **73.73 mg/Kg** and for Vadinar the value observed within the range of **11.47 to 104.87 mg/Kg**, with average **46.997 mg/Kg**. With reference to the guidelines mentioned in table 35, the sediment quality with respect to zinc falls in non-polluted class and for some instance its location MS-1, MS-3, MS-6 and MS-8 fall in Moderately polluted class.
- **Cadmium** was observed in the range of **0.15 to 7.53 mg/Kg** for Kandla with average value **1.325 mg/Kg**. During the monitoring period majority of time **Cadmium** found BQL, which falls in non-polluted. While exception on one location MS-6 fall within moderately polluted for the duration of July to August 2023. **Cadmium** was observed BQL for all locations at Vadinar during sampling period. With reference to the guidelines mentioned in table 35, the sediment quality with respect to cadmium falls in non-polluted class.

Analysis of the sediments indicates moderate pollution. However, it may be noted that, the sediments are highly dynamic being constantly deposited and carried away by water currents. Hence maintaining the quality of sediments is necessary as it plays a significant role in regulating the quality of the marine water and the marine ecology.

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



## **CHAPTER 12: MARINE ECOLOGY MONITORING**



## 12.1 Marine Ecological Monitoring

The monitoring of the biological and ecological parameters is important in order to assess the marine environment. A marine sampling is an estimation of the body of information in the population. The theory of the sampling design is depending upon the underlying frequency distribution of the population of interest. The requirement for useful water sampling is to collect a representative sample of suitable volume from the specified depth and retain it free from contamination during retrieval. Deendayal Port and its surroundings have mangroves, mudflats and creek systems as major ecological entities.

As defined in the scope by DPA, the Marine Ecological Monitoring is required to be carried out once a month specifically at eight locations, six at Kandla and two at Vadinar. The sampling of the Benthic Invertebrates has been carried out with the help of D-frame nets, whereas the sampling of zooplankton and phytoplankton has been carried out with the help of Plankton Nets (60 micron and 20 micron). The details of the locations of Marine Ecological Monitoring have been mentioned in **Table 35** as follows:

**Table 34: Details of the sampling locations for Marine Ecological**

Sr. No.	Location Code	Location Name	Latitude Longitude	
1.	Kandla	ME-1	Near Passenger Jetty One	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 Marine Ecological Monitoring: Locations at Kandla





Map 21: Marine Ecological Monitoring Locations at Vadinar

The various parameters to be monitored under the study for Marine Ecological Monitoring are mentioned in **Table 36** as follows:

**Table 35: List of parameters to be monitored for Marine Ecological Monitoring**

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

## Methodology

- **Processing for chlorophyll estimation:**

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

- **Phytoplankton Estimation**

Phytoplankton are free floating unicellular, filamentous and colonial eutrophic organisms that grow in aquatic environments whose movement is more or less dependent upon water currents. These micro flora acts as primary producers as well as the basis of food chain, source of protein, bio-purifier and bio-indicators of the aquatic ecosystems of which diverse array of the life depends. They are considered as an important component of aquatic flora, play a key role in maintaining equilibrium between abiotic and biotic components of aquatic ecosystem. The phytoplankton includes a wide range of photosynthetic and phototrophic organisms. Marine phytoplankton is mostly microscopic and unicellular floating flora, which are the primary producers that support the pelagic food-chain. The two most prominent groups of phytoplankton are Diatoms (*Bacillariophyceae*) and Dinoflagellates (*Dinophyceae*). Phytoplankton also include numerous and diverse collection of extremely small, motile algae which are termed micro

flagellates (naked flagellates) as well as Cyanophytes (Bluegreen algae). Algae are an ecologically important group in most aquatic ecosystems and have been an important component of biological monitoring programs. Algae are ideally suited for water quality assessment because they have rapid reproduction rates and very short life cycles, making them valuable indicators of short-term impacts. Aquatic populations are impacted by anthropogenic stress, resulting in a variety of alterations in the biological integrity of aquatic systems. Algae can serve as an indicator of the degree of deterioration of water quality, and many algal indicators have been used to assess environmental status.

- **Zooplankton Estimation**

**Zooplankton** includes a taxonomically and morphologically diverse community of heterotrophic organisms that drift in the waters of the world's oceans. Qualitative and quantitative studies on zooplankton community are a prerequisite to delineate the ecological processes active in the marine ecosystem. Zooplankton community plays a pivotal role in the pelagic food web as the primary consumers of phytoplankton and act as the food source for organisms in the higher trophic levels, particularly the economically essential groups such as fish larvae and fishes. They also function in the cycling of elements in the marine ecosystem. The dynamics of the zooplankton community, their reproduction, and growth and survival rate are all significant factors determining the recruitment and abundance of fish stocks as they form an essential food for larval, juvenile and adult fishes. Through grazing in surface waters and following the production of sinking faecal matters and also by the active transportation of dissolved and particulate matter to deeper waters via vertical migration, they help in the transport of organic carbon to deep ocean layers and thus act as key drivers of 'biological pump' in the marine ecosystem. Zooplankton grazing and metabolism also, transform particulate organic matter into dissolved forms, promoting primary producer community, microbial demineralization, and particle export to the ocean's interior. The categorisation of zooplankton into various ecological groups is based on several factors such as duration of planktonic life, size, food preferences and habitat. As they vary significantly in size from microscopic to metazoic forms, the classification of zooplankton based on size has paramount importance in the field of quantitative plankton research.

- **Diversity Index**

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

1. **Shannon-Wiener's index:**

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



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

Where,  $\sum$  = Summation symbol,

$p_i$  = Relative abundance of the species,

$\ln$  = Natural logarithm

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

## 2. Simpson's index:

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

The formula for calculating D is presented as:

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

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

## 3. Margalef's diversity index:

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

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

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

Where, N = total number of individuals collected

S = No. of taxa or species or genera

## 4. Berger-Parker index:

This is a useful tool for tracking the biodiversity of deteriorated ecosystems. Environmental factors have a considerable impact on this index, which accounts for the

dominance of the most abundant species over the total abundance of all species in the assemblage. The preservation of their biodiversity and the identification of the fundamental elements influencing community patterns are thus critical for management and conservation. Successful colonising species will dominate the assemblage, causing the Berger-Parker index to rise, corresponding to well-documented successional processes. The environmental and ecological features of the system after disturbance may therefore simply but significantly determine the identity of the opportunistic and colonising species through niche selection processes.

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

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

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

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

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

## 5. Evenness index-

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

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

Where, H= Shannon value

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

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

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

The basic idea of index is to obtain a quantitative estimate of biological variability that can be used to compare biological entities composed of discrete components in space and time. Biodiversity is commonly expressed through indices based on species richness and species abundances. Biodiversity indices are a non-parametric tool used to describe the relationship between species number and abundance. The most widely used bio diversity indices are Shannon Weiner index and Simpson’s index.

**Monitoring Frequency:**

Monitoring is required to be carried out once a month for both the locations of Kandla and Vadinar. Sample Collected from this location during the monitoring period April 2023 to March 2024.

**12.2 Result and Discussion**

The details of Marine Ecological Monitoring conducted for the locations of Kandla and Vadinar during the monitoring period has been summarized in the **Table 37**.

**Table 36: Values of Biomass, Net Primary Productivity (NPP), Gross Primary Productivity (GPP), Pheophytin and Chlorophyll for Kandla and Vadinar**

Sr. No.	Parameters	Kandla						Vadinar	
		ME-1 (Near Passenger Jetty One)	ME-2 (Kandla Creek)	ME-3 (Near Coal Berth)	ME-4 (Khorī Creek)	ME-5 (Nakti Creek-near Tuna Port)	ME-6 (Nakti Creek near NH - 8A)	ME-7 (Near SPM)	ME-8 (Near Vadinar Jetty)
		Avg.	Avg.	Avg.	Avg.	Avg.	Avg.	Avg.	Avg.
1.	Biomass	115	115	96	142	102	121	78	111
2.	Net Primary Productivity	2.91	3.77	3.08	2.99	5.47	2.49	4.16	2.64
3.	Gross Primary Productivity	2.95	3.04	3.73	3.26	2.44	2.85	3.67	3.09
4.	Pheophytin	1.10	1.28	0.80	1.35	0.82	5.81	2.66	2.43
5.	Chlorophyll-a	2.40	1.61	1.72	1.72	2.04	12.43	2.37	3.24
6.	Particulate Oxidisable Organic Carbon	1.34	1.12	1.18	1.51	1.45	1.40	1.26	1.20
7.	Secchi Depth	0.61	0.63	0.56	0.60	0.56	0.62	3.93	2.61

- Biomass:**

With reference to **Table 37**, the average concentration of biomass during the monitoring period, for locations ME-1 to ME-6 was reported within the range of **96-142 mg/L**, with the lowest biomass present in **ME-3 (near coal berth)** and the highest biomass present in **ME-4 (Khorī Creek)** during the sampling period. In Vadinar, the value of biomass was observed at **78 mg/L** at ME-7 (near SPM) and **111 mg/L** at ME-8 (near Vadinar Jetty) monitoring station.

- Productivity (Net and Gross)**

**Gross primary productivity (GPP)** is the rate at which organic matter is synthesised by producers per unit area and time (GPP). The amount of carbon fixed during photosynthesis by all producers in an ecosystem is referred to as gross primary productivity. During the Monitoring Period, the monitoring location of Kandla reported GPP value in range between **2.44 to 3.73 mg/L/48 Hr** where the highest value recorded

for ME-3 (Near Coal Bearth) and lowest recorded at ME-5 (Nakti creek-near tuna port). In Vadinar, the value of **GPP** was observed **3.67** at ME-7 (Near SPM) and **3.09** mg/L/48 Hr at ME-8 (Near Vadinar Jetty) monitoring station.

**Net primary productivity**, is the amount of fixed carbon that is not consumed by plants, and it is this remaining fixed carbon that is made available to various consumers in the ecosystem. During the monitoring period of 2023 to 2024 the Net primary productivity of the monitoring location at Kandla from (ME-1 to ME-6) has been estimated to be between **2.49 to 5.47 mg/L/48 Hr**. While in Vadinar, the value of **NPP** was observed **4.16** at ME-7 (Near SPM) and **2.64** mg/L/48 Hr at ME-8 (Near Vadinar Jetty) monitoring station.

- **Pheophytin**

The level of Pheophytin was detected in the range from **0.8 to 5.81 mg/m<sup>3</sup>** where the highest value observed at ME-6 (Nakti Creek (Near NH-8A)) and the lowest value observed at ME-3(Near Coral Breth), While in Vadinar, the value of Pheophytin was observed **2.66** mg/m<sup>3</sup> at ME-7 and **2.43** mg/m<sup>3</sup> at ME-8 monitoring station.

- **Chlorophyll-a**

In the sub surface water, the value of Chlorophyll-a reported in range from **1.61 to 12.43 mg/m<sup>3</sup>**. The highest value observed at ME-6 (Nakti Creek (Near NH-8A)), while the lowest value observed at ME-2 (Kandla Creek). In Vadinar, the value of chlorophyll-a was observed **2.37** mg/m<sup>3</sup> at ME-7 (Near SPM) and **3.24** mg/m<sup>3</sup> in ME-8 (Near Vadinar Jetty) monitoring station.

- **Particulate Oxidisable Organic Carbon**

During the sampling period, the particulate oxidisable organic carbon falls within the range of **1.12 to 1.51 mg/L** from monitoring location ME-1 to ME-6 at Kandla, whereas for Vadinar, the value of POC observed **1.26** mg/L at ME-7 (Near SPM) and **1.20** mg/L in ME-8 (Near Vadinar Jetty) monitoring station.

- **Secchi Depth**

In monitoring station of Kandla (ME-1 to ME-6) the level of Secchi Depth was observed between **0.56 to 0.63 ft** whereas at Vadinar, the value recorded at ME-7 i.e. Near SPM is **3.93** ft and in Near Vadinar Jetty is **2.61** ft.

### Ecological Diversity

**Phytoplankton:** For the evaluation of the Phytoplankton population in DPA Kandla and Vadinar within the immediate surroundings of the port, sampling was conducted during the study period. Total 8 sampling locations were studied i.e. sampling locations (6 from Kandla and two from Vadinar).

The details of variation in abundance and diversity in phytoplankton communities is mentioned in **Table 38**.

**Table 37: Phytoplankton variations in abundance and diversity in sub surface sampling stations**

Genera	ME-1 (Near Passenger Jetty One)	ME-2 (Kandla Creek)	ME-3 (Near Coal Berth)	ME-4 (Khorī Creek)	ME-5 (Nakti Creek-near Tuna Port)	ME-6 (Nakti Creek near NH - 8A)	ME-7 (Near SPM)	ME-8 (Near Vadinar Jetty)
	Avg	Avg	Avg	Avg	Avg	Avg	Avg	Avg
<i>Bacillaria sp.</i>	360	391	271	404	374	521	390	347
<i>Biddulphia sp.</i>	492	340	73	542	315	434	402	274
<i>Chaetoceros sp.</i>	279	379	316	258	627	322	462	394
<i>Chlamydomonas sp.</i>	286	312	147	329	478	456	325	503
<i>Cyclotella sp.</i>	367	443	284	418	454	609	303	378
<i>Coscinodiscus sp.</i>	455	412	290	206	330	376	370	244
<i>Ditylum sp</i>	342	322	124	241	225	205	227	294
<i>Fragilaria sp.</i>	395	381	336	300	355	0	350	360
<i>Bacteriastrum sp.</i>	178	96	52	166	111	252	162	252
<i>Pleurosigma sp.</i>	236	236	129	565	276	675	352	219
<i>Navicula sp.</i>	366	488	472	393	420	332	375	856
<i>Nitzschia sp.</i>	309	272	249	295	366	284	418	435
<i>Synedra sp.</i>	479	328	82	322	144	541	192	327
<i>Skeletonema sp.</i>	270	566	130	0	488	536	521	495
<i>Oscillatoria sp.</i>	341	351	176	251	493	423.5	144	306
<i>Thalassiosira</i>	147	134	64	132	170	224	235	161
<i>Gomphonema sp.</i>	550	495	128	360	600	310	564	500
<i>Planktothrix sp.</i>	140	302	123	411	393	495	272	353
<i>Gyrosigma sp.</i>	410	560	130	750	0	685	400	667
<i>Actinestrum sp.</i>	0	0	0	0	0	500	0	0
<i>Cymbella</i>	500	500	0	550	0	685	700	500
<i>Limnothrix sp.</i>	0	700	0	650	0	800	750	0
<i>Scendesmus sp.</i>	0	0	0	485	0	630	0	0
<i>Mougeotia sp.</i>	0	0	0	8	0	20	0	4
<i>Chlorella sp.</i>	0	0	0	0	0	850	0	0
<b>Density-Units/L</b>	3107.1	3525	3177.3	2918	3073	3704	3357	3576
<b>No. of genera</b>	<b>20</b>	<b>21</b>	<b>19</b>	<b>22</b>	<b>18</b>	<b>24</b>	<b>21</b>	<b>21</b>

The phytoplankton community of the sub surface water in the Kandla and Vadinar was represented by, Diatoms, green algae and filamentous Cynobacteria. Diatoms were



represented by 15 genera; green algae were represented by 1 genera and filamentous Cynobacteria were represented by 1 genera during the sampling period.

The density of phytoplankton of the sampling stations from ME-1 to ME-6 (Kandla) varying from **2918** to **3704** units/L, while for Vadinar its density of phytoplankton observed **3357** units/L at ME-7 and **3576** units/L at ME-8. During the sampling, all communities were contributing in phytoplankton on both location of Kandla & Vadinar except *Gyrosigma sp*, *Actinestrum sp*, *cymbella*, *Limnothrix sp*, *Scendesmus sp*, *Mougeotia sp* and *cholera sp*.

The details of Species richness Index and Diversity Index in Phytoplankton is mentioned in **Table 39**.

**Table 38: Species richness Index and Diversity Index in Phytoplankton**

Indices	ME-1 (Near Passenger Jetty One)	ME-2 (Kandla Creek)	ME-3 (Near Coal Berth)	ME-4 (Khorl Creek)	ME-5 (Nakti Creek-near Tuna Port)	ME-6 (Nakti Creek near NH - 8A)	ME-7 (Near SPM)	ME-8 (Near Vadinar Jetty)
	Avg	Avg	Avg	Avg	Avg	Avg	Avg	Avg
Taxa S	13	14	13	14	13	15	14	13
Individuals	3099	3408	3202	2926	3094	3768	3357	3597
Shannon diversity	2.09	2.12	2.05	1.97	1.94	2.02	2.10	1.95
Simpson 1-D	0.86	0.86	0.85	0.83	0.83	0.84	0.86	0.80
Species Evenness	0.92	0.91	0.90	0.89	0.90	0.87	0.90	0.85
Margalef richness	1.03	1.09	1.02	1.00	0.93	1.01	1.07	1.01
Berger-Parker	0.20	0.21	0.22	0.24	0.25	0.24	0.22	0.28
Relative abundance	0.41	0.44	0.38	0.44	0.38	0.41	0.40	0.41

- **Shannon- Wiener’s Index (H):** During monitoring period 2023 to 2024, Average Shanon- Wiener’s index of phytoplankton communities was in the range of **1.94 to 2.12** between selected sampling stations from ME-1 to ME-6. While for Vadinar, Average Shannon Wiener’s index of phytoplankton communities recorded to be **2.10** at ME-7 and **1.95** at ME-8. The apportionment of the numbers of individuals among the species observed higher stability at all monitoring location of Kandla and Vadinar.
- **Simpson diversity index (1-D):** During the monitoring period **2023 to 2024**, average Simpson diversity index (1-D) of phytoplankton communities was ranged between **0.83 to 0.86** at all sampling stations in the Kandla creek and nearby creeks. Similarly, for Vadinar average Simpson diversity index (1-D) of phytoplankton communities was **0.86** at ME-7 and **0.80** at ME-8.
- **Margalef’s diversity index (Species Richness):** During the monitoring period **2023 to 2024**, average margalef’s diversity index of phytoplankton communities in Kandla and nearby creeks sampling stations was varying from **0.93 to 1.09**. While for Vadinar, average Margalef’s diversity index (Species Richness) of phytoplankton communities observed **1.07** at ME-7 and **1.01** at ME-8.
- **Berger-Parker Index (d):** During the monitoring period **2023 to 2024**, average Berger-Parker Index (d) of phytoplankton communities was in the range of **0.20 to 0.25** between selected sampling stations from ME-1 to ME-6. at Kandla creek and nearby creeks.

Average Berger-Parker Index (d) of phytoplankton communities in the sampling stations of Vadinar, was in the range of **0.22 to 0.28**. All the monitoring station signifies a low diversity with an even distribution among the different species.

- The Average **Species Evenness** is observed in the range of **0.87 to 0.92** for all the six-monitoring station of Kandla and for the Vadinar the average species evenness is observed in the range of **0.85 to 0.90**.
- During the sampling period, average **Relative Abundance** of phytoplankton communities was in range of **0.38 to 0.44** between selected sampling stations from ME-1 to ME-6 at Kandla creek and nearby creeks. Whereas for Vadinar the Average relative Abundance value **0.40** at ME-7 and **0.41** at ME-8. thus, it is concluded that the studied species can be stated as neither highly dominant nor rare.

The details of variation in abundance and diversity in zooplankton communities is mentioned in **Table 40**.

**Table 39: Zooplankton variations in abundance and diversity in sub surface sampling stations**

Genera	ME-1 (Near Passenger Jetty One)	ME-2 (Kandla Creek)	ME-3 (Near Coal Berth)	ME-4 (Khori Creek)	ME-5 (Nakti Creek-near Tuna Port)	ME-6 (Nakti Creek near NH - 8A)	ME-7 (Near SPM)	ME-8 (Near Vadinar Jetty)
	Avg	Avg	Avg	Avg	Avg	Avg	Avg	Avg
<i>Acartia sp.</i>	2	2	2	2	2	2	3	2
<i>Acrocalanus</i>	2	2	2	2	2	2	2	4
<i>Amoeba</i>	3	2	3	3	4	2	3	2
<i>Brachionus sp.</i>	3	2	2	2	2	3	4	2
<i>Calanus sp.</i>	2	3	3	2	2	3	2	3
<i>Cladocera sp.</i>	2	3	5	2	3	2	3	3
<i>Cyclopoid sp.</i>	5	4	4	4	2	2	4	2
<i>Copepod larvae</i>	2	3	2	3	2	4	2	2
<i>Diaptomus sp.</i>	5	2	4	2	3	2	3	3
<i>Eucalanus sp.</i>	3	2	2	4	3	6	3	4
<i>Mysis sp.</i>	3	9	7	5	1	6	6	8
<i>Oithona sp.</i>	1	2	4	2	1	4	4	9
<i>Paracalanus sp.</i>	8	7	4	8	11	8	9	10
<b>Density Unit/L</b>	24.45	24.91	25.82	26.00	22.91	26.45	27.64	27.36
<b>No. of genera</b>	13	13	13	13	13	13	13	13

A total of 13 groups/taxa of zooplankton were recorded in Kandla and Vadinar during the study period which mainly constituted by *diaptomus*, *copepods*, *brachionus*, *cladocera*, fish and shrimp larval forms. *Amoeba* and *Cyclopoida* had the largest representation at all stations from (ME-1 to ME-8). The average density of Zooplankton of the sampling stations from ME-1 to ME-6 (Kandla) varying from **22.91 to 26.45** units/L, while for Vadinar its average density of zooplankton observed **27.64** units/L at ME-7 and **27.36** units/L at ME-8. During

the sampling, all communities were contributing in zooplankton except *Oithana sp.* in Kandla and Vadinar.

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

**Table 40: Species richness Index and Diversity Index in Zooplankton**

Indices	ME-1 (Near Passenger Jetty One)	ME-2 (Kandla Creek)	ME-3 (Near Coal Berth)	ME-4 (Khorri Creek)	ME-5 (Nakti Creek-near Tuna Port)	ME-6 (Nakti Creek near NH - 8A)	ME-7 (Near SPM)	ME-8 (Near Vadinar Jetty)
	Avg	Avg	Avg	Avg	Avg	Avg	Avg	Avg
Taxa S	11	13	10	13	10	12	13	10
Individuals	24	57	26	26	23	26	28	27
Shannon diversity	1.77	1.74	1.76	1.79	1.67	1.76	1.79	1.72
Simpson (1-D)	0.79	0.75	0.79	0.79	0.76	0.77	0.79	0.77
Species Evenness	0.78	0.61	0.78	0.79	0.79	0.73	0.82	0.76
Margalef	2.15	2.21	2.07	2.21	2.06	2.34	2.22	2.16
Berger-Parker	0.34	0.42	0.32	0.34	0.35	0.37	0.31	0.35
Relative abundance	34.93	40.08	31.95	37.76	39.98	38.18	39.18	37.27

- Shannon- Wiener’s Index (H):** During monitoring period 2023 to 2024, Average Shanon- Wiener’s index of zooplankton communities was in the range of **1.67 to 1.79** between selected sampling stations from ME-1 to ME-6, at Kandla creek and its nearby creeks. While for Vadinar, average Shannon Wiener’s index of zooplankton communities recorded to be **1.79** at ME-7 and **1.72** at ME-8. The apportionment of the numbers of individuals among the species observed higher stability at all monitoring location of Kandla and Near SPM (Vadinar).
- Simpson diversity index (1-D):** During the monitoring period **2023 to 2024**, average Simpson diversity index (1-D) of zooplankton communities was ranged between **0.75 to 0.79** at all sampling stations in the Kandla creek and nearby creeks, for Vadinar average Simpson diversity index (1-D) of zooplankton communities was **0.79** at ME-7 and **0.77** at ME-8.
- Margalef’s diversity index (Species Richness):** During the monitoring period **2023 to 2024**, average margalef’s diversity index of zooplankton communities in Kandla and nearby creeks sampling stations was varying from **2.06 to 2.34**, during the sampling period. While for Vadinar, average Margalef’s diversity index (Species Richness) of zooplankton communities observed **2.2** at ME-7 and **2.16** at ME-8.
- Berger-Parker Index (d):** During the monitoring period **2023 to 2024**, average Berger-Parker Index (d) of zooplankton communities was in the range of **0.32 to 0.42** between selected sampling stations from ME-1 to ME-6, at Kandla creek and nearby creeks. Average Berger-Parker Index (d) of zooplankton communities in the sampling stations of Vadinar, was in the range of **0.31 to 0.35**. All the monitoring station signifies a low diversity with an even distribution among the different species.

- The average **Species Evenness** is observed in the range of **0.61 to 0.79** for all the six-monitoring station of Kandla whereas, for the Vadinar the average species evenness was observed in the range of **0.76 to 0.82**, during the monitoring period.
- During the sampling period, **average Relative Abundance** of zooplankton communities was in range of **31.95 to 40.08** between selected sampling stations from ME-1 to ME-6. at Kandla creek and nearby creeks. Whereas for Vadinar the average relative abundance value **39.18** at ME-7 and **37.27** at ME-8, thus it can be concluded that the studied species is stated as neither highly dominant nor rare.

The details of variation in abundance and diversity in **Benthic organism** is mentioned in **Table 42**.

**Table 41: Benthic Fauna variations in abundance and diversity in sub surface sampling**

Genera	ME-1 (Near Passenger Jetty One)	ME-2 (Kandla Creek)	ME-3 (Near Coal Berth)	ME-4 (Khor Creek)	ME-5 (Nakti Creek- near Tuna Port)	ME-6 (Nakti Creek near NH - 8A)	ME-7 (Near SPM)	ME-8 (Near Vadinar Jetty)
	Avg	Avg	Avg	Avg	Avg	Avg	Avg	Avg
<i>Thiaridae</i>	2	1	2	2	2	2	1	3
<i>Mollusca sp.</i>	2	1	2	2	3	2	2	3
<i>Odonata sp.</i>	2	1	2	3	2	2	2	3
<i>Lymnidae</i>	2	1	5	2	2	2	3	2
<i>Planorbidae</i>	1	1	2	1	2	2	2	1
<i>Atydae</i>	2	1	2	2	1	2	2	2
<i>Gammaridae</i>	2	1	1	2	1	2	2	3
<i>Portunidae</i>	1	1	1	1	0	1	1	1
<i>Turbinidae</i>	2	1	3	1	1	2	2	2
<i>Palaemonidae</i>	1	1	2	3	3	1	2	2
<i>Diapatra sp.</i>	2	1	3	4	2	4	2	3
<i>Coleoptera sp.</i>	2	1	3	3	0	1	3	2
<i>Crustacea sp.</i>	3	1	3	3	3	3	2	1
<i>Hemiptera sp.</i>	2	1	0	2	2	2	3	2
<i>Tricoptera sp.</i>	2	1	3	4	3	5	2	1
<i>Hydrobidae</i>	1	1	1	2	1	3	0	3
<i>Viviparidae</i>	3	1	0	1	2	2	3	3
<i>Neridae</i>	2	1	2	0	4	2	1	2
<b>Density-m<sup>3</sup></b>	10.18	8.82	9.64	10.09	8.5	9.73	9.73	9.55
<b>No of genera</b>	18	18	16	5.00	16	18	17	18

Few Benthic organisms were observed in the collected sample by using the Van-Veen grabs during the sampling conducted for DPA Kandla and Vadinar. Majority of the species were found under the Macro-benthic organisms during the sampling period were represented by *Atyde*, *Palaemonidae*, *Mollusca sp.*, etc. The average density of benthic fauna was varying from **8.55 to 10.18 m<sup>3</sup>**.

The details of Species richness Index and Diversity Index in Benthic Organisms is mentioned in **Table 43**.

**Table 42: Species richness Index and Diversity Index in Benthic Organisms**

Indices	ME-1 (Near Passenger Jetty One)	ME-2 (Kandla Creek)	ME-3 (Near Coal Berth)	ME-4 (Khorl Creek)	ME-5 (Nakti Creek-near Tuna Port)	ME-6 (Nakti Creek near NH - 8A)	ME-7 (Near SPM)	ME-8 (Near Vadinar Jetty)
	Avg.	Avg	Avg	Avg	Avg	Avg	Avg	Avg
Taxa S	6	7	6	6	7	6	6	6
Individuals	10	9	10	10	9	10	9	10
Shannon diversity	1.55	1.42	1.47	1.50	1.43	1.48	1.43	1.43
Simpson 1-D	0.76	0.73	0.75	0.75	0.73	0.75	0.73	0.74
Species Evenness	0.89	0.89	0.92	0.92	0.90	0.91	0.90	0.89
Margalef	1.92	1.77	1.73	1.81	1.83	1.79	1.76	1.68
Berger-Parker	0.33	0.37	0.33	0.34	0.37	0.34	0.38	0.36
Relative abundance	55.92	57.66	53.67	56.55	60.63	56.18	57.46	51.58

- Shannon- Wiener’s Index (H):** During monitoring period 2023 to 2024, Average Shanon- Wiener’s index of benthic organism was in the range of **1.42 to 1.55** between selected sampling stations from ME-1 to ME-6, at Kandla creek and its nearby creeks. While for Vadinar, average Shannon Wiener’s index of benthic organism recorded to be **1.43** at ME-7 and ME-8. The apportionment of the numbers of individuals among the species observed higher stability at all monitoring location of Kandla and Vadinar.
- Simpson diversity index (1-D):** During the monitoring period **2023 to 2024**, average Simpson diversity index (1-D) of benthic organism was ranged between **0.73 to 0.76** at all sampling stations in the Kandla creek and nearby creeks, Similarly, for Vadinar average Simpson diversity index (1-D) of benthic organism was **0.73** at ME-7 and **0.74** at ME-8.
- Margalef’s diversity index (Species Richness):** During the monitoring period **2023 to 2024**, average margalef’s diversity index of benthic organism in Kandla and nearby creeks sampling stations was varying from **1.73 to 1.92**. While for Vadinar, average Margalef’s diversity index (Species Richness) of benthic organism observed to be **1.76** at ME-7 and **1.68** at ME-8.
- Berger-Parker Index (d):** During the monitoring period **2023 to 2024**, average Berger-Parker Index (d) of benthic organism was in the range of **0.33 to 0.37** between selected sampling stations from ME-1 to ME-6, at Kandla creek and nearby creeks. average Berger-Parker Index (d) of benthic organism in the sampling stations of Vadinar, was in the range of **0.36 to 0.38**. All the monitoring station signifies a low diversity with an even distribution among the different species.



- The average **Species Evenness** is observed in the range of **0.89 to 0.92** for all the six-monitoring station of Kandla and for the Vadinar the species evenness is observed in the range of **0.89 to 0.90**.
- During the sampling period, **average Relative Abundance** of Benthic organisms was in range of **53.67 to 60.63** between selected sampling stations from ME-1 to ME-6 at Kandla creek and nearby creeks. Whereas for Vadinar the Average relative abundance value **57.46** at ME-7 and **51.58** at ME-8, thus it is concluded that the studied species can be stated as neither highly dominant nor rare.



## **CHAPTER 13: SUMMARY AND CONCLUSION**

### 13.1 Summary and Conclusion

The report, prepared by the Gujarat Environment Management Institute (GEMI), details the environmental monitoring and management plan for the Deendayal Port Authority (DPA) at Kandla and Vadinar. The monitoring covers the period from April 2023 to March 2024.

The primary objective is to systematically assess and monitor environmental parameters including ambient air, water (drinking and surface), soil, sediment, noise, and ecology to ensure compliance with environmental standards and statutory norms.

#### Methodology

Environmental monitoring was conducted using standard operating procedures, protocols, and guidelines to ensure accurate data collection. Various parameters were measured, including air quality, water quality, soil characteristics, noise levels, and meteorological data.

Based on the results obtained for both study areas, Kandla and Vadinar, during the monitoring period from April 2023 to March 2024, the following observations are concluded.

- **Ambient Air Quality Monitoring**

Particulate matter (PM<sub>10</sub> and PM<sub>2.5</sub>) levels exceeded the national ambient air quality standards (NAAQS) at most monitoring locations, especially at the coal storage area. The high particulate matter levels were attributed to heavy vehicular traffic, loading/unloading of cargo, and dust from unpaved roads. For Gaseous monitoring, sulfur dioxide (SO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), volatile organic compounds (VOCs), and carbon monoxide (CO) were generally within the NAAQS limits.

The noise level was within the permissible limits for the industrial, commercial, and residential zones for daytime and nighttime.

- **DG Stack Monitoring**

Monitoring of the diesel generator (DG) stacks was conducted at one location each in Kandla and Vadinar. Parameters like suspended particulate matter, SO<sub>2</sub>, NO<sub>x</sub>, CO, and CO<sub>2</sub> were measured and found to be within the prescribed emission limits.

- **Soil Monitoring**

The pH in Kandla varies from slightly alkaline to strongly alkaline, while the soil at Vadinar was found to be moderately alkaline. The soil texture was observed as “sandy loam” to “loamy sand” at all the monitoring locations in Kandla, and the soil texture of Vadinar varies from “loam” to “slit loam. Kandla displays higher salinity and nutrient levels, while Vadinar exhibits lower nutrient levels. Vadinar generally shows moderate conditions with higher water holding capacity and more consistent soil composition. The presence of heavy metals such as aluminium, chromium, nickel, copper, zinc, lead, arsenic, and cadmium vary considerably at both study area.

- **STP Monitoring**

After the effluent treatment in both the study areas, the treated water followed the GPCB discharge norms except for total coliform.

- **Drinking Water Quality Monitoring**

Drinking water samples were collected from 20 locations across Kandla and Vadinar. Most water quality parameters like pH, color, turbidity, chloride, and total hardness were within the drinking water standards (IS 10500:2012). A few locations showed slightly elevated levels of electrical conductivity, salinity, and total dissolved solids, likely due to the coastal location.

- **Marine Water and Sediment Quality Monitoring**

Marine water and sediment samples were collected from 6 locations in Kandla and 2 locations in Vadinar. The water quality parameters like pH, salinity, dissolved oxygen, and nutrients were within the acceptable limits for coastal waters. The sediment quality in terms of heavy metals and organic contaminants was also found to be within the prescribed standards.

- **Marine Ecology Monitoring**

Monitoring of marine ecology was conducted at 6 locations in Kandla and 2 locations in Vadinar. The analysis indicates that both regions exhibit low diversity with an even distribution among species, as evidenced by the Berger-Parker Index and Simpson Diversity Index values. These indices suggest a stable ecosystem where no single species overwhelmingly dominates, nor are any species exceedingly rare. The even distribution of species, coupled with moderate levels of biomass and primary productivity, highlights the resilience of these ecosystems.

Overall, the report concludes that the environmental monitoring conducted by the DPA during the period of April 2023 to March 2024 indicates compliance with the applicable environmental regulations, with some exceptions related to particulate matter levels in the ambient air.



**Annexure 1: Photographs of the Environmental Monitoring conducted at Kandla**

STP Monitoring



Noise Monitoring



Soil Monitoring



Marine Monitoring



Air Monitoring

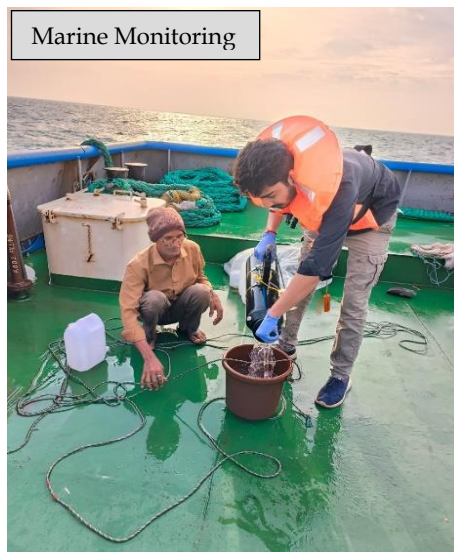


Drinking Water Monitoring





**Annexure 2: Photographs of the Environmental Monitoring conducted at Vadinar**



Source: GEMI



## **CHAPTER 14: REFERENCES**



## References:

- (1) National ambient air quality standards central pollution control board, 2009
- (2) Ambient Air Quality Standards in respect of Noise,2000.
- (3) American Public Health Association 23<sup>rd</sup> Addition, Standard Methods for Water and Waste water analysis, 2017.s
- (4) Indian Standard DRINKING WATER – SPECIFICATION (Second Revision), 2012.



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