# Deendayal Port Authority
# (Erstwhile :Deendayal Port Trust)

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Website: www.deendayalport.gov.in

Office of the Dy.CE & EMC (i/c),
ANNEX, Administrative Office
Gandhidham - Kutch
Pin – 370 201.

ISO 9001 – 2015 &
ISO 14001 –2015 Certified Port

EG/WK/4751/Part (Revamping – EC onwards/ 136 Dated: 29/12/2025

To,
Shri M.C. Macwana,
The Unit Head, Kachchh,
Gujarat Pollution Control Board,
Paryavaran Bhavan, Sector 10A,
Gandhinagar- 382 010.

**Sub:** "Augmentation of Liquid Cargo Handling Capacity from 8 MMTPA to 23.8 MMTPA Through Modernisation of Existing Pipeline Network at Oil Jetty Area, Deendayal Port Trust, Kandla – **Pointwise Compliances of the conditions stipulated in NOC ( CTE – 115467) issued by the GPCB reg.**

**Ref.:**
1. NOC/CTE order issued by the GPCB vide letter no. PC/CCA-KUTCH-812(5)/GPCB ID 28494/609592 dated 23/12/2021
2. DPA letter no. EG/WK/4751/Part (Revamping- EC onwards)/102 dated 29/07/2024
3. DPA letter no. EG/WK/4751/Part (Revamping- EC onwards)/23 dated 03/02/2025
4. DPA letter no. EG/WK/4751/Part (Revamping- EC onwards)/10 dated 02/06/2025

Sir,

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

In this connection, it is to state that, the Gujarat Pollution Control Board had granted Consent to Establish (CTE- **115467**) with certain specific & general conditions and validity up to 11/02/2026. . In this regard, it is relevant to mention here that, DPA had already obtained Environmental & CRZ Clearance for the subject project from the MoEF&CC, GoI dated 01/01/2024, based on the recommendation of the Gujarat Coastal Zone Management Authority dated 25/08/2022.

Also, Environmental and CRZ Clearance has been accorded by the MoEF&CC, GOI vide letter dated 01/01/2024.

Now, as per the statutory requirement to submit the compliance of stipulated conditions in the CTE – 115467, we are hereby submitting the compliance report (Period April 2025 to September 2025) along with necessary enclosures as **Annexure I,** for kind perusal & record please.

.....Cont.....

Further, of the , we are submitting herewith soft copy of the compliance of stipulated conditions in the CTE - 115467 through e-mail in ID: kut-uh-gpcb@gujarat.gov.in

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

Yours faithfully,

Encl.: As above

XEN (EMC)
Deendayal Port Authority

**Copy, to:**

Regional Officer,
Gujarat Pollution Control Board,
Regional office, Kutch (East),
Gandhidham-370201.
Email Id. ro-gpcb-kute@gujarat.gov.i

# Annexure–I

## CTE Compliance Report

**Compliance Report Up to September, 2025**

**Subject: Point wise compliance report of stipulated conditions mentioned in the Consent to Establish no CTE - 115467 dated 23/12/2021 to Deendayal Port Authority, (New Name) PCB ID -28494**

**Reference: CTE amendment issued vide consent order no. PC/CCA-Kutch-812(5)/GPCB ID-28494/609592 dated 23/12/2021**

| Sr. No | Conditions | Compliance Status |
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| **1** | **Specific Conditions** | |
| 1. | Industry shall not start any activities w.r.t augmentation of liquid cargo handling capacity from 8 MMTPA to 23.8 MTPA without prior Environment Clearance & CRZ clearance of the competent authority | Point Noted for the compliance. |
| 2. | Unit shall strictly comply with all conditions of Terms of Reference granted by MoEF & CC vide order dated 10-26/2018-1A-lll dated 14/06/2018 & 11/06/2020 | Compliance of the conditions stipulated in Terms of reference (ToR) granted by the MoEF&CC vide order dated 14/06/2018 and revised ToR dated 11/06/2020 prepared by M/s Mecon, Ranchi and submitted in the Final EIA report (January 2022). A copy of same had already been submitted along with compliance report submitted on 29/07/2024. |
| 3. | Unit shall strictly adhere all conditions of Environment Clearance vide order no. 11-82/2011-IA-III, dated 19/12/2016 | The compliance reports of stipulated conditions mentioned in the EC & CRZ Clearance accorded by the MoEF&CC,GoI vide File no. 11-82/2011-IA-III dated 19/12/2016, are being submitted regularly, to the concerned authorities viz. Regional Office, MoEF&CC,GoI, Bhopal with a copy to the MoEF&CC,GoI, New Delhi, RO,CPCB, Vadodara, GPCB, Gandhinagar as well as GPCB Regional Office, Gandhidham.<br>Last compliance report submitted on 02/06/2025 is attached herewith as **Annexure-A** |
| 4. | There shall be no change in existing water consumption, waste water generation, fuel consumption, flue gases emission & process gases emission & hazardous waste category & quantity, due to proposed CTE-Amendment. | Point Noted for the compliance. |
| 5. | Unit shall also strictly adhere to all conditions of Environment and CRZ Clearance issued by MoEF vide letter no. F. no. 11-70/2006-IA-III dated 01/10/2008 | The compliance reports of stipulated conditions mentioned in the EC & CRZ Clearance accorded by the MoEFCC,GoI vide File no. 11-70/2006-IA.III dated September, 2008, are being submitted regularly, to the concerned authorities viz. Regional Office, MoEF&CC,GoI, Bhopal with a copy to the MoEF&CC,GoI, New Delhi, RO,CPCB, Vadodara, GPCB, Gandhinagar as well as GPCB Regional Office, Gandhidham.<br>Last compliance report submitted on 07/08/2025 is attached herewith as **Annexure-B** |

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| 6. | Applicant shall comply with Manufacture, storage and import of Hazardous Chemicals Rules-1989 (MSIHC) as amended time to time. | As per the Lease deed all the statutory clearance and its compliance needs to be done by the plot allotee/BOT operator.<br>All plot allotees/BOT operators are complying with the said rules |
| 7. | Applicant shall ensure that all storage terminal located within DPT area shall strictly comply with MSIHC rules including site notification & submit details periodically to board with<br>relevant details. | As per the Lease deed all the statutory clearance and its compliance needs to be done by the plot allotee/BOT operator.<br>All plot allotees/BOT operators are complying with the said rules |
| 8. | Applicant shall renew Public Liability Insurance time to time & submit a copy to this Board. | DPA has been renewing the Public Liability Insurance from time to time as required. The Public Liability Insurance is valid till 23rd July 2026. The same is attached herewith as **Annexure C**. |
| 9. | Unit shall notify site under MSIHC Rule – 1989 from component authority as mentioned in Schedule – 5 of MSIHC notification. | As per the Lease deed all the statutory clearance and its compliance needs to be done by the plot allotee/BOT operator.<br>All plot allotees/BOT operators are complying with the said rules |
| 10. | Industry shall not withdraw groundwater without prior NOC from CGWA as per Hon. National Green tribunal order. | Point noted. The Water requirement is being met through GWSSB (Narmada Pipeline) & through private tankers. |
| 11. | Industry shall manage Solid waste generated from Industrial activities as per Solid Waste Management Rules-2016 (Solid waste as defined in Rule -3 (46)) | Garbage facility is provided as per MARPOL Act 73/78 to the vessel berthed at Deendayal Port Trust. A copy of same had already been submitted along with compliance report submitted on 02/06/2025<br><br>Companies authorized by Central Pollution Control Board(CPCB) and State Pollution Control Board (SPCB) have been awarded the work of collection, transporting and disposal of solid waste by the Deendayal Port Trust.<br><br>In additional to the above, DPA has accorded work for "Preparation of Plan for Management of Plastic Wastes, Solid waste including C&D wastes, E-wastes, Hazardous wastes including Biomedical". To Gujarat Environment Management Institute (GEMI), Gandhinagar vide work order dated 24/01/2023. The work is completed Copy of final report communicated along with compliance report submitted on 03/02/2025. |
| 12. | Industry shall comply with Plastic Waste Management Rules – 2016 and amendments made therein. If applicable | DPA is managing its plastic waste as per Plastic Waste Management Rules – 2016 and amendments made therein. In order to strictly implement the said rules, DPA had issued a circular regarding plastic waste minimization, source segregation, recycling etc.<br><br>In additional to the above, DPA has accorded work for "Preparation of Plan for Management of Plastic Wastes, Solid waste including C&D wastes, E-wastes, Hazardous wastes including Biomedical". To Gujarat Environment |

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| | | Management Institute (GEMI), Gandhinagar vide work order dated 24/01/2023. The work is completed and final report communicated along with compliance report submitted on 03/02/2025. |
| 13. | Industry shall strictly comply with coal handling guidelines of this board. | Deendayal Port Authority issued a Circular (SOP) to the trade with regard to control of dust pollution arising out of coal handling and ensuring safety in coal handling (circular no. TF/SH/Circulars/2019/1256 dated 10/10/2019). A copy of same had already been submitted along with compliance report submitted on 29/07/2024<br><br>Further, an additional circular addressing coal-handling–related environmental compliance and GPCB requirements was issued on 07/05/2025, bearing Circular No. TF/SH/GPCB/2019-N/434, which is attached herewith as **Annexure D**.<br><br>It is submitted that, the continuous steps are being taken by DPA to control/minimize dust pollution within Port area, which are enumerated as under:<br><br>DPA already installed Sprinkling system inside Cargo Jetty area for Coal Dust Suppression in Coal Yard (40 Ha. area) at the cost of Rs. 14.44 crores. Continues water sprinkling is being carried out on the heap of coal, at regular intervals to prevent dusting, fire and smoke<br><br>DPA has undertaken the project of dust supersession sprinkling system for the 34-hectare coal storage yard.<br><br>Two Road sweeper machines with compressor have been deployed along with two mist cannon machine for a contract period of 3 years, which are being operated continuously<br><br>Protection wall along the periphery of coal storage yard is made<br><br>Further, to control dust pollution in other area, regular sprinkling through tankers on roads and other staking yards is being done<br><br>Regular sweeping of spilled cargo from roads is done by parties on regular basis<br><br>Most of the roads and plots inside Port area are paved in order to prevent dusting |

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| | | The directions have already been issued from time to time to all the traders in order to ensure that all trucks before leaving the storage yards will be covered with tarpaulin, no overloading of trucks are allowed and there should not be spillage of cargo during transportation.<br><br>DPA has appointed Gujarat Institute of Desert Ecology (GUIDE) for "Green belt development in Deendayal Port Authority and its Surrounding Areas, Charcoal site' (Phase-l)" vide Work Order No.EG/WK/4757/Part [Greenbelt GUIDE, dated 31st May, 2022. The work completed.<br><br>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. final report communicated along with compliance report submitted on 03/02/2025.<br><br>Further DPA has accorded the work of "Green belt development in DPA and its surrounding area (Phase III) to Gujarat Institute of Desert Ecology (GUIDE), Bhuj for the plantation of 5000 saplings at DPA and 200 saplings at Gopalpuri colony. The inception report is attached herewith as **Annexure E**.<br><br>DPA has appointed Gujarat Environment Management Institute (GEMI), Gandhinagar for regular monitoring of environmental parameters for the whole port area including Air Quality Monitoring vide work order dated 15/02/2023. Latest monitoring report is attached herewith as **Annexure F**<br><br>Further, DPA has accorded GUIDE, Bhuj, for Continuous Ambient Air Quality Monitoring (CAAQMS) on a nomination basis, vide Work Order dated 24/06/2025. The work order is attached herewith as **Annexure G** |
| 14. | Industry shall provide dedicated storage facility for dry cargo and ensure to take adequate measure to prevent dusting. | DPA has provided dedicated storage facilities for all type of Cargo including 33 warehouse and 67 open storage space.<br><br>DPA vide its circular no. TF/SH/Circulars/2019/1256 dated 10/10/2019 has issued a circular for "controlling of Dust pollution arising out of Coal Handling". A copy |

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| | | of same had already been submitted along with compliance report submitted on 29/07/2024<br><br>Further, an additional circular addressing coal-handling–related environmental compliance and GPCB requirements was issued on 07/05/2025, bearing Circular No. TF/SH/GPCB/2019-N/434, which is attached herewith as **Annexure D.**<br><br>It is relevant to mention here that DPT has installed Mist Canon at the Port area to minimize the coal dust. The work related to construction of protection wall with wind screen to prevent coal dust deposition in building has already been completed during the year 2011-2012.<br><br>Continues water sprinkling is being carried out on the top of the heap of coal, at regular intervals to prevent dusting, fire and smoke. DPT already installed Sprinkling system inside Cargo Jetty area for Coal Dust Suppression in Coal Yard (40 Ha. area) at the cost of Rs. 14.44 croes. The DPA is taking all the required measures to reduce coal dust by implementing the Coal Handling Guidelines through Port users.<br><br>DPA has appointed Gujarat Environment Management Institute (GEMI), Gandhinagar for regular monitoring of environmental parameters for the whole port area including Air Quality Monitoring vide work order dated 15/02/2023. latest monitoring report is attached herewith as **Annexure F**. |
| 15. | Applicant shall ensure that there shall be no damage to the existing mangrove patches near site and also ensure the free flow of water to avoid damage to the mangroves. | Point noted. The entire project area is located within the Customs Bonded Area of Deendayal Port Authority, Kandla (Oil Jetty Complex). The project involves replacement and revamping of existing Pipeline network at Oil Jetty area (Scrapping of 125 old existing pipelines and laying of 84 new pipelines) located on existing Pipeline trestle.<br><br>As per the directions of the GCZMA and MoEF&CC,GoI, till date, DPA had already undertaken Mangrove Plantation in an area of 1650 Ha. till date since the year 2005. A copy of same had already been submitted along with compliance report submitted on 29/07/2024<br><br>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 |

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| | | conservation and management plan formulated by Gujarat Institute of Desert Ecology during the study period of Jan-April, 2015. A copy of same had already been submitted along with compliance report submitted on 29/07/2024.<br><br>In addition to the above, DPA appointed M/s GUIDE, for "Regular Monitoring of Mangrove Plantation carried out by DPA" since 2017 In continuation of same DPA appointed M/s GUIDE, for "Regular Monitoring of Mangrove Plantation carried out by DPA" vide work order dated 10/06/2024 (Period 10/06/2024 to 09/06/2025). A copy of final report is attached herewith as **Annexure H** |
| 16. | Applicant shall ensure as per EC condition that no creeks or rivers are blocked due to any activities at the site and free flow of water is maintained. | Point noted. The entire project area is located within the Customs Bonded Area of Deendayal Port Authority, Kandla (Oil Jetty Complex). The project involves replacement and revamping of existing Pipeline network at Oil Jetty area (Scrapping of 125 old existing pipelines and laying of 84 new pipelines) located on existing Pipeline trestle. |
| 17. | Applicant shall provide proper system for collection, storage and treatment and disposal of waste water generated by vessel as per MARPOL & maintain records & submit periodically to this office | DPA has a dedicated Sewage Treatment Plant (STP)at Deendayal Port, Kandla Township, Gandhidham for treatment of waste water. The water is being stored at underground tanks at various locations at Kandla. |
| 18. | Applicant shall install storm drainage catch basin to avoid directly discharge into surface water. | Point Noted. Necessary surface drainage system including storm water network has already been provided for proper drainage |
| 19. | Waste effluent accumulated with port activities including storm water & sewage from port operation including sewage ballast water, bilge water & clean waste from ships shall be as per MARPOL norms. | Point Noted for compliance. A copy of Grant of License/Permission to carry out the work of collection and disposal of "Hazardous Waste/Sludge/ Waste Oil" from Vessels calling at Deendayal Port" given to the authorized recycler. |
| 20. | Applicant shall make separate records regarding generation, collection, transportation and disposal of waste generation from ship & maintain its records | Point noted for the compliance. |
| 21. | Applicant shall made necessary arrangement for plastic waste, solid waste or other waste generation due to port activities & for facilitation of reception facilities under MARPOL & Environment (Protection) Act – 1986 rules etc. | Complied with the condition. A copy of "Grant of Permission / License for removal of Dry Solid Waste (Non Hazardous) from Vessels calling at Deendayal Port" is assigned to the authorized recycler by CPCB/GPCB.<br><br>It is relevant to mention here, DPA has accorded work for "Preparation of Plan for Management of Plastic Wastes, Solid waste including C&D wastes, E-wastes, Hazardous wastes including Biomedical". To Gujarat Environment Management Institute (GEMI), Gandhinagar vide work order dated 24/01/2023. The work is completed and final report communicated along with compliance report submitted on 03/02/2025. |

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| 22. | Ports shall obtain approval of their oil spill contingency plan (OSCP) as required under national oil spill disaster contingency plan (NOS-DCP) of coast guard. Ministry of defense, govt. of India. | DPT is already having Oil Spill Contingency Plan. A copy of same is communicated along with compliance report submitted on 03/02/2025. |
| 23. | Best environmental practices by ports may be uploaded on "Indian ports Association" as well as the same may be linked to websites of CPCB and respective SPCBs | DPA is ISO 14001:2015 certified port for "Providing port facility and related maritime services for vessel and Cargo handling including storage" a copy of same had already been submitted along with compliance report submitted on 02/06/2025.<br><br>As per the directions of the GCZMA and MoEF&CC, GoI, till date, DPA had already undertaken Mangrove Plantation in an area of 1650 Ha. till date since the year 2005. A copy of same had already been submitted along with compliance report submitted on 29/07/2024<br><br>DPA has appointed M/s GEMI, Gandhinagar for the work "Making Deendayal Port a Green Port– Intended Sustainable Development under the Green Port Initiatives". M/s GEMI, Gandhinagar had submitted the Final Report on 10/03/2021<br><br>In addition to the above, DPA has been submitting regularly the compliance of the conditions stipulated in Environmental & CRZ Clearance, CRZ recommendation and CTE to MoEF&CC along with all statutory bodies. The same is being uploaded in MoEF&CC parivesh portal on regular basis.<br><br>DPA also has been regularly submitting Annual Return of Hazardous waste in Form IV and Environmental Statement in Form V for the entire port area and uploading the same in GPCB site on regular basis. Copies of Form IV and Form V for the year 2024–25 are attached herewith as **Annexure I**.<br><br>It is relevant to mention here that DPA is regularly sharing the details of Best Environmental Practices to the "Ministry of Ports Shipping and Water Ways" under the Green Port Initiatives, Maritime India Vision 2030 etc. |
| 24. | Manually handling of cargo should be converted into mechanized system, in time bound manner. | DPA being an old establishment and the area is quite big, possibilities of mechanization is being explored. The work of mechanization at Cargo berth 8 and 9 were attended in 2023. However, both the tenders were discharged as none of the bidders were meeting the eligibility criteria. Based on stipulations requirement the project will be restructured accordingly |

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| 25. | Industry shall not carry out any activities, which may attract the applicability of EIA notification-2006 & its amendment. | Not Applicable. This CTE is granted against the Terms of reference (ToR) granted by the MoEF&CC vide order dated 14/06/2018 and revised ToR dated 11/06/2020. EC is in process |
| 26. | No ground water shall be withdrawal without prior permission from CGWA as per Hon'ble NGT order. | Point Noted |
| 27. | Industry shall renew Public Liability insurance Policy time to time & submit a copy of the same to this office | DPA has been renewing the Public Liability Insurance from time to time as required. The Public Liability Insurance is valid till 23rd July 2026. The same is attached herewith as **Annexure C**. |
| 3. | CONDITIONS UNDER HAZARDOUS WASTE RULES | |
| 3.1 | The applicant shall have to comply with provisions of Hazardous and other Waste (Management and Trans Boundary Movement) Rules 2016 | Point Noted |
| 3.2 | The applicant shall obtain membership of common TSDF site for disposal of Hazardous waste as categorized in Hazardous and other Waste (Management and Trans Boundary Movement) Rules 2016 | DPA appointed GPCB approved vendors for collection and recycling of the hazardous waste. |
| 3.3 | The applicant shall obtain membership of common Hazardous Waste incinerator for disposal of incinerable waste. | DPA appointed GPCB approved vendors for collection and recycling of the hazardous waste |
| 3.4 | The applicant shall provide temporary storage facilities for each type of Hazardous Waste as per Hazardous and other Waste (Management and Trans Boundary Movement) Rules 2016 | Point Noted |
| 3.5 | The applicant shall obtain registration/authorization for recycling/reprocessing any hazardous waste before procuring material/starting production as per HW Rules 2016 | DPA appointed GPCB approved vendors for collection of hazardous waste and they are collecting it regularly |
| 3.6 | The applicant shall obtain authorization for recovery/reuses of any hazardous waste material as per HW Rules 2016 | DPA appointed GPCB approved vendors for collection and recycling of the hazardous waste |
| 4. | General Conditions: - | |
| 4.1 | Adequate plantation shall be carried out all along the periphery of the industrial premises in such a way that the density of plantation is at east 1000 trees per acre of land and a green belt of 03 meters'width is developed | Point noted for compliance |
| 4.2 | Any change in personnel, equipment or working conditions as mentioned in the consents from order should immediately be intimated to this Board. | Point noted for compliance |
| 4.3 | In case of change of ownership/management the name and address of the new owners/partners/directors/proprietor should immediately be intimated to the Board | Point Noted |

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| 4.4 | The applicant shall however, not without the prior consent of the Board bring into use any new or altered outlet for the discharge of effluent or gaseous emission or sewage waste from the proposed industrial plant. The applicant is required to make applications to this Board for this purpose in the prescribed forms under the provisions of the Water Acl-1974, the Air Act-1981 and the Environment (Protection) Act-1986 | Point Noted |
| 4.5 | The concentration of Noise in ambient air within the premises of industrial unit shall not exceed following levels: Between 6 A.M. and 10 P.M.: 75 dB(A) Between 10 P.M and 6 A.M.: 70 dB(A) | DPA has appointed Gujarat Environment Management Institute (GEMI), Gandhinagar for regular monitoring of environmental parameters for the whole port area including Air Quality Monitoring vide work order dated 15/02/2023. latest monitoring report is attached herewith as **Annexure F** |
| 4.6 | Applicant is required to comply with the manufacturing, Storage and import of Hazardous Chemicals Rules-1989 framed under the Environment (Protection) Act-1986 | Point Noted. |
| 4.7 | If it is established by any competent authority that the damage is caused due to their industrial activities to any person or his property in that case, they are obliged to pay the compensation as determined by the competent authority | Point Noted. |

# Annexure–A

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

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

www.deendayalport.gov.in

EG/WK/4751/Part (Comp. 1)/ 12 Dated: 02/06/2025

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

**Sub:** "Development of 7 Integrated facilities (Stage I) within the existing Kandla Port Trust limit at District Kutch (Gujarat) by M/s Kandla Port Trust Limited" – Environmental & CRZ Clearance – **Pointwise Compliances of the conditions stipulated in the EC&CRZ Clearance and Monitoring Report in Datasheet reg.**

**Ref.:** 1) MoEF&CC, GoI letter F. No. 11-82/2011-IA.III dated 19/12/2016
2) Ministry's letter vide F.No. 6-1/2017 (ENV) dated 1/5/2017.
3) KPT letter no. EG/WK/4751/Part (Compliance)/77 dated 3/6/2017.
4) DPT letter no. EG/WK/4751/part(Compliance)/610 dated 13/12/2017-Submission of Six Monthly Compliance Report (June, 2017 to Nov., 2017).
5) DPT letter dated 14(21)/6/2018-Submission of Six Monthly Compliance Report (Dec, 2017 to May, 2018).
6) DPT letter dated 30(2)/3(4)/2019– Submission of Six Monthly Compliance Report (up to March, 2019).
7) DPT letter no. 14/11/2019– Submission of Compliance Report (up to October, 2019).
8) DPT letter dated 29/12/2020– Submission of Compliance Report (up to Nov., 2020).
9) DPT letter dated 07/10/2021– Submission of Compliance Report (up to May, 2021).
10) DPA letter dated 30/01/2023– Submission of Compliance Report (up to May, 2022).
11) DPA letter dated 20/04/2023– Submission of Compliance Report (up to Nov. 2022).
12) DPA letter dated 12/09/2023– Submission of Compliance Report (up to May, 2023).
13) DPA letter dated 20/2/2024– Submission of Compliance Report (up to Nov 2023).
14) DPA letter dated 25/7/2024– Submission of Compliance Report (up to May 2024).
15) DPA letter dated 21/1/2025– Submission of Compliance Report (up to Sep. 2024).

Sir,

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

In this regard, it is to state that, Ministry of Environment, Forest and Climate Change (MoEF&CC), GoI vide F. No. 11-82/2011-IA.III dated 19/12/2016 has accorded Environmental and CRZ Clearance for the 7 project activities of Deendayal Port Authority.

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Subsequently, DPA vide above referred letter dated 3/6/2017 had submitted details/information (including point-wise compliance of stipulated conditions & duly filled in data sheet) asked by the Regional Office, MoEF&CC, GoI, Bhopal in connection with the EC & CRZ Clearance granted by the MoEF&CC, GoI dated 19/12/2016 for the subject mentioned above. Further, DPA vide above referred letters had submitted compliance report of stipulated conditions.

Now, as directed in above referred letter dated 1/5/2017 of the Regional Office, MoEF&CC, GoI, Bhopal, please find enclosed herewith compliance report of stipulated conditions mentioned in the EC & CRZ Clearance granted by the MoEF&CC, GoI dated 19/12/2016 **(Annexure 1)** & Monitoring Report in Data Sheet **(Annexure 2)** (for the period up October 2024 to March 2025) for kind information and record please.

Further, as per the MoEF&CC, Notification S.O.5845 (E) dated 26.11.2018, stated that "**In the said notification, in paragraph 10, in sub-paragraph (ii), for the words "hard and soft copies" the words "soft copy" shall be substituted**". Accordingly, we are submitting herewith soft copy of the same through e-mail in ID eccompliance-guj@gov.in.

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

Thanking You.

Yours faithfully,

02/6/25

Dy.CE & EMC(I/c)

Deendayal Port Authority

**Encl.:** As above

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

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

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

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

4) The Regional Officer,
Gujarat Pollution Control Board,
Regional Office (East Kutch)
Administrative Office Building,
Deendayal Port Authority,
Gandhidham 370201
Email Id. ro-gpcb-kute@gujarat.gov.in

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

# Acknowledgement

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| **Proposal Name** | Development of 7 Integrated facilities (Stage I) within the existing Kandla Port Trust limit at District Kutch (Gujarat) by M/s Kandla Port Trust |
| **Name of Entity / Corporate Office** | Deendayal Port Authority |
| **Village(s)** | N/A |
| **District** | KACHCHH |

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| **Proposal No.** | IA/GJ/MIS/28772/2011 |
| **Plot / Survey / Khasra No.** | N/A |
| **State** | GUJARAT |
| **MoEF File No.** | F.No.11-82/2011-IA III |

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| **Category** | INFRA-2 |
| **Sub-District** | N/A |
| **Entity's PAN** | *****EQUIRED |
| **Entity name as per PAN** | Deendayal Port Authority |

## Compliance Reporting Details

**Reporting Year** 2025

**Remarks (if any)**

**Reporting Period** 01 Jun(01 Oct - 31 Mar)

## Details of Production and Project Area

**Name of Entity / Corporate Office** Deendayal Port Authority

| | Project Area as per EC Granted | Actual Project Area in Possession |
|---|---|---|
| Private | 0 | 0 |
| Revenue Land | 0 | 0 |
| Forest | 0 | 0 |
| Others | 111.5 | 111.5 |
| Total | 111.5 | 111.5 |

## Production Capacity

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

### Specific Conditions

| Sr.No. | Condition Type | Condition Details |
|---|---|---|
| 1 | Statutory compliance | Construction activity shall be carried out strictly according to the provisions of CRZ Notification, 2011. No construction work other |

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| | | than those permitted in Costal Regulation Notification shall be carried out in coastal regulation zone area. |
| **PPs Submission:** Complied<br>a) For Project at Sr. No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at Annexure A. b) Further, w.r.t. project at Sr. No. 2 and 4 (construction not yet started), it is assured that no activity other than those permissible in Coastal Regulation Notification shall be carried out in the CRZ area. | | Date: 13/05/2025 |
| 2 | Marine/Coastal | The Project Proponent shall ensure that there shall be no damage to the existing mangrove patches near site and also ensure the free flow of water to avoid damage to the mangroves. |
| **PPs Submission:** Agreed to Comply<br>a) For Project at Sr. No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at Annexure A. b) Further, w.r.t. project at sr.no. 2 and 4 (construction not yet started), it is assured that due care shall be taken to protect existing mangrove patches near the site and also the free flow of water to avoid damage to the mangroves. | | Date: 13/05/2025 |
| 3 | Marine/Coastal | The Project Proponent shall ensure that no creeks or rivers are blocked due to any activities at the project site and free flow of water is maintained. |
| **PPs Submission:** Agreed to Comply<br>a) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at Annexure A. b) Further, w.r.t. project at sr.no. 2 and 4 (construction not yet started), it is assured that no creeks or rivers shall be blocked due to any activities at the project site, and the free flow of water shall be maintained. | | Date: 13/05/2025 |
| 4 | Marine/Coastal | Shoreline should not be disturbed due to dumping. Periodical study on shore line changes shall be conducted and mitigation carried out, if necessary. The detail shall be submitted along with the six monthly monitoring report. |
| **PPs Submission:** Complied<br>Deendayal Port Authority (Erstwhile, Deendayal Port Trust) vide Work order no. EG/WK/4751/Part (EC Shoreline study)/98 dated 12/10/2021 had appointed NCSCM, Chennai for carrying out the work Shoreline Change Study for Deendayal Port Trust, Kandla, Kachchh District, Gujarat, to Study the Effect of Dumping, if any . The study is completed and the final report submitted by NCSCM, Chennai has already been communicated to the MoEF and CC, GoI, Gandhinagar with six monthly compliance report submitted vide letter dated 30/1/2023. | | Date: 13/05/2025 |
| 5 | Marine/Coastal | The foreshore facilities shall be set up in the stable / low or medium eroding site as demarcated in the shoreline change map by NCSCM. Further, NCSCM shall be authorized to monitor the project during construction and operation phases so as to ensure that the foreshore facilities cause minimum or no impact to the geomorphological systems. |
| **PPs Submission:** Complied<br>Necessary CRZ recommendation from the Gujarat Coastal Zone Management Authority had already been obtained for establishment of 7 project facilities dated 1/7/2015 (Copy submitted along with earlier compliance report submitted) and accordingly, the MoEF and CC, GoI had accorded EC and CRZ Clearance dated 19/12/2016 for the proposed 7 project facilities. | | Date: 13/05/2025 |
| 6 | Marine/Coastal | The PP should take measures to ensure that construction materials / debris (Mortar, cementing materials etc.) do not fall into the water. Construction materials including labour camps should be located at adequate distance from CRZ areas. |

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| **PPs Submission:** Agreed to Comply<br>a) For project no. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at Annexure A. b) Further, w.r.t. project at sr.no. 2 and 4 (construction not yet started), it is assured that, the construction activities shall be carried out, with due care so that construction material /debris do not fall into the water. Further, it is also assured that, construction materials including labour camps will be located outside CRZ areas. | | Date: 13/05/2025 |
| 7 | WASTE MANAGEMENT | Dredged materials should be analyzed for presence of contaminants and also to decide the disposal options. Monitoring of dredging activities should be conducted and the findings should be shared with the Gujarat SPCB and regional office of the ministry. |
| **PPs Submission:** Being Complied<br>Dredged Material will be disposed of at designated location as identified by the CWPRS, Pune. DPA assigned work to M/s GUIDE, Bhuj for analysis of dredged material since the year 2017 and the reports are being submitted from time to time along with compliance reports submitted. Final report for the year 2023-2024 is attached herewith as Annexure B In continuation of same, DPA had issued work order to GUIDE, Bhuj for Study on dredged material for presence of Contaminants for year 2024-2027 vide work order dated 07/10/2024 . The Copy of Inception report is attached herewith as Annexure- C | | Date: 02/06/2025 |
| 8 | Statutory compliance | PP in consultation with GCZMA should prepare a regional strategic Impact Assessment Report with a special focus on region where the PP started construction without permission. The cost towards the study should be borne by the PP. |
| **PPs Submission:** Complied<br>Based on the ToR finalized by the GCZMA vide letter dated 13/10/2022, M/s GUIDE, Bhuj had prepared and submitted final RSIA report dated 12/01/2024 Copy of same also submitted along with compliance report submitted on 25/07/2024 Further, a copy of final RSIA report has already been submitted to the GCZMA vide DPA letter dated 30/01/2024 and to the MoEF and CC, GOI vide DPA letter dated 30/01/2024 Copy of same also submitted along with compliance report submitted on 25/07/2024 | | Date: 13/05/2025 |
| 9 | Statutory compliance | A comprehensive and integrated conservation plan including detailed Bathymetry Study and protection of Creeks / Mangrove area including buffer zone, mapping of coordinates, running length, HTL, CRZ boundary should be put in place. The plan should take note of all the conditions of approvals granted to all the project Proponents in this area, and the reported cases of disappearance of Mangroves near project site. The preservation of entire area to maintain the fragile ecological conditions should be a part of the plan in relation to the creek and Mangrove conservation. |
| **PPs Submission:** Complied<br>The final report submitted by M/s GUIDE, Bhuj (vide letter dated 21/5/2018) had already been communicated to the MoEF and CC, GoI, Bhopal and copy to the MoEF and CC, GoI, New Delhi, along with six monthly compliance report submitted vide letter dated 21/06/2018. | | Date: 13/05/2025 |
| 10 | Statutory compliance | The commitments made during the Public Hearing and recorded in the minutes shall be complied with letter and spirit. A hard copy of the action taken shall be submitted to the ministry. |
| **PPs Submission:** Complied<br>The commitments made during the Public Hearing has already been complied with letter and spirit. In this regard, the details of CSR Activities implemented as well as proposed are enclosed herewith as Annexure D. | | Date: 02/06/2025 |
| 11 | Statutory compliance | All the conditions stipulated in the earlier clearance including the |

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| | | recommendations of Environment Management Plan, Disaster Management Plan shall be strictly complied with. |
| **PPs Submission:** Complied<br>a) DPA has already taken necessary steps for compliance with all the conditions stipulated in the earlier clearance, including the recommendations of the Environment Management Plan, Disaster Management Plan. DPA already has an updated Disaster Management Plan. Further, for monitoring of environmental parameters, DPA has been appointing NABL Accredited laboratory and reports are being submitted from time to time to the GPCB, IRO, MoEF and CC, GoI, Gandhinagar. Recently, DPA appointed GEMI, Gandhinagar for regular monitoring of environmental parameters vide Work Order dated 15/02/2023. The work is in progress and the latest monitoring report submitted by GEMI, Gandhinagar is attached herewith as Annexure E. b) Further, w.r.t. Project at Sr.No.1, kindly refer to the Monitoring reports submitted by M/s KOTPL along with compliance report placed at Annexure A. | | Date: 02/06/2025 |
| 12 | Marine/Coastal | Disposal sites for excavated materials should be so designed that the revised land use after dumping and changes in the land use pattern do not interfere with the natural drainage. |
| **PPs Submission:** Agreed to Comply<br>a) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at Annexure A. b) For the remaining projects Sr.No 2 and 4 (construction not yet started), it is assured that the land use pattern will not interfere with the natural drainage. | | Date: 13/05/2025 |
| 13 | WASTE MANAGEMENT | All the operational areas will be connected with the network of liquid waste collection corridor comprising of storm water, oily waste and sewage collection pipelines. |
| **PPs Submission:** Agreed to Comply<br>The 4 projects completed are of modification/strengthening/up-gradation of existing facilities, having already developed network of storm water drainage and other facilities. Further, oil wastes are being disposed of by selling to the authorized vendor of GPCB/CPCB, as per norms. However, for the operational phase of the ongoing as well as the remaining projects, DPA/BOT operator will provide the necessary facilities. | | Date: 13/05/2025 |
| 14 | AIR QUALITY MONITORING AND PRESERVATION | PP shall install a continuous automatic ambient air quality monitoring system (24 x 7) for all relevant parameters at two locations to monitor the ambient air quality status of the project area. Data should be transferred online to CPCB and SPCB websites. |
| **PPs Submission:** Being Complied<br>a) For monitoring of environmental parameters, DPA has been appointing NABL Accredited laboratory and reports are being submitted from time to time to the GPCB, IRO, MoEF and CC, GoI, Gandhinagar. Recently, DPA appointed GEMI, Gandhinagar for regular monitoring of environmental parameters vide Work Order dated 15/02/2023. The work is in progress and the Latest environmental monitoring report submitted by GEMI, Gandhinagar is attached herewith as Annexure E. DPA has already initiated the action for inviting the tenders for carrying out online ambient air quality monitoring system (24 X 7). However, no response received. Hence, now, DPA after obtaining in principal approval of the competent authority is in process to assign work to GUIDE, Bhuj on nomination basis b) Further, w.r.t. Project at Sr.No.1, kindly refer to the Monitoring reports submitted by M/s KOTPL along with compliance report placed at Annexure A. | | Date: 02/06/2025 |
| 15 | WATER QUALITY MONITORING AND PRESERVATION | The ground water shall not be tapped within the CRZ areas by the PP to meet with the water requirement in any case. |
| **PPs Submission:** Complied<br>a) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at Annexure A. b) Further, w.r.t. Project at Sr. no.2 | | Date: 13/05/2025 |

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| and 4 (construction not yet started), Water requirement will be met through procurement from GWSSB or private tankers. No ground water will be tapped. In addition, for completed projects, the Water requirement is being met through GWSSB (Narmada Pipeline) and through private tankers | | |
| 16 | WASTE MANAGEMENT | Necessary arrangements for the treatment of the effluents and solid wastes must be made and it must be ensured that they confirm to the standards laid down by competent authorities including the state or Central Pollution Control Board and under the Environmental (Protection) Act, 1986 |
| **PPs Submission:** Complied<br>a) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at Annexure A. b) Further, it is also relevant to submit here that, w.r.t. completed projects (modification/ strengthening/ up-gradation of existing facilities), Sewage is being treated in the STP of Kandla (1.5 MLD). The treated sewages from STP of DPA are utilized for plantation / Gardening. DPA has entered into Selling Agency' agreement with M/s. MSTC (Govt. of India Entreprise), Vadodara since 04/01/2022 for collection, transporting and disposal of scrap, surplus items, unserviceable equipment etc. Further, DPA has appointed GEMI, Gandhinagar for the work of Preparation of Plan for Management of Plastic Wastes, Solid Waste, including C and D waste, E-waste, Hazardous waste, including Biomedical and Non-Hazardous Waste in the Deendayal Port Authority vide Work Order dated 24/01/2023. The work is completed. Final report submitted along with compliance report submitted on 21/01/2025. | | Date: 02/06/2025 |
| 17 | WASTE MANAGEMENT | Automatic/Online monitoring system (24 x 7 monitoring devices) for water pollution in respect of flow measurement and relevant pollutants in the treatment system to be installed. The data to be made available to the respective SPCB and in the company s website. |
| **PPs Submission:** Being Complied<br>For monitoring of environmental parameters, DPA has been appointing NABL Accredited laboratory and reports are being submitted from time to time to the GPCB, IRO, MoEF and CC, GoI, Gandhinagar. Recently, DPA appointed GEMI, Gandhinagar for regular monitoring of environmental parameters vide Work Order dated 15/02/2023. The work is in progress and the latest environmental monitoring report submitted by GEMI, Gandhinagar is attached herewith as Annexure E. | | Date: 02/06/2025 |
| 18 | Marine/Coastal | Marine ecology shall also be monitored regularly in terms of sea weeds, grasses, mudflats, sand dunes, fisheries, echinoderms, shrimps, turtles, corals, coastal vegetation, mangroves and other marine bio diversity components as part of the management plan. Marine ecology shall be monitored regularly also in terms of all micro, macro and mega floral and faunal components of marine biodiversity. |
| **PPs Submission:** Being Complied<br>DPA assigned work to M/s GUIDE, Bhuj, for regular monitoring of Marine Ecology since the year 2017 and final reports prepared by GUIDE,Bhuj have already been communicated to the Integrated Regional Office, MoEF and CC, GoI, Gandhinagar as well as to the MoEF and CC, GoI, New Delhi along with compliance reports submitted from time to time. (Period from 2017 to 2021). Further, it is again to submit that DPA issued a work order to M/s GUIDE vide its letter no. EG/ WK/ 4751/ Part (Marine Ecology Monitoring) /11 dated 03/05/2021 for Regular monitoring of Marine Ecology in and around Deendayal Port Authority (Erstwhile Deendayal Port Trust) and continuous Monitoring Program covering all seasons on various aspects of the Coastal Environs for the period 2021 24. Final Reports for the period 2021-22 , 2022-23 and 2023-24, have already been submitted along with compliance report submitted from time to time. In continuation of the same, DPA issued a work order to M/s GUIDE vide its letter no. EG/ WK/ 4751/ Part (Marine Ecology Monitoring) /72 dated 10/06/2024 for further period of 2024 27. A copy of 1s season report is placed herewith as Annexure F | | Date: 02/06/2025 |
| 19 | WASTE MANAGEMENT | Measure should be taken to contain, control and recover the |

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| | | accidental spills of fuel and cargo handle. |
| **PPs Submission:** Complied<br>DPA already having Oil Spill Contingency Plan. An adequate control measure has already been taken to control and recover accidental fuel and cargo handle spills. | | Date: 13/05/2025 |
| 20 | Statutory compliance | All the mitigation measures submitted in the EIA report shall be prepared in a matrix format and the compliance for each mitigation plan shall be submitted to RO, MoEF and CC along with half yearly compliance report |
| **PPs Submission:** Being Complied<br>Compliance of mitigation measures suggested in the EIA report in the matrix format is attached herewith as Annexure G. | | Date: 02/06/2025 |
| 21 | WASTE MANAGEMENT | Ship/barges shall not be allowed to release any oily bilge waste or ballast water in the sea. Any effluent from the jetty which have leachable characteristics shall be segregated and recycled/disposed as per SPCB guideline. |
| **PPs Submission:** Complied<br>It is assured that Ships/barges shall not be allowed to release any oily bilge waste or ballast water in the sea. It is assured that any effluent from the jetty which has leachable characteristics shall be segregated, treated and recycled/disposed of as per SPCB guidelines. DPA issued a Grant of License/Permission to collect and dispose of Hazardous Waste/Sludge/ Waste Oil from Vessels calling at Deendayal Port through DPA contractors. Further, it is to state that, all ships are required to follow DG Shipping circulars regarding the reception facilities at Swachch Sagar portal. | | Date: 13/05/2025 |
| 22 | AIR QUALITY MONITORING AND PRESERVATION | Location of DG sets and other emission generating equipment shall be decided keeping in view the predominant wind direction so that emission do not effect nearby resident areas. Installation and operation of DG Sets shall comply with the guideline of CPCB |
| **PPs Submission:** Complied<br>a) DG sets will be installed keeping in view the predominant wind direction; as per prescribed guidelines, DG sets shall be used in case of power failure only. b) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at Annexure A. | | Date: 13/05/2025 |
| 23 | AIR QUALITY MONITORING AND PRESERVATION | All the mechanized handling systems and other associated equipments such as hoppers, belt conveyors, stacker cum reclaimers shall have integrated dust suppression system. Dust suppression system shall be provided at all transfer point. |
| **PPs Submission:** Agreed to Comply<br>a) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at Annexure A. b) DPA being an old establishment and the area is quite big, possibilities of mechanization is being explored. The work of mechanization at Cargo berth 8 and 9 were attended in 2023. However, both the tenders were discharged as none of the bidders were meeting the eligibility criteria. Based on stipulations requirement the project will be restructured accordingly. Further, w.r.t. Project at Sr.No.2 (construction not yet started), BOT operator will take the necessary step to provide all the mechanized handling systems and other associated equipment, such as hoppers, belt conveyors, and stacker cum reclaimers with integrated dust suppression systems. DPA/BOT operator will provide a Dust suppression system at all transfer points. DPA has already installed a water sprinkling system in the Port area for coal handling areas. | | Date: 13/05/2025 |
| 24 | Statutory compliance | No products other than permitted under the CRZ Notification, 2011 shall be stored in the CRZ area. |

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| **PPs Submission:** Agreed to Comply<br>It is hereby assured that only products permitted under the CRZ Notification, 2011 shall be stored in the CRZ area. | | Date: 13/05/2025 |
| 25 | Marine/Coastal | It shall be ensured by the Project Proponent that the activities does not cause disturbance to the fishing activity, movement of fishing boats and destruction to mangroves during the construction and operation phase. |
| **PPs Submission:** Agreed to Comply<br>a) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at Annexure A. b) Further, it is assured that, due care is being taken so that the activities do not cause disturbance to the fishing activity, movement of fishing boats and destruction to mangroves. | | Date: 13/05/2025 |
| 26 | GREENBELT | As proposed, green belt over an area of 36.8 ha shall be developed with at least 10 meter wide green belt on all sides along the periphery of the project area, in downward direction and along road side etc. Selection of plant species shall be as per the CPCB guidelines in consultation with the DFO. |
| **PPs Submission:** Complied<br>a) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at Annexure A. b) As already informed, DPA entrusted work of green belt development in and around the Port area to the Forest Department, Gujarat at Rs. 352 lakhs (Area 32 hectares). The work is completed. Further, DPA has appointed the Gujarat Institute of Desert Ecology (GUIDE) for Green belt development in Deendayal Port Authority and its Surrounding Areas, Charcoal site' (Phase-l) vide Work Order No.EG/WK/4757/Part Greenbelt GUIDE, dated 31st May 2022. The final report submitted by GUIDE, already submitted along with compliance report submitted on 12/04/2023. 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 work is completed final report is submitted along with compliance report submitted on 03/02/2025. | | Date: 13/05/2025 |
| 27 | GREENBELT | Mangrove plantation in an area of 100ha shall be carried out by KPT within 2 years in a time bound manner. Action taken report shall be submitted to the Regional Office of MoEF and CC. |
| **PPs Submission:** Complied<br>Mangrove Plantation carried out during (2018-2020) through the Gujarat Ecology Commission. Totally DPA has undertaken Mangrove Plantation in an area of 1600 Hectares since the year 2005, through various agencies viz. GUIDE, GEC, State Forest Department etc., which includes 100 Ha.. The details have already been communicated with the earlier compliance reports submitted. | | Date: 13/05/2025 |
| 28 | WASTE MANAGEMENT | Municipal Solid Waste and Hazardous wastes shall be managed as per Municipal Solid Waste Rule, 2016 and Hazardous Waste Management Rules 2016 |
| **PPs Submission:** Complied<br>Municipal solid waste and hazardous waste management by DPA are undertaken by appointing GPCB authorized vendor per the Municipal solid waste Rule, 2016 and Hazardous waste management Rules, 2016, for further treatment. Further, DPA has appointed GEMI, Gandhinagar for the work of Preparation of Plan for Management of Plastic Wastes, Solid Waste, including C and D waste, E-waste, Hazardous waste, including Biomedical and Non-Hazardous Waste in the Deendayal Port Authority vide Work Order dated 24/01/2023. Copy is already submitted along with compliance report submitted on 21/01/2025. | | Date: 02/06/2025 |
| 29 | Corporate Environmental Responsibility | The project Proponent shall take up and earmark adequate fund for socio-economic development and welfare measure as proposed under |

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| | | the CSR programmed. This shall be taken up on priority |
| **PPs Submission:** Complied<br>a) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at Annexure A. b) The details of the fund earmarked under CSR activities and CSR activities undertaken by DPA to date and proposed activities are placed at Annexure D | | Date: 02/06/2025 |
| 30 | MISCELLANEOUS | The Project Proponent shall set up separate Environmental Management Cell for effective implementation of the stipulated environmental safeguards under the supervision of a senior executive |
| **PPs Submission:** Being Complied<br>a) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at Annexure A. b) DPA is already having Environment Management cell. Further, DPA has also appointed expert agency for providing Environmental Experts from time to time. Recently, DPA appointed M/s Precitech Laboratories, Vapi for providing Environmental Experts vide work order dated 05/02/2021 (for a period of 2 years and further extendable for 1 year). In addition, it is relevant to submit here that, DPA has appointed Manager (Environment) on contractual basis for the period of 3 years and further extendable to 2 years (Copy of the details has already been communicated with the earlier compliance report submitted). | | Date: 13/05/2025 |
| 31 | MISCELLANEOUS | The funds earmarked for environmental management plan shall be included in the budget and this shall not be diverted for any other purpose. |
| **PPs Submission:** Complied<br>a) The allocation made under the Environmental Services and Clearance of other related Expenditure scheme during RBE 2025-26 is Rs. 585 Lakhs. The funds earmarked for EMP by the b) b. Concessionaire M/s KOTPL w.r.t. project at Sr.No. 1 are delineated in the compliance report submitted (Annexure A). | | Date: 02/06/2025 |
| 32 | MISCELLANEOUS | The proponent shall abide by all the commitments and recommendations made in the EIA/EMP reports so also during their presentation to the EAC. |
| **PPs Submission:** Complied<br>a) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at Annexure A. b) DPA has installed Mist Canon at the Port area to minimize the dust. Further, DPA has already installed continuous sprinkling system in coal stack yard in DPA (40 ha. area) to prevent dust pollution. Further, to control dust pollution in other area, regular sprinkling through tankers on roads and other staking yards is being done. Regular sweeping of spilled cargo from roads is done by parties on regular basis. c) DPA has undertaken the project of dust supersession sprinkling system for the 34 hectare coal storage yardd) For monitoring of environmental parameters, DPA has been appointing NABL Accredited laboratory and reports are being submitted from time to time to the GPCB, IRO, MoEF and CC, GoI, Gandhinagar. Recently, DPA appointed GEMI, Gandhinagar for regular monitoring of environmental parameters vide Work Order dated 15/02/2023. The work is in progress and the latest environmental monitoring report submitted by GEMI, Gandhinagar is attached herewith as Annexure E. e) For ship waste management, DPA issued Grant of License/Permission to carry out the work of collection and disposal of Hazardous Waste/Sludge/ Waste Oil and Dry Solid Waste (Non- Hazardous) from Vessels calling at Deendayal Port through DPA contractors. Further, it is to state that, all ships are required to follow DG Shipping circulars regarding the reception facilities at Swachch Sagar portal. f) DPA assigned work to M/s GUIDE, Bhuj, for regular monitoring of Marine Ecology since the year 2017 (From 2017 2024), and the reports of the same submitted by GUIDE, Bhuj has already been communicated to the Regional Office, MoEF and CC, GoI, Gandhinagar as well as to the MoEF and CC, GoI, New Delhi along with compliance reports submitted. In continuation of the same, DPA issued a work order to M/s GUIDE vide its letter no. EG/ WK/ 4751/ Part (Marine Ecology Monitoring) /72 dated 10/06/2024. A copy of 1st season report is attached | | Date: 02/06/2025 |

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| | | herewith as Annexure F g) As already informed, DPA entrusted work of green belt development in and around the Port area to the Forest Department, Gujarat at Rs. 352 lakhs (Area 32 hectares). The work is completed. h) Further, DPA has appointed the Gujarat Institute of Desert Ecology (GUIDE) for Green belt development in Deendayal Port Authority and its Surrounding Areas, Charcoal site' (Phase-l) vide Work Order No.EG/WK/4757/Part Greenbelt GUIDE, dated 31st May 2022. The work has been completed and the final report submitted by GUIDE, Bhuj has already been communicated with the last compliance report. i) 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 work is completed and final report is attached submitted along with compliance report submitted on 21/01/2025 j) DPA assigned work to M/s GUIDE, Bhuj for analysis of dredged material since the year 2017 and the reports are being submitted from time to time along with compliance reports submitted. Final report for the year 2023-24 is attached herewith as Annexure B k) In continuation of same, DPA had issued work order to GUIDE, Bhuj for Study on dredged material for presence of Contaminants for year 2024 2027. The copy of Inception report is attached herewith as Annexure C l) Further, Dredged Material will be disposed of at designated location as identified by the CWPRS, Pune. m) For energy conservation measures, DPA is already generating 20 MW of Wind energy. In addition to it, DPA has commissioned a 45 kWP Solar Plant at Gandhidham. Further, it is relevant to mention that, two out of four Nos. of Harbour Mobile Crane (HMC) made electric operated. Balance 02 Nos. shall be made electric operated by 2023-2024. Four Nos. of Diesel operated RTGs converted to e-RTGs. Retrofitting of hydrogen fuel cell in Tug Kalinga and Pilot Boat Niharika to be done as a pilot project under the guidance of MoPSW. Also, 14 Nos. of EV cars to be hired in this year and 03 Nos. EV Bus to be procured by the year 2023-24. n) Further, for Oil Spill Management, DPA is already having Oil Spill Contingency Plan in place and Oil Response System as per the NOS-DCP guidelines. | |
| 33 | MISCELLANEOUS | Company shall prepare operating manual in respect of all activities. It shall cover all safety and environment related issues and system. Measure to be taken for protection. One set of environmental manual shall be made available at the project site. Awareness shall be created at each level of the management. All the schedules and results of environmental monitoring shall be available at the project site office | |
| | | **PPs Submission:** Complied<br>The operating manual plan in respect of all activities has already been communicated along with the compliance report submitted vide letter dated 2/4/2019. | Date: 13/05/2025 |
| 34 | Corporate Environmental Responsibility | Corporate Social Responsibility a. The company shall have a well laid down Environmental Policy approved by the Board of Directors b. The Environmental policy shall prescribe for standard operating process/procedure to bring into focus any infringements / deviation/violation of the environmental or forest norms c. The system or Administrative order of the hierarchical company to deal with environmental issues and for ensuring compliance with the environmental clearance conditions shall be furnished. d. To have proper checks and balances, the company shall have a well laid down system of reporting of non compliances / violations of environmental norms to the board of directors of the company and/or share holders or stake holders at large. | |
| | | **PPs Submission:** Complied<br>The DPA has an Environmental Policy approved by the Board of Directors. The Environmental policy has already prescribed standard operating processes/procedures, bringing into focus any infringements/deviations/violations of the environmental or forest norms. DPA already has a well-established environmental Cell for ensuring proper checks on non- compliances/violations of Environmental norms. The organogram has already been communicated with the last compliance report submitted. | Date: 13/05/2025 |

## General Conditions

| Sr.No. | Condition Type | Condition Details |
|---|---|---|
| 1 | Statutory compliance | The Proponent shall upload the status of compliance of the stipulated Clearance conditions, including results of monitored data on their website and shall update the same periodically. It shall simultaneously be sent to the Regional Office of MoEF, the respective Zonal Office of CPCB and the SPCB. |
| **PPs Submission:** Complied<br>The status of compliance with the various stipulated Environmental conditions is being uploaded on the website of DPA. The present compliance report has already been uploaded to the website www.deenbdayalport.gov.in. Copy of the compliance report has also been marked to the Regional Office of MoEF and CC, GoI, the respective Zonal Office of CPCB and the SPCB. | | Date: 13/05/2025 |
| 2 | Statutory compliance | The Project Authorities must strictly adhere to the stipulations made by the State Pollution Control Board (SPCB), State Govt. and any other statutory authority. |
| **PPs Submission:** Agreed to Comply<br>a) Point Noted. b) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at Annexure A. | | Date: 13/05/2025 |
| 3 | Statutory compliance | Full support shall be extended to the officers of this ministry/regional office at Bhopal by the project Proponent during inspection of the project for monitoring purposes by furnishing full details and action plan including action taken reports. In respect of mitigation measures and other environmental protection activities. |
| **PPs Submission:** Agreed to Comply<br>a) Point Noted. b) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at Annexure A. | | Date: 13/05/2025 |
| 4 | Statutory compliance | A six monthly monitoring report shall need to be submitted by the project proponents to the regional office of this ministry at Bhopal regarding the implementation of the stipulated conditions. |
| **PPs Submission:** Agreed to Comply<br>a) Point Noted. b) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at Annexure A. | | Date: 13/05/2025 |
| 5 | Statutory compliance | Ministry of Environment Forest and Climate Change or any other competent authority may stipulate any other additional conditions or modify the existing one, if necessary in the interest of environment and the same shall be complied with. |
| **PPs Submission:** Agreed to Comply<br>a) Point Noted. b) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at Annexure A. | | Date: 13/05/2025 |
| 6 | Statutory compliance | The ministry reserves the right to revoke this clearance if any of the condition stipulated are not complied with the satisfaction of the ministry |
| **PPs Submission:** Agreed to Comply<br>a) Point Noted. b) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at Annexure A. | | Date: 13/05/2025 |
| 7 | MISCELLANEOUS | In the event of a change in project profile or change in the implementation agency, a fresh reference shall be made to the ministry of Environment, Forest and Climate Change. |

| | | |
|---|---|---|
| **PPs Submission:** Agreed to Comply<br>a) Point Noted. b) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at Annexure A | | Date: 13/05/2025 |
| 8 | Statutory compliance | The Project Proponents shall inform the regional office as well as the ministry, the date of the financial closure and final approval of the project by the concerned authorities and the date of start of Land Development work. |
| **PPs Submission:** Complied<br>DPA vide letter dated 14/12/2020 w.r.t. project No.1, i.e. Development of Oil Jetty to Handle Liquid Cargo and Ship Bunkering Terminal at Old Kandla under PPP Mode , has already informed the Regional Office, MoEF and CC, GoI, Bhopal and copy to MoEF and CC, GoI, New Delhi about the award of the concession granted to the Concessionaire M/s Kandla Oil Terminal Limited dated 11/12/2020, and the project implementation work has commenced . | | Date: 13/05/2025 |
| 9 | Statutory compliance | A copy of the clearance letter shall be marked to concerned panchayat / local NGO, if any, from whom any suggestion/representation has been made received while processing the proposal |
| **PPs Submission:** Complied<br>DPA vide letter dated 29/12/2016 had already informed to Conservation Action Trust and Paryavaran Mitra (from whom DPA received the representation during the Public Hearing). | | Date: 13/05/2025 |
| 10 | Statutory compliance | A copy of the environmental clearance letter shall also be displayed on the website of the concerned State Pollution Control Board. The EC letter shall also be displayed at the Regional Office, District Industries Centre and Collector s Office / Tehsildar s office for30 days. |
| **PPs Submission:** Agreed to Comply<br>Point Noted. | | Date: 13/05/2025 |
| 11 | Statutory compliance | The stipulations would be enforced among others under the provisions of water (Prevention and Control of Pollution) Act 1974, the Air (Prevention and control of Pollution) Act 1981, the environment (Protection) Act, 1986, the Public Liability (Insurance) Act, 1991 and EIA Notification 1994, including the amendments and rules made thereafter. |
| **PPs Submission:** Being Complied<br>For monitoring of environmental parameters, DPA has been appointing NABL Accredited laboratory and reports are being submitted from time to time to the GPCB, IRO, MoEF and CC, GoI, Gandhinagar. Recently, DPA appointed GEMI, Gandhinagar for regular monitoring of environmental parameters vide Work Order dated 15/02/2023. The work is in progress and the latest environmental monitoring report submitted by GEMI, Gandhinagar is attached herewith as Annexure E. For Project at Sr.No. 1 which is under construction, kindly refer monitoring data submitted by M/s KOTPL along with compliance submitted placed at Annexure A. | | Date: 02/06/2025 |
| 12 | Statutory compliance | All other statutory clearance such as the approvals for storage of diesel from Chief Controller of Explosives, Fire Department, Civil Aviation Department, Forest Conservation Act, 1980 and Wildlife (Protection) Act, 1972 etc. shall be obtained, as applicable by project proponents from the respective competent authorities |
| **PPs Submission:** Complied<br>DPA/BOT Operator will obtain all other statutory clearance applicable as per the condition stipulated. | | Date: 13/05/2025 |

| | | |
|---|---|---|
| 13 | Statutory compliance | The project proponent shall advertise in at least two local Newspapers widely circulated in the region, one of which shall be in the vernacular language informing that the project has been accorded Environmental and CRZ Clearance and copies of clearance letters are available with the state Pollution Control Board and may also be seen on the website of the Ministry of Environment and Forests at http://www.envfor.nic.in. the advertisement should be made within 10 days from the date if receipt of the clearance letter and a copy of the same should be forwarded to the Regional Office of this Ministry at Bhopal. |
| **PPs Submission:** Complied<br>Deendayal Port had already given advertisement in two newspapers, i.e., in KUTCHMITRA (Gujarati) and in The Indian Express (Ahmedabad Edition) (English) dated 20/12/2016. Further, DPA forwarded the copies to the Regional Office, MoEF and CC, GoI, Gandhinagar vide letter dated 22/12/2016. | | Date: 13/05/2025 |
| 14 | Statutory compliance | This Clearance is subject to final order of the Hon ble Supreme Court of India in the matter of Goa Foundation Vs. Union of India in Writ Petition (Civil) No. 460 of 2004 as may be applicable to this project. |
| **PPs Submission:** Agreed to Comply<br>a) Point Noted. b) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at Annexure A. | | Date: 13/05/2025 |
| 15 | Statutory compliance | Status of compliance to the various stipulated Environmental conditions and environmental safeguards will be uploaded by the project proponent in its website. |
| **PPs Submission:** Complied<br>Status of compliance with the various stipulated Environmental conditions being uploaded on the website of DPA. The present compliance report has already been uploaded to the website www.deendayalport.gov.in | | Date: 13/05/2025 |
| 16 | Statutory compliance | Any appeal against this clearance shall be lie with the National Green Tribunal, if preferred, within a period of 30 days as prescribed under Section 16 of the National Green Tribunal Act, 2010. |
| **PPs Submission:** Agreed to Comply<br>a) Point Noted. b) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at Annexure A. | | Date: 13/05/2025 |
| 17 | Statutory compliance | A copy of the clearance letter shall be sent by the proponent to concerned Panchayat, Zilla Parisad / Municipal Corporation, Urban Local Body and the Local NGO, if any, from whom suggestions / representations, if any, were received while processing the proposal. The clearance letter shall also be put on the website of the company by the proponent. |
| **PPs Submission:** Complied<br>DPA vide letter dated 29/12/2016 had already informed to Conservation Action Trust and Paryavaran Mitra (from whom KPT received the representation during the Public Hearing). | | Date: 13/05/2025 |
| 18 | Statutory compliance | The environmental statement for each financial year ending 31st March in Form V as is mandated to be submitted by the project proponent to the concerned State Pollution Control Board as prescribed under the Environment (Protection) Rules, 1986, as amended subsequently, shall also be put on the website of the company along with the status of compliance of clearance conditions |

| | | |
|---|---|---|
| | | and shall also be sent to the respective Regional Office of MoEF by e Mail. |

| | |
|---|---|
| **PPs Submission:** Being Complied<br>a) For Project at Sr.No. 1 which is under construction, kindly refer compliance submitted by M/s KOTPL (concessionaire of the project) placed at Annexure A. b) As informed earlier, out of 7 projects, the projects mentioned at Sr. No. 3, 5, 6 and 7 in the EC Letter dated 19/12/2016 are not new projects (strengthening/ upgradation work). These projects are already covered under consent to operate granted by the GPCB for the whole DPA area (GPCB ID 28494 Renewed Consent Order no-AWH- 110594 dated issue-8/12/2020- Valid up to 21/7/2025) and for which DPA regularly submitted the Environmental statement in Form V to the GPCB. A copy of the Environmental Statement submitted to the GPCB (the year 2023 24) for the entire DPA area is communicated along with compliance report submitted on 21/01/2025. .Further, DPA also uploaded the said Environmental statement in Form V in the website www.deendayalport.gov.in. | Date: 02/06/2025 |

## Visit Remarks

| | |
|---|---|
| **Last Site Visit Report Date:** | N/A |
| **Additional Remarks:** | |

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

**Monitoring the Implementation of Environmental Safeguards**
**Ministry of Environment, Forest & Climate Change**
**Regional Office, Gandhinagar**
(For the period up to October 2024 to March, 2025)

**DATA SHEET**

| | | | | |
|---|---|---|---|---|
| 1. | Project type: –River-valley/ Mining / Industry / Thermal / Nuclear / Other (specify) | | : | Infrastructure & miscellaneous projects + CRZ |
| 2. | Name of the project | | : | Development of 7 Integrated facilities (Stage I) within existing KPT by Deendayal Port Authority (Erstwhile: Deendayal Port Trust). |
| 3. | Clearance letter (s) / OM No. and Date | | : | Environment and CRZ clearance by MoEF&CC vide file no. 11-82/2011-IA III dated 19/12/2016. |
| 4. | Location | | : | |
| | a. | District (s) | : | Kutch |
| | b. | State (s) | : | Gujarat |
| | c. | Latitude/ Longitude | : | $23^{0}01'$ N, $70^{0}13'$ E |
| 5. | Address for correspondence | | | |
| | a. | Address of Concerned Project Chief Engineer (with pin code & Telephone/telex/fax numbers | : | Chief Engineer, Deendayal Port Authority, P.O. Box no. 50. A.O. Building, Gandhidham- 370 201.Phone: 02836 233192, Fax. : 02836 220050 |
| | b. | Address of Project: Engineer/Manager (with pin code/ Fax numbers) | : | Same as above |
| 6. | Salient features | | | |
| | a. | of the project | | 1) Development of Oil Jetty to handle liquid cargo and ship bunkering terminal at old Kandla under PP mode (jetty: 300mx15m, back up area 5.5HA, capacity – 3.39MMTPA, as per the concession agreement Tank farm capacity - 1,64,500 KL & Allied facilities, Capital dredging 1,73,660$m^3$ maintenance dredging 1,56,294$m^3$; Estimated cost: Rs 233.5 Cr., Revised Cost: Rs 343.0 Cr.<br>2) Multipurpose cargo Terminal at Tekra off Tuna on BOT basis (T shape jetty 600mX80m Capacity 18MMTPA, back up area 101Ha capital dredging 1,26,57,175$m^3$ maintenance dredging 18,98,576. 25 $m^3$ Estimated cost: Rs 1686.66 Crore<br>3) Up gradation of Barge handling capacity at Bundar basis at Kandla capacity 3.33 MMTPA backup area 5 Ha Estimated cost Rs 109.59 Cr<br>4) Construction of Rail over Bridge at NH8-A near Nakti Bridge (crossing of NH8-A Estimated cost: 32.17Cr.)<br>5) Mechanization of Dry Cargo handling capacity at Kandla Port (Berth 7 and 8 capacity 7.35MMTPA).<br>6) Strengthening of Oil jetty 1.<br>7) Modification and strengthening of Cargo berth No. 6 at Kandla Port. |
| | b. | of the environmental management plans | : | The salient features of the EMP had already been communicated in earlier compliance reports submitted. |

| | | | | |
|---|---|---|---|---|
| 7. | Production details during the compliance period and (or) during the previous financial year | | : | It is under Infrastructure & miscellaneous projects so production is not involved |
| 8. | The breakup of the project area | | : | ~111.5 Ha |
| | a. | submergence area forest &non-forest | | NIL |
| | b. | Others | | NIL |
| 9. | The breakup of the project affected the Population with an enumeration of Those losing houses/dwelling units Only agricultural land only, both Dwelling units & agricultural Land &landless labours/artisan | | : | NIL |
| | a. | SC, ST/Adivasis | : | Nil |
| 10. | Financial details | | : | |
| | a. | Project cost as originally planned and subsequently revised estimates and the year of price reference: | | |
| | 1. | Estimated Cost of the Project | : | Total Estimated Project Cost: Rs. 2271.03 Crore<br><br>1) Development of oil jetty to handle liquid cargo and ship bunkering terminal at old Kandla under PP mode - Estimated cost: Rs 233.5 Crore, Revised Estimated Cost: Rs 343.0 Cr.<br><br>2) Multipurpose cargo Terminal at Tekra off Tuna on BOT basis - Estimated cost: 1686.66 Cr. (Revised Cost Rs 2250.64 Cr)<br><br>3) Upgradation of Barge handling capacity at Bundar basis at Kandla: Estimated cost: Rs 109.59 Cr.<br><br>4) Construction of Rail over Bridge at NH 8 A near Nakti Bridge (crossing of NH 8 A - Estimated cost: Rs 32.17 Cr.).<br><br>5) Mechanization of Dry Cargo handling capacity at Kandla Port (Berth 7 and 8)- Estimated cost Rs 80.61 Cr..<br><br>6) Strengthening Oil jetty 1 (Estimated cost: Rs 7.5 Cr.).<br><br>7) Modification and strengthening of Cargo berth No. 6 at Kandla Port Estimated cost: Rs 11.5 Cr. |
| | b. | The allocation made for environmental management plans with item-wise and year-wise Break-up. | : | a) The allocation made by DPA under the scheme of "Environmental Services & Clearance thereof other related Expenditure" during BE 2025-26 is Rs. 585 Lakhs.<br><br>b) The allocation made by the Concessionaire M/s KOTPL of the project "Development of oil jetty to handle liquid cargo and ship bunkering terminal at old Kandla under PP mode" - EMP: Rs. 06 Lacs |
| | c. | Benefit-cost ratio / Internal rate of Return and the year of assessment | : | 1) Development of an oil jetty to handle liquid cargo and ship bunkering terminal at old Kandla under PP mode (Project IRR 14.01% and EIRR 14.53%).<br>2) Multipurpose cargo Terminal at Tekra off Tuna on BOT basis (Project IRR 16.03% and equity IRR 17.4%).<br>5) Mechanization of Dry Cargo handling capacity at Kandla Port (Project IRR 18.3% and equity IRR23.6%).<br>Rest of the projects are of up-gradation/strengthening/modification. |
| | d. | Whether (c) includes the Cost of environmental management as | : | Yes |

| | | | | |
|---|---|---|---|---|
| | | shown in above. | | |
| | e. | Actual expenditure incurred on the project so far | : | 1) Development of oil jetty to handle liquid cargo and ship bunkering terminal at old Kandla under PP mode - Actual expenditure incurred on the project: Rs 93.79 Cr<br>2) Multipurpose cargo Terminal at Tekra off Tuna on BOT basis - Actual cost: NIL (Project under bidding stage).<br>3) Upgradation of Barge handling capacity at Bundar basis at Kandla: Actual cost: Rs 109.59 Cr..<br>4) Construction of Rail over Bridge at NH 8 A near Nakti Bridge (crossing of NH 8 A) - Actual cost: NIL – Construction activity has not started yet.<br>5) Mechanization of Dry Cargo handling capacity at Kandla Port (Berth 7 and 8)- Actual cost: Rs 80.61 Cr.<br>6) Strengthening of Oil jetty 1 - Actual cost: Rs 7.5 Cr.<br>7) Modification and strengthening of Cargo berth No. 6 at Kandla Port Actual cost: Rs 11.5 Cr. |
| | f. | Actual expenditure incurred on the environmental management plans so far | | a) The expenditure made by DPA under the scheme of "Environmental Services & Clearance thereof other related Expenditure" is Rs.172 Lakhs from October, 2024 to March 2025.<br>b) The expenditure made by the Concessionaire M/s KOTPL of the project "Development of oil jetty to handle liquid cargo and ship bunkering terminal at old Kandla under PP mode" - EMP: Rs. 4 Lakhs |
| 11. | Forest land requirement | | : | |
| | a. | The status of approval for the diversion of forest land for non-forestry use | : | NIL |
| | b. | The status of clearing felling | : | NIL |
| | c. | The status of compensatory afforestation it any | : | NIL |
| | d. | Comments on the viability & sustainability of the compensatory afforestation program in light of actual field experience so far | : | NIL |
| 12. | The status of clear felling in non-forest areas (such as the submergence area of the reservoir and approach roads) is any with quantitative information. | | : | NIL |
| 13. | Status of construction | | : | |
| | a. | Date of commencement (Actual and/or planned) | : | 1) Development of oil jetty to handle liquid cargo and ship bunkering terminal at old Kandla under PP mode – Award of the concession granted on 11/12/2020; **Project is under Construction Stage**<br><br>2) Multipurpose cargo Terminal at Tekra off Tuna on BOT basis - Construction activity not started yet – **Project is under bidding stage**<br><br>3) Upgradation of Barge handling capacity at Bundar basin at Kandla – **Work Completed**<br><br>4) Construction of Rail over Bridge at NH 8 A near Nakti Bridge - **Construction activity has not started yet**<br><br>5) Mechanization of Dry Cargo handling capacity at Kandla Port –**Mechanization work already completed**<br><br>6) Strengthening of Oil jetty 1 – **Work Completed** |

| | | | | |
|---|---|---|---|---|
| | | | | 7) Modification and strengthening of Cargo berth No. 6 at Kandla Port –**Work completed** |
| | b. | Date of completion<br>( Actual and/or planned ) | : | 1) Development of oil jetty to handle liquid cargo and ship bunkering terminal at old Kandla under PP mode – Construction Schedule – December, 2020<br><br>Planned date of completion: On the request of Concessionaire, DPA has approved to grant time extension of COD till 04/09/2026 subject to certain conditions.<br><br>2) Multipurpose cargo Terminal at Tekra off Tuna on BOT basis - Construction activity not started yet – **Project is under bidding stage.**<br><br>3) Up gradation of Barge handling capacity at Bundar basis at Kandla– **Work Completed (May 2017).**<br><br>4) Construction of Rail over Bridge at NH 8 A near Nakti Bridge - Construction activity not started yet<br><br>5) Mechanization of Dry Cargo handling capacity at Kandla Port– work completed **(April, 2017).**<br><br>6) Strengthening of Oil jetty 1 – Work Completed **(May, 2017)**<br><br>**7)** Modification and strengthening of Cargo berth No. 6 at Kandla Port – Work completed **(May, 2017).** |
| 14 | Reasons for the delay if the Project is yet to start | | : | a) Out of a total of 7 project activities, construction activities of 3 projects (project at Sr. No. 3, 5, 6 & 7 mentioned in the EC & CRZ Clearance) have already been completed. Projects at Sr. No. 2 & 4 are still under the planning stage.<br><br>b) For the Project at Sr. No. 1, reason for delay matter is pending adjudication before Arbitration Tribunal . |
| 15. | Date of the site visit | | | |
| | a) | The dates on which the regional office Monitored the project on pervious occasion. if any | | --- |
| | b) | The date site visit for this monitoring report. | | --- |
| 16. | Details of correspondence with project authorities for obtaining action plans/ information on status of compliance to safeguards other than the routine letters for logistic support for site visit.<br><br>(The first monitoring report may contain the details of all the letters issued so far<br>but the later reports may cover only the letters issued subsequently). | | | --- |

# Annexure–B

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

दीनदयाल पत्तन प्राधिकरण
DEENDAYAL PORT AUTHORITY

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

www.deendayalport.gov.in

EG/WK/4660 (EC)/ Part-V/ 59

Date: 06/08/2025
07

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

**Sub:** "Construction of 13th to 16th Cargo Berths at Kandla" by M/s Deendayal Port Authority (Erstwhile Deendayal Port Trust) – **Compliance Report of conditions stipulated in Environmental & CRZ Clearance and Monitoring Report in Data Sheet reg.**

**Ref.:** 1) EC & CRZ Clearance dated 1/10/2008.
2) KPT letter no.EG/WK/4660 (EC)/654 dated 6/10/2010.
3) KPT letter no.EG/WK/4660 (EC)/ 112 dated 4/2/2012.
4) KPT letter no. EG/WK/4660(EC)/223 dated 4/9/2012.
5) KPT letter no. EG/WK/4660(EC)/144 dated 16 (17) /5/2013.
6) KPT letter no. EG/WK/4660 (EC)/Part 111/1087 dated 9/12/2013.
7) KPT letter no. EG/WK/4660 (EC)/Part 111/250 dated 17/05/2014.
8) KPT letter no. EG/WK/4660 (EC)/Part 111/198 dated 14/11/2014.
9) KPT letter no. EG/WK/4660 (EC)/Part 111/256 dated 11/05/2015.
10) KPT letter no. EG/WK/4660 (EC)/Part 111/162 dated 15/10/2015.
11) KPT letter no. EG/WK/4660 (EC)/Part 111/133 dated 09/05/2016.
12) KPT letter no. EG/WK/4660 (EC)/Part IV/167 dated 26/12/2016.
13) DPT letter no. EG/WK/4660 (EC)/Part IV/325 dated 26/06/2018.
14) DPT letter no. EG/WK/4660 (EC)/Part V/53 dated 14(16)/2/2019.
15) DPT letter no. EG/WK/4660 (EC)/Part V/205 dated 30(6)/11 (12)/2019.
16) DPT letter no. EG/WK/4660 (EC)/Part V dated 15/01/2021.
17) DPT letter no. EG/WK/4660 (EC)/Part V/92 dated 30(07)/9(10)/2021.
18) DPT letter no. EG/WK/4660 (EC)/Part V dated 28/03/2022
19) DPA letter no. EG/WK/4660 (EC)/Part V/149 dated 19/07/2022
20) DPA letter no. EG/WK/4660 (EC)/Part V/230 dated 02/02/2023
21) DPA letter no. EG/WK/4660 (EC)/Part V/350 dated 14/08/2023
22) DPA letter no. EG/WK/4660 (EC)/Part V/37 dated 19/03/2024
23) DPA letter no. EG/WK/4660 (EC)/Part V/93 dated 24/07/2024
24) DPA letter no. EG/WK/4660 (EC)/Part V/05 dated 17/01/2025

Sir,

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

In this connection, it is to state that, as directed under above referred letter dated 5/8/2009 of MoEF, Regional Office, Gandhinagar, Deendayal Port Authority (Erstwhile

.....cont.....

Deendayal Port Trust) vide above referred letters had regularly submitted Six Monthly compliance report of stipulated conditions and Monitoring report in Data Sheet, in connection with subject project.

Now, as directed in above referred letter dated 5/8/2009 of MoEF, GoI, we are submitting herewith compliance report in the PARIVESH 2 PORTAL for the period October, 2024 to March, 2025. Further, we are also submitting herewith Monitoring Report in Data Sheet.

This is for your kind information and record please.

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

Thanking You.

Yours faithfully,

XEN (EMC)
Deendayal Port Authority

# Annexure -1

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

# Acknowledgement

| | |
|---|---|
| **Proposal Name** | Construction of 13th to 16th Cargo Berth at Kandla by M/s Kandla Port Trust (KPT) (Now: Deendayal Port Trust) |
| **Name of Entity / Corporate Office** | Deendayal Port Authority |
| **Village(s)** | N/A |
| **District** | KACHCHH |

| | |
|---|---|
| **Proposal No.** | IA/GJ/MIS/75528/2018 |
| **Plot / Survey / Khasra No.** | N/A |
| **State** | GUJARAT |
| **MoEF File No.** | No.11-70/2006-IA-III |

| | |
|---|---|
| **Category** | INFRA-2 |
| **Sub-District** | N/A |
| **Entity's PAN** | *****EQUIRED |
| **Entity name as per PAN** | Deendayal Port Authority |

## Compliance Reporting Details

**Reporting Year** 2025

**Remarks (if any)**

**Reporting Period** 01 Jun(01 Oct - 31 Mar)

## Details of Production and Project Area

**Name of Entity / Corporate Office** Deendayal Port Authority

| | Project Area as per EC Granted | Actual Project Area in Possession |
|---|---|---|
| Private | 0 | 0 |
| Revenue Land | 0 | 0 |
| Forest | 0 | 0 |
| Others | 6.6 | 6.6 |
| Total | 6.6 | 6.6 |

## Production Capacity

| Sr. no | Product Name | units | Valid Upto | Capacity | Production last year | Capacity as per CTO |
|---|---|---|---|---|---|---|

## Conditions

### Specific Conditions

| Sr.No. | Condition Type | Condition Details |
|---|---|---|
| 1 | Statutory compliance | All measures indicated in the letter dated 4/8/2008 shall be strictly complied with. |

| | | |
|---|---|---|
| | **PPs Submission:** Being Complied<br>Compliance Report of conditions stipulated in the CRZ recommendation granted by Forest and Environment Department, GoG vide letter dated 14/02/2008 is placed in Annexure A. | Date: 06/08/2025 |
| 2 | Statutory compliance | Necessary clearances from the Gujarat State Pollution Control Board shall be obtained before initiating the project. |
| | **PPs Submission:** Complied<br>GPCB vide order no. PCC/CCA-BHUJ-179(3)/575 dated 9/1/2009 granted a No Objection Certificate to the said project. Currently, all the 4 berths are under operation. Further, GPCB vide order dated 22/1/2021 has issued Consolidated Consent and Authorization (Valid up to 21/7/2025). Subsequently, GPCB issued a Correction in the CCA order vide letter no. PC/CCA-KUTCH-812(5)/GPCB ID 28494/ 588116 dated 9/4/2021. | Date: 05/08/2025 |
| 3 | Marine/Coastal | The project proponent shall not undertake any destruction of mangroves during construction and operation of project. |
| | **PPs Submission:** Complied<br>Point noted. All the 4 berths are under operation. As per the directions of the GCZMA and MoEFCC, GoI, to date, DPA has undertaken a Mangrove Plantation in an area of 1600 Hectares since the year 2005. The details have already been communicated with the earlier compliance reports submitted. Further DPA has assigned work to to M/s GUIDE, Bhuj vide work order dated 10/06/2024 for 'Mangrove Plantation in an area of 50 Ha for Deendayal Port Authority' for the period of 10/06/2024 to 09/03/2025. The Final report submitted by GUIDE, Bhuj is attached herewith as Annexure B. It is also relevant to mention here that, as per the direction of the Gujarat Coastal Zone Management Authority, DPA has already prepared and submitted a report on the mangrove conservation and management plan formulated by the Gujarat Institute of Desert Ecology during the study period of Jan-April, 2015 (Report already submitted along with earlier compliance reports submitted). For regular monitoring, DPA vide work order dated 3/5/2021 has assigned work to M/s GUIDE, Bhuj for Monitoring of mangrove plantation carried out by DPA (Period from 24/5/2021 to 23/5/2022). The final report submitted by M/s GUIDE has already been communicated with the earlier compliance report submitted. 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 inception report has already been communicated with earlier compliance report submitted. | Date: 06/08/2025 |
| 4 | WASTE MANAGEMENT | Sewage arising in the Port area shall be treated to conform to the standards stipulated by Gujarat State Pollution Control Board and shall be utilized/ recycled or gardening, plantation and irrigation. |
| | **PPs Submission:** Complied<br>The sewage generated in the port area is treated in the 1.5 MLD STP at Kandla. The treated wastewater is utilized for gardening and plantation purposes. In addition to that, it also has septic tanks at places where STP is inaccessible. DPA has been appointing a NABL-accredited laboratory to monitor environmental parameters, and reports are being submitted from time to the GPCB, IRO, MoEFCC, GoI. Recently, DPA appointed GEMI, Gandhinagar, to regularly monitor environmental parameters vide Work Order dated 15/02/2023. The work is in progress, and the latest environmental monitoring report submitted by GEMI, Gandhinagar, is attached herewith as Annexure C. | Date: 06/08/2025 |
| 5 | Risk Mitigation and Disaster Management | Project proponent shall prepare Disaster Management Plan covering emergency evacuation mechanisms etc. deal with natural disaster events and regularly update from time to time. |
| | **PPs Submission:** Complied<br>DPA is already having a Disaster Management Plan. A copy of the same has been communicated with earlier submitted compliance reports. | Date: 14/07/2025 |
| 6 | Marine/Coastal | The facilities to be constructed in the COASTAL REGULATION ZONE area as part of this project shall be strictly in conformity with the provisions of the COASTAL REGULATION ZONE Notification, |

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| | | 1991 as amended subsequently. |
| **PPs Submission:** Complied<br>All the 4 berths are currently under operation. | | Date: 14/07/2025 |
| 7 | Marine/Coastal | No product other than those permissible in the COASTAL REGULATION ZONE Notification, 1991 shall be stored in the COASTAL REGULATION ZONE area. |
| **PPs Submission:** Complied<br>Point Noted. Cargo is being stored at the backup area of berths, viz. 13th to 16th CB, as per the EC and CRZ Clearance accorded by the MoEFCC, GoI. | | Date: 14/07/2025 |
| 8 | Marine/Coastal | There shall be no withdrawal of groundwater in the COASTAL REGULATION ZONE area for this project. The proponent shall ensure that as a result of the proposed constructions, ingress of saline water into ground water does not take place. Piezometers shall be installed for regular monitoring for this purpose at appropriate locations on the project site. |
| **PPs Submission:** Complied<br>All the 4 berths are currently under operation. | | Date: 14/07/2025 |
| 9 | GREENBELT | Green belt area shall be developed along the project and budget earmarked. |
| **PPs Submission:** Complied<br>DPA had entrusted the work to the Forest Department, Gujarat, for developing a green belt in and around the Port area at a cost of Rs. 352 lakhs in an area of about 32 hectares, and the work is already completed. Further, DPA has appointed the Gujarat Institute of Desert Ecology (GUIDE) for 'Green belt development in Deendayal Port Authority and its Surrounding Areas, Charcoal site' (Phase-l)' vide Work Order No.EG/WK/4757/Part (Greenbelt GUIDE), dated 31st May 2022. The final report has already been communicated with the earlier compliance report. DPA has assigned the Greenbelt development in Deendayal Port Authority and its surrounding areas, Phase II, to M/s GUIDE vide Work order EG/WK/4751/Part (Greenbelt)/327 dated 23.06.2023. The Final Report have already been communicated along with the last compliance report. | | Date: 14/07/2025 |

## General Conditions

| Sr.No. | Condition Type | Condition Details |
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| 1 | Human Health Environment | Adequate provisions for infrastructure facilities such as water supply, fuel, sanitation etc. shall be ensured for construction workers during the construction phase of the project so as to avoid feeling of trees / mangroves and pollution of water and surroundings. |
| **PPs Submission:** Complied<br>All the 4 berths are currently under operation. | | Date: 14/07/2025 |
| 2 | WASTE MANAGEMENT | The project authorities must make necessary arrangement for disposal of solid wastes and for the treatment of Effluents by providing a proper wastewater treatment plant outside the COASTAL REGULATION ZONE area. The quality of treated effluents, solid wastes and noise level etc. must conform to the standards laid down by the competent authorities including the Central/State Pollution Control Board and the Union Ministry of Environment and Forests under the Environment (Protection) Act, 1986, whichever are more stringent. |

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| | **PPs Submission:** Complied<br>Companies authorized by the State Pollution Control Board (SPCB) have been awarded the work of collecting, transporting, and disposing of solid waste by the Deendayal Port Authority. Further, DPA has appointed GEMI, Gandhinagar, for the work of Preparation of Plan for Management of Plastic Wastes, Solid Waste, including C and D waste, E-waste, Hazardous waste, including Biomedical and Non-Hazardous Waste in the Deendayal Port Authority vide Work Order dated 24/01/2023. The work is completed and the Final report has already been communicated along with last compliance report. Generated sewage is treated in DPA's existing STP (1.5 MLD capacity). In addition to that, it also has septic tanks at places where STP is inaccessible. DPA has been appointing a NABL-accredited laboratory to monitor environmental parameters, and reports are being submitted from time to the GPCB, IRO, MoEFCC, GoI, and Gandhinagar. Recently, DPA appointed GEMI, Gandhinagar, to regularly monitor environmental parameters vide Work Order dated 15/02/2023. The work is in progress, and the latest environmental monitoring report submitted by GEMI, Gandhinagar, is attached herewith as Annexure C. | Date: 05/08/2025 |
| 3 | MISCELLANEOUS | In order to carry out the environmental monitoring during the operational phase of the project, the project authorities shall provide an environmental laboratory well equipped with standard equipment and facilities and qualified manpower to carry out the testing of various environmental parameters. |
| | **PPs Submission:** Complied<br>DPA has been appointing a NABL-accredited laboratory to monitor environmental parameters, and reports are being submitted from time to the GPCB, IRO, MoEFCC, GoI, and Gandhinagar. Recently, DPA appointed GEMI, Gandhinagar, to regularly monitor environmental parameters vide Work Order dated 15/02/2023. The work is in progress, and the latest environmental monitoring report submitted by GEMI, Gandhinagar, is attached herewith as Annexure C. | Date: 06/08/2025 |
| 4 | LAND RECLAMATION | The sand dunes if any on the site shall not be disturbed in any way. |
| | **PPs Submission:** Complied<br>No sand dunes at project site prevail. | Date: 14/07/2025 |
| 5 | MISCELLANEOUS | A copy of the clearance letter will be marked to the concerned Panchayat/local NGO, if any from whom any suggestion/ representation has been received while processing the proposal. |
| | **PPs Submission:** Complied<br>No suggestion/ representation has been received while processing the proposal. | Date: 14/07/2025 |
| 6 | WASTE MANAGEMENT | The proponents shall provide for a regular monitoring mechanism as to ensure that the treated effluents conform to the prescribed standards. The records of analysis reports must be properly maintained and made available for inspection to the concerned State/Central officials during their visits. |
| | **PPs Submission:** Complied<br>DPA has been appointing a NABL-accredited laboratory to monitor environmental parameters, and reports are being submitted from time to the GPCB, IRO, MoEFCC, GoI, and Gandhinagar. Recently, DPA appointed GEMI, Gandhinagar, to regularly monitor environmental parameters vide Work Order dated 15/02/2023. The work is in progress, and the latest environmental monitoring report submitted by GEMI, Gandhinagar, is attached herewith as Annexure C. | Date: 06/08/2025 |
| 7 | Statutory compliance | Construction of the proposed structures shall be undertaken meticulously conforming to the existing Central/Local rules and regulations including COASTAL REGULATION ZONE Notification, 1991 and its amendments. All the construction design/drawings relating to the proposed construction activities must |

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| | | have approvals of the concerned State Government Department/Agencies. |
| **PPs Submission:** Complied<br>Currently, all the 4 berths are under operation. | | Date: 14/07/2025 |
| 8 | Statutory compliance | The Gujarat Pollution Control Board shall display a copy of the clearance letter at the Regional Office, District Industries Centre and Controller's Office/Tehsildar's Office for 30 days. |
| **PPs Submission:** Complied<br>- | | Date: 14/07/2025 |
| 9 | Corporate Environmental Responsibility | The funds earmarked for environment protection measures shall be maintained, in a separate account and there shall be no diversion of these funds for any other purpose. A year-wise expenditure on environmental safeguards shall be reported to this Ministry's Regional Office at Bhopal and the State Pollution Control Board. |
| **PPs Submission:** Complied<br>Point noted. The allocation made under the scheme of Environmental Services and Clearance thereof other related Expenditure during RBE 2024-25 is Rs. 585 Lakhs. The expenditure made under the Environmental Services and Clearance of other related Expenditure is Rs. 522 Lakhs from October 2024 to March 2025. The yearly expenditure on environmental safeguards is regularly submitted in the monitoring datasheet to the Ministrys Regional Office at Bhopal (Now Gandhinagar). | | Date: 14/07/2025 |
| 10 | MISCELLANEOUS | Full support shall be extended to the officers of this Ministry's Regional Office at Bhopal and the officers of the central and State Pollution Control Board by the project proponents during their inspection for monitoring purpose, by furnishing full details and action plans including the action taken reports in respect of mitigate measures and other environment protection activities. |
| **PPs Submission:** Complied<br>DPA had given the required support to the officer of the Ministry's Regional Office, Bhopal, during a site inspection carried out on 29/12/2016 for the purpose of certifying EC Conditions. DPA has also given required support to the officials of the Gujarat Pollution Control Board during their visits to DPA for inspection, etc. Further, it is also assured that DPA shall extend full support in future to the officials of the Ministry's Regional Office at Bhopal (Now Gandhinagar) and the officers of the Central and State Pollution Control Board during their inspection. | | Date: 14/07/2025 |
| 11 | MISCELLANEOUS | This ministry reserves the right to revoke this clearance, if any of the conditions stipulated are not complied with to satisfaction of this ministry. |
| **PPs Submission:** Complied<br>Point Noted. | | Date: 14/07/2025 |
| 12 | MISCELLANEOUS | This Ministry or any other competent authority may stipulate any other additional conditions subsequently, if deemed necessary, for environment protection, which shall be complied with. |
| **PPs Submission:** Complied<br>Point Noted. | | Date: 14/07/2025 |
| 13 | MISCELLANEOUS | In case of deviation of alteration in the project including the implementing agency, a fresh reference shall be made to this Ministry for modification in the clearance conditions or imposition of new |

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| | | ones for ensuring environment protection. |
| **PPs Submission:** Agreed to Comply<br>Point Noted. | | Date: 14/07/2025 |
| 14 | Statutory compliance | The project proponent shall advertise in at least two local newspapers widely circulated in the region around the project, one of which shall be in the vernacular language of the locality Concerned, informing that the project has been accrued environment clearance and copies of clearance letters are available with the State Pollution Control Board and may also be seen at website of the Ministry of Environment and Forests at http;//www.envfornic.in. The advertisement shall be made within 7 days from the date of issue of the clearance letter and a copy of the same shall be forwarded to the Regional office of this Ministry at Bangalore. |
| **PPs Submission:** Complied<br>Advertisements had already been made in Kutch Mitra on 21/10/2008 and Kutch Uday on 22/10/2008. Further, Newspaper cuttings had already been sent to the Regional Office, MoEFCC, Bhopal, vide DPA letter No.: EG/WK/4660(EC)/01 dated 31/10/2008. | | Date: 14/07/2025 |
| 15 | Statutory compliance | The above-mentioned stipulations will be enforced among others under the water (Prevention and Control of Pollution) Act, 1974, the Air (Prevention and Control of Pollution) Act, 1981, the Environment (Protection) Act 1986, the Hazardous Chemicals (Manufactures, storage and Import) Rules, 1989, the Coastal Regulation Zone Notification, 1991 and its subsequent amendments and the Public Liability Insurance Act, 1991 and the Rules made there under from time to time. The project proponents shall also ensure that the proposal complies with the provisions of the approved Coastal Zone Management Plan of Gujarat State. |
| **PPs Submission:** Complied<br>DPA has obtained consolidated consent and authorization vide GPCB (Consent Order no-AWH-110594 dated of issue-8/12/2020, with a validity period up to 21/7/2025)- Detailed Order issued by the GPCB vide outward no. 581914 dated 22/1/2021 and subsequently, issued Correction in CCA order vide letter no. PC/CCA-KUTCH-812(5)/GPCB ID 28494/ 588116 dated 9/4/2021. A copy of the same has already been communicated with the earlier compliance reports submitted. Further an amendment has issued by GPCB vide letter no. PC/CCA-KUTCH-812(6)/GPCB ID-28494/781072 dated 11/01/2024. DPA has been appointing a NABL-accredited laboratory to monitor environmental parameters, and reports are being submitted from time to the GPCB, IRO, MoEFCC, GoI, and Gandhinagar. Recently, DPA appointed GEMI, Gandhinagar, to regularly monitor environmental parameters vide Work Order dated 15/02/2023. The work is in progress, and the latest environmental monitoring report submitted by GEMI, Gandhinagar, is attached herewith as Annexure C. Public Liability Insurance is renewed from time to time as required. The Public Liability Insurance has been renewed and is valid till 23/07/2025. A copy is attached herewith as Annexure D. Deendayal Port Authority had already obtained Coastal Regulation Zone Recommendations dated 14/02/2008 from the State Forest and Environment Department, Government of Gujarat, for the project. All the 4 berths are under operation. | | Date: 06/08/2025 |
| 16 | Statutory compliance | The project proponent shall inform the Regional office at Bhopal as well as the Ministry the date of financial closer and final approval of the Project by the concerned authorities and the date of Start of Land Development work. |
| **PPs Submission:** Complied<br>The necessary details have already been provided by the DPA from time to time, along with the earlier compliance reports submitted. Now, all the 4 berths are under operation. | | Date: 14/07/2025 |

## Visit Remarks

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| **Last Site Visit Report Date:** | N/A |
| **Additional Remarks:** | |

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

# Annexure -A

**Annexure 1**

## Compliance Report for the Period October, 2024 to March, 2025.

**Name of Work:** Construction of 13th to 16th Cargo Berth at Kandla, District Kachchh.

**CRZ Recommendations:** Letter No. ENV-I0-2006-138-P dated 14/02/2008 of Director (Environment), Forest & Environment Department, GoG. Further, the Ministry of Environment & Forest–New Delhi, Govt. of India accorded the Environmental/ CRZ clearance vide letter no. 11-70/2006-IA.III dated Sep 2008 & the validity of the same had been extended by MoEF, GoI vide letter No.F.NO.11–70/2006–IA.III dated 7th February, 2014 for a further period of 5 years.

## STATUS OF Berths:

13th Cargo Berth: Under operation since 18/2/2013.
15th Cargo Berth: Under Operation since 16/11/2013.
14th Cargo Berth: Under Operation since 8/4/2019.
16th Cargo Berth: Under Operation since 10/3/2019.

## CONSENT TO OPERATE:

Consolidated Consent & Authorization (CC&A) issued by the GPCB (Consent Order no. AWH-110594 dated issue-8/12/2020, with a validity period up to 21/7/2025)– Detailed Order issued by the GPCB vide outward no. 581914 dated 22/1/2021 & subsequently, issued Correction in CC&A order vide letter no. PC/CCA-KUTCH-812(5)/GPCB ID 28494/588116 dated 9/4/2021.

| Sr. No. | Conditions in CRZ Recommendation Letter | Compliance |
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| **Specific Conditions** | | |
| 1 | The provisions of the CRZ notification of 1991 and subsequent amendments issued from time to time shall be strictly adhered to by the KPT. No activity in contradiction to the Provisions of the CRZ Notification shall be carried out by the KPT. | All the 4 berths are under operation.<br><br>The provisions of the CRZ notification of 1991 and subsequent amendments issued from time to time are being strictly followed by Deendayal Port Authority (Erstwhile Deendayal Port Trust). |
| 2 | The KPT shall participate financially for installing and operating the Vessel Traffic Management System in the Gulf of Kachchh and shall also take lead in preparing and operationalizing and updating regularly after getting it vetted by the Indian Coast Guard. | DPA had already contributed an amount of Rs. 41.25 Crores for installing and operating the VTMS in the Gulf of Kachchh.<br><br>VTMS has been handed over to the Directorate General of Lighthouse and Lightships, Ministry of Shipping, and GoI for operating and updating regularly to statutory authorities. |
| 3 | The KPT shall strictly ensure that no creeks or rivers are blocked due to any activity at Kandla. | All the four berths are under operation |
| 4 | Mangrove plantation in an area of 1000 ha. Shall be carried out by the KPT within 5 years in time bound manner on Gujarat coastline either within or outside the Kandla port Trust area at an appropriate place in consultation with the Forest and Environment Department.<br><br>A six-monthly compliance report along with the satellite images shall be submitted to the Ministry of Environment and Forest as well as to this Department without fail. | As per the directions of the GCZMA and MoEF&CC, GoI, to date, DPA has undertaken a Mangrove Plantation in an area of 1600 Hectares since the year 2005. The details have already been communicated with the earlier compliance reports submitted.<br><br>Further DPA has assigned work to to M/s GUIDE, Bhuj vide work order dated 10/06/2024 for "Mangrove Plantation in an area of 50 Ha for Deendayal Port Authority" for the period of 10/06/2024 to 09/03/2025. The Final report submitted by GUIDE, Bhuj is attached herewith as **Annexure A**.<br><br>It is also relevant to submit here that, as per the direction of the Gujarat Coastal Zone Management Authority, DPA had already prepared & submitted a report on mangrove conservation and management plan formulated by Gujarat Institute of Desert Ecology during the study period of Jan-April, 2015 (Report already submitted along with earlier compliance reports submitted). |

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| | | For regular monitoring, DPA vide work order dated 3/5/2021 has assigned work to M/s GUIDE, Bhuj, for Monitoring of mangrove plantation carried out by DPA (Period from 24/5/2021 to 23/5/2022). The final report submitted by GUIDE, Bhuj has already been communicated with the earlier compliance report submitted.<br><br>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 inception report has already been communicated with earlier compliance report submitted. |
| 5 | No activities other than those permitted by the competent authority under the CRZ Notification shall be carried out in the CRZ area. | All the four berths are under operation |
| 6 | No groundwater shall be tapped for any purpose during the proposed expansion modernization activities. | All the four berths are under operation |
| 7 | All necessary permissions from different Government Departments / agencies shall be obtained by the KPT before commencing the expansion activities. | DPA obtained Consolidated Consent & Authorization (CC&A) from the GPCB vide Consent Order no AWH-110594 date of issue-8/12/2020, with a validity period up to 21/7/2025– Detailed Order issued by the GPCB vide outward no. 581914 dated 22/1/2021 & subsequently, issued Correction in CC&A order vide letter no. PC/CCA-KUTCH-812(5)/GPCB ID 28494/588116 dated 9/4/2021 (The copy of the Order has already been communicated with the earlier compliance report submitted). |
| 8 | No effluent or sewage shall be discharged into the sea/creek or in the CRZ area and It shall be treated to conform to the Norms prescribed by Gujarat Pollution Control Board and would be reused/recycled within the plant premises to the extent possible. | Generated sewage is treated in DPA's existing STP (1.5 MLD capacity). In addition to that, it also has septic tanks at places where STP is inaccessible.<br><br>The treated sewage is being used for gardening and plantation purposes.<br><br>DPA has been appointing a NABL-accredited laboratory to monitor environmental parameters, and reports are being submitted from time to the GPCB, IRO, MoEF&CC, GoI, and |

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| | | Gandhinagar. Recently, DPA appointed GEMI, Gandhinagar, to regularly monitor environmental parameters vide Work Order dated 15/02/2023. The work is in progress, and the latest environmental monitoring report submitted by GEMI, Gandhinagar, is attached herewith as **Annexure B**. |
| 9 | All the recommendations and suggestion given by the NIOT in their Comprehensive Environment Impact Assessment report for conservation / protection and betterment of environment shall be implemented strictly by the KPT. | Currently, all the four berths are under operation.<br><br>As per the directions of the GCZMA and MoEF&CC, GoI, to date, DPA has undertaken a Mangrove Plantation in an area of 1600 Hectares since the year 2005. The details have already been communicated with the earlier compliance reports submitted.<br><br>Further DPA has assigned work to to M/s GUIDE, Bhuj vide work order dated 10/06/2024 for "Mangrove Plantation in an area of 50 Ha for Deendayal Port Authority" for the period of 10/06/2024 to 09/03/2025. The Final report submitted by GUIDE, Bhuj is attached herewith as **Annexure A**.<br><br>For regular monitoring, DPA vide work order dated 3/5/2021 has assigned work to M/s GUIDE, Bhuj for "Monitoring of mangrove plantation" carried out by DPA (Period from 24/5/2021 to 23/5/2022). The final report submitted by GUIDE, Bhuj, has already been communicated with the last compliance report submitted.<br><br>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 inception report submitted by GUIDE has already been submitted with earlier compliance report.<br><br>DPA assigned work to M/s GUIDE, Bhuj for "Regular monitoring of Marine Ecology in and around Deendayal Port Authority (Erstwhile Deendayal Port Trust) and continuous Monitoring Program covering all seasons on various aspects of the Coastal Environs" since 2017. |

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| | | In continuation of same, DPA had issued work order to GUIDE, Bhuj for "Regular Monitoring of Marine Ecology in and around Deendayal Port Authority" for the year 2024-2027. The work is in progress. The First season report submitted by GUIDE is attached herewith as **Annexure C.**<br><br>To control fugitive emissions, DPA has installed Mist Canon in the Port area. Further, regular sprinkling through tankers on roads and other staking yards is being done to control dust pollution in other areas.<br><br>it is relevant to mention that Pollution under Control (PUC) Certificates have been made mandatory for vehicles in the port area.<br><br>For waste generated from ships, DPA issued a Grant of License/Permission to carry out the work of collection and disposal of "Hazardous Waste/Sludge/ Waste Oil" and for removal of "Dry Solid Waste (Non- Hazardous)" from Vessels calling at Deendayal Port through DPA contractors. Further, all ships are required to follow DG Shipping circulars regarding the reception facilities at the Swachch Sagar portal.<br><br>Further, DPA vide work order dated 24/01/2023 has appointed GEMI, Gandhinagar, for "Preparation of Plan for Management of Plastic Wastes, Solid Waste including C&D waste, Hazardous wastes including Biomedical and Non-Hazardous Waste in the Deendayal Port Authority area". The Final report submitted by GEMI has already communicated with earlier compliance report.<br><br>DPA has been appointing a NABL-accredited laboratory to monitor environmental parameters, and reports are being submitted from time to the GPCB, IRO, MoEF&CC, GoI, and Gandhinagar. Recently, DPA appointed GEMI, Gandhinagar, to regularly monitor environmental parameters vide Work Order dated 15/02/2023. The work is in progress, and the latest environmental |

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| | | monitoring report submitted by GEMI, Gandhinagar, is attached herewith as **Annexure B.** |
| 10 | The construction activities and dredging shall be carried out only under the constant supervision and guidelines of the NIOT. | All the four berths are currently under operation. |
| 11 | The KPT shall contribute financially for any common study or project that may be proposed by this Department for environmental management/conservation/improvement for the Gulf of Kachchh. | Point noted |
| 12 | The construction debris and/or any other of waste shall not be disposed of into the sea, creek or the CRZ areas. The debris shall be removed from the construction site immediately after the construction is over. | All the 4 berths are currently under operation. |
| | **General Conditions** | |
| 13 | The construction camps shall be located outside the CRZ area and the construction labour shall be provided with the necessary amenities, including sanitation, water supply and fuel and it shall be ensured that the environmental conditions are not deteriorated by the construction labours. | All the 4 berths are currently under operation. |
| 14 | The KPT shall bear the cost of the external agency that may be appointed by this Department for supervision / monitoring of proposed activities and the environmental impacts of the proposed activities. | Point noted |
| 15 | The KPT shall take up massive greenbelt development activities in and around Kandla and also within the KPT limits. | Deendayal Port Authority had taken up massive greenbelt development activities in and around Kandla, Residential colony, administrative building, etc.<br><br>DPA had entrusted the work to the Forest Department, Gujarat, in August 2019 for developing a green belt in and around the Port area at a cost of Rs. 352 lakhs in an area of about 32 hectares, and the work is completed.<br><br>Further, DPA has appointed the Gujarat Institute of Desert Ecology (GUIDE) for "Green belt development in Deendayal |

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| | | Port Authority and its Surrounding Areas, Charcoal site' (Phase-I) (5,000 plants)" vide Work Order No.EG/WK/4757/Part [Greenbelt GUIDE, dated 31st May 2022. The work is completed.<br><br>Further, DPA assigned work to GUIDE, Bhuj, via a work order dated 23/06/2023 for "Green belt development in Deendayal Port Authority and its Surrounding Areas (Phase II) (10,000 plants). The Final report has already been submitted along with earlier compliance report. |
| 16 | The KPT shall have to contribute financially for talking up the socio-economic upliftment activities in this region in construction with the Forest and Environment Department and the District Collector / District Development Officer. | The details of CSR activities undertaken /to be undertaken by DPA are placed at **Annexure D.** |
| 17 | A separate budget shall be earmarked for environmental management and socioeconomic activities and details there of shall be furnished to this Department as well as the MoEF, GOI. The details with respect to the expenditure from this budget head shall also be furnished. | The allocation made under the scheme of "Environmental Services & Clearance thereof other related Expenditure" during RBE 2024-25 is Rs. 585 Lakhs.<br><br>The expenditure made under the "Environmental Services & Clearance of other related Expenditure" is Rs. 522 Lakhs from October 2024 to March 2025. |
| 18 | A separate environmental management cell with qualified personnel shall be created for environmental monitoring and management during construction and operational phases of the project. | DPA already has an Environment Management Cell. Further, the DPA has also appointed an expert agency to provide Environmental Experts from time to time.<br><br>DPA appointed M/s Precitech Laboratories, Vapi, to provide Environmental Experts via a work order dated 5/2/2021 for a period of 3 years.<br><br>Further, DPA appointed M.s Precitech Laboratories, Vapi, to Provide Environmental Experts via work order dated 4/10/2024. The work order is attached herewith as **Annexure E**.<br><br>In addition, it is relevant to submit here that DPA has appointed a Manager (Environment) on a contractual basis for a period of 3 years, further extendable to 2 years (A copy of the details has |

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| | | already been communicated with the last compliance report submitted). |
| 19 | An Environmental report indicating the changes, if any, with respect to the baseline environmental quality in the coastal and marine environment shall be submitted every year by the KPT to this Department as well as to the MoEF, GOI. | DPA has been appointing a NABL-accredited laboratory to monitor environmental parameters, and reports are being submitted from time to the GPCB, IRO, MoEF&CC, GoI, and Gandhinagar. Recently, DPA appointed GEMI, Gandhinagar, to regularly monitor environmental parameters vide Work Order dated 15/02/2023. The work is in progress, and the latest environmental monitoring report submitted by GEMI, Gandhinagar, is attached herewith as **Annexure B.** |
| 20 | The KPT shall have to contribute financially to support the National Green Corps Scheme being implemented in Gujarat by the GEER Foundation, Gandhinagar, in construction with Forests and Environment Department | Point noted |
| 21 | Six monthly reports on compliance of the conditions mentioned in this letter shall have to be furnished by the KPT on regular basis to this department/ MoEF, GOI. | DPA has regularly submitted the compliance reports to GCZMA, Gandhinagar, MoEF&CC, and GOI. The last compliance report of the conditions stipulated in CRZ recommendations issued by GCZMA was submitted on 17/01/2025. |
| 22 | Any other condition that may be stipulated by this department from time to time for environmental protection/management purpose shall also have to be complied with by the KPT. | Point noted |

# Annexure -B

**FINAL REPORT**

for the Project entitled

# Mangrove Plantation in an area of 50 Hectares for Deendayal Port Authority, Kandla

(As per EC & CRZ Clearance Dt.01.01.2024. Annexure-B, Specific condition No.7)

DPA Work order No. EG/WK/4751/Part (Revamping-EC onwards)/69. Dt. 10.06.2024


**Submitted by**

Gujarat Institute of Desert Ecology

Mundra Road, Bhuj-370 001

Dist: Kachchh, Gujarat, India


**Submitted to**

Deendayal Port Authority

Gandhidham- 370201

Dist: Kachchh, Gujarat-, India

February
2025

Gujarat Institute of Desert Ecology

## Certificate

This is state that the Final Report for project entitled "**Mangrove Plantation in an area of 50 Hectares for Deendayal Port Authority, Kandla**" has been prepared in line with the Work order issued by the Deendayal Port Authority Vide. Ref. No. EG/WK/4751/Part (Revamping-EC onwards)/69. Dt.10.06.2024. In order to comply with the stipulated condition of the EC & CRZ Clearance dated 1/1/2024 read with CRZ Recommendation dated 25/8/2022 - Condition no.7.

The work order is for a period of Nine months (10.06.2024 - 09.03.2025) for the above-mentioned study.

Authorized Signatory

DIRECTOR
Gujarat Institute of Desert Ecology
Bhuj - Kachchh.

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## Project Team

**Project Coordinator: Dr. V. Vijay Kumar, Director**

**Project Personnel**

**Principal Investigator**

Dr. B. Balaji Prasath, Senior Scientist

**Co-Investigator**

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**Team Members**

Dr. L. Prabhadevi, Advisor

Mr. Dayesh Parmar, Senior Scientific Officer

Mr. Ketan Kumar Yogi, Junior Research Fellow

# Contents

**Snapshot of the Project," Mangrove Plantation in an area of 50 Hectares for Deendayal Port Authority, Kandla"**

| S.No | Components of the Study | Remarks |
|---|---|---|
| 1 | Deendayal Port letter sanctioning the project | EG/WK/4751/Part (Revamping-EC onwards)/69, dated 10.06.2024 |
| 2 | Duration of the project | Nine months (10.06.2024 - 09.03.2025) |
| 3. | Location of Mangrove Plantation Site | The location finalized for mangrove plantation is shown in Figure 1. Suitable site was selected based on water and sediment quality, intertidal fauna, and propagules. |
| 4. | Total Area | 50 Hectares |
| 5. | EC & CRZ Clearance Reference | As per EC & CRZ Clearance Dt. 01.01.2024, Annexure-B, Specific condition No. 7 |
| 6 | **Field Studies** | |
| 6a | Site Overview | Inspection to understand site conditions and potential risks (e.g., grazing). |
| 6b | Geographical Patterns | Study existing mangrove species to determine their distribution and identify suitable planting locations. |
| 6c | Landscape Assessment | The stability of the root system of existing mangroves were be examined. |
| 7 | **Plantation Techniques** | |
| 7a | Raised Bed Method (Otla Method) | Create earthen mounts to plant 15-30 seeds; suitable for areas with low to moderate water currents. |
| 7b | Transplantation of Nursery Raised Saplings | Grow saplings in polythene bags; nature for 3-4 months before transplanting; higher success rate |

## 1. Background of the study

Mangroves are among the most productive ecosystems, providing various ecosystem services and resources to both the ocean environment and humankind. This unique ecosystem occurs in the tropics and subtropics, where land meets the oceans, often bordering estuaries and backwaters. Mangrove forests have the remarkable ability to rise upward in place or move landward or seaward in response to sea level changes (Woodroffe *et al*. 2016). Mangroves typically grow on wet, muddy substrates with minimal water fluctuations, specifically in the mudflat regions of tropical and subtropical areas. These are dense forests of trees and shrubs that are tolerant to salt, usually flourishing in tidal areas. The importance derived from these forests is critical, including coastal protection, biodiversity conservation, and climate change mitigation. All mangroves produce fertilizer from rotting litter fall and root growth deceiving ambient water sediment. Mangrove ecosystems support various plant and animal species, breeding, nursery and feeding grounds for numerous marine and terrestrial organisms. Despite their ecological importance, mangrove forests face different threats such as deforestation, pollution, and climate change. Specific measures have been taken towards conserving these valuable ecosystems including them into biosphere reserves and Ramsar sites.

According to the Forest Survey of India (FSI, 2019), the global mangrove cover is approximately 14.79 million hectares. Asia leads with 5.55 million hectares, followed by Africa with 3.24 million hectares, North and Central America with 2.57 million hectares, and South America with 2.13 million hectares. South Asia has the highest mangrove area, constituting about 6.8% of the world's total mangrove cover. Anthropogenic pressures have reduced global range of these forests to less than even half of their original total cover throughout the globe as mentioned by Ragavan *et al.* (2016) while Singh (2020) observed that almost 75% of the tropical coast has been taken up by mangrove forests. India's mangrove ecosystems are incredibly important, covering around 4,992 $km^2$, which makes up about 0.15% of the country's total land area. Despite occupying a relatively small fraction of India's geographical area, mangroves are hotspots of biological activity, supporting a wide range of flora and fauna. They help in sequestering carbon, thus mitigating climate change effects. Major mangrove areas in India include the Sundarbans in West Bengal, which is the largest mangrove forest in the world.

The present study on "Mangrove Plantation in an area of 50 Hectares for Deendayal Port Authority, Kandla" is being conducted to comply with the specific conditions outlined in the EC & CRZ Clearance dated 01.01.2024 and CRZ Recommendation condition no. 7 as given in Annexure B.

## 1.1. Mangrove status in Gujarat and Gulf of Kachchh

Gujarat state has the longest coast (1650 $km^2$) with largest coastal area (28,000 $km^2$) under cover of mangroves. Gujarat mangrove ecosystem is the second largest after Sundarbans in West Bengal (ISFR 2019). Though contentious, around 15 mangrove species are reported from 13 coastal districts of Gujarat. Of these, the southern coast of Gulf of Kachchh and South Gujarat coast are important for mangrove diversity. The species *Avicennia marina* is the most populous along the Gujarat coast. Along the coastal stretch of Gulf of Kachchh (GoK) has the most considerable mangrove extent of 986 $km^2$ out of 1140 $km^2$. Kachchh district, constituting the northern coast (northern shore) of GoK alone has 798 $km^2$ of mangroves constituting 70% of the whole Gujarat mangroves. Waterlogged mud with low oxygen levels supports such vegetation in tropical and subtropical regions. In the Kachchh coast has various habitats such as expansive mudflats and small sandy beaches with different physico-chemical variables like extreme salinity temperature inundation factor. This vibrating ecosystem can allow the species to thrive and exhibit many adaptive modifications.

Biodiversity-oriented planting schemes aim to boost species richness through ongoing plantation and meticulous monitoring activities. Restoring mangrove ecosystems with dominant species like *Avicennia marina, Ceriops tagal,* and *Rhizophora mucronata* plays a crucial role in enhancing species diversity. By increasing the variety of plant species, these schemes not only create a more resilient and productive ecosystem but also help in providing essential resources and services to local populations, such as fish breeding habitats, wood, and other forest products. Continuous planting and monitoring ensure that these ecosystems remain healthy and sustainable, benefiting both the environment and the people living in coastal regions. Mangrove biodiversity seeks attention towards such spots on the Kachchh coast, which require supplementation of plant cover at selected sites. For instance, although successful efforts at restoring mangroves exist, the presence of *A. marina* alone in most parts corroborates the role of high salinity of the water because of limited fresh water influx annually. The arid coastal conditions lack of

continuous freshwater flow through the river inhibits the spread and growth of mangroves which are constantly exposed to tidal inundation. The plantation of mangroves as well as creation of awareness regarding the importance of mangrove and their ecosystem services are the crucial tasks to avoid such loss.

## 1.2. Rationale of the project

Deendayal Port Authority (DPA) has been one of India's largest ports in terms of cargo volume handled. Being located in Gujarat state on the northwest coast of India, the port is one of the biggest creek-based ports in India. In India, it is one among twelve major ports and situated at Gulf of Kachchh's tail end, Gujarat's western part. The greatest advantage of this location is a high semi-diurnal tidal range of about 6 to 7 meters which allows for sufficient draft in the dredged channels at the Port. DPA has been and still is undergoing continuous development and expansion particularly over recent times and is located in the creek environment encompassing mangroves (193.1 $km^2$) and mudflats (312.9 $km^2$).

Over the last seven decades, it should be noted that due to these vast resources available at its doorstep; the port authorities have a desire to conserve, protect and enhance these coastal habitats. The coastal belt in and around Kandla region is characterized by a network of creek systems and mudflats which are covered by sparse halophytic vegetation like scrubby to dense mangroves, creek water and salt encrusted land mass which forms the major land component. The surrounding environment in a radius of 10 km from the Port is mostly built-up areas consisting salt works, human habitations and Port related structures on west and north, creek system, mangrove formations and mudflats in the east and south.

Deendayal Port as part of the expansion of the infrastructure facility has significant movements of materials and people within the area and construction activities as well. Additionally, as part of the environmental policy intended to accomplish 50 ha mangrove plantation and the task is entrusted with the Gujarat institute of Desert ecology, Bhuj, Kachchh district Similar efforts towards conserving and preserving mangrove cover in the prospective areas have been implemented by the Deendayal Port Authority (DPA) to maintain numerous unheralded ecological services by these marine plants. Total mangrove plantation till date by DPA through several implementing agencies at Sat Saida Bet, Nakti Creek and Kantiyajal.. To ensure the project follows the

most contemporary standards and practices in the field. In accordance with the CRZ Recommendation Condition, Mr. Nischal Joshi of the Gujarat Ecology Commission (GEC) was consulted for his expert opinion during the initial stages of the work.

## 2. Objectives

Within the overall objective of mangrove plantation in the DPA port limits the following activity wise objectives are envisaged.

- Assess the technical suitability of the proposed land for mangrove plantation
- Assess the physico-chemical properties of soil and nearby water and tidal pattern in the proposed plantation site.
- Formulate site specific plantation strategy and execute it with the adopting appropriate techniques.

## 3. Study Area

The location finalized for mangrove plantation is shown in Figure 1, as per their suitability including water and sediment quality characteristics, occurrence of intertidal fauna, availability of propagules, signs of natural regeneration etc. Further, based on the water quality characteristics reported elsewhere, the site is better choice for the plantation of mangrove species, *A. marina*. In the studies conducted earlier, the salinity levels of this area is reported to be ranging between 35 - 40 ppt which is suitable for the selected species. The pH of the pour water is recorded to be in the range of 6.0 - 8.5. In addition to the above said criteria, plantation in general should be established in Intertidal areas where a good tidal flushing is happening atleast 15 days in a month.


**Figure.1** Proposed location for Mangrove plantation activities at DPA area

# 4. Methodology

## 4.1. Field Studies

4.1.1. Site Overview:

- The inspection were provide an overall understanding of the site, not only for the plantation but also for potential risks (such as camel or cattle grazing).
- Accessibility for post-plantation monitoring were be evaluated to ensure ease of assessment.

4.1.2. Geographical Patterns:

- Existing mangrove species in the area were be studied to understand their presence and distribution.
- Geographical patterns were be analyzed to identify suitable locations for planting mangroves.

4.1.3. Landscape Assessment:

- Rainwater runoff into the creeks and the influencing zones were be observed to assess its impact on the mangrove ecosystem.
- The stability of the root system of existing mangroves were be examined.
- Sources of freshwater within the area were also be considered.

## 4.2. Plantation Techniques

Three methods preferred for the sake of mangrove plantation which were be as follows in this study period:

4.2.1. Raised bed method (Otla method)

- This is popular method of mangrove plantation in Gujarat useful for a few species such as *A. marina* and provide better result compare to other methods.
- In this method, earthen mounts of a specific height were be made which support to plant 15 to 30 seeds/ propagules.
- This method is suitable in the areas where the current of water is low and moderate (Plate 1).

4.2.2. Transplantation of nursery raised saplings (Poly bag method).

- This technique has higher success rate unlike other methods and therefore, nursery of the various species is required to grow the saplings (Plate 2).
- This technique is time consuming and laborious compared to direct dibbling and raised bed methods.
- On the open intertidal mudflats, the saplings were be grown in polythene bags through sowing the matured seeds or propagules.
- The saplings were be nurtured 3-4 months before transplantation and after attaining a height 30-45 cm in polythene bags.
- Site specific conditions were determining the number of saplings to be transplanted, however, 2500 saplings per ha is generally followed.
- In some occasions also nursery raised saplings were be used for gap filling and thereby increasing the survival rate of the plants table1.

After being successfully raised in the nursery, saplings between 30 and 45 cm tall should be chosen at different times to be transplanted at the intended location. Below are the specifics of the plantation's sapling height and germination period (plate 3). A total of 46 nursery beds were established, with each bed containing 800 to 1,200 polybags. Each polybag is sown with 3 to 4 seeds, facilitating optimal seedling production (Figures 8-13). In addition, otla raised method, in each bed sown 5 – 6 seeds were raised in plantation site (Figures 15-17)

**Table 1: Details of sapling for plantation**

| Species | Germination period (days) | Germination percentage | Height (cm)of saplings |
|---|---|---|---|
| *Avicennia marina* | 6-10 | 70-80 | 30-45 |
| *Rhizophora mucronata* | 30-35 | 50-60 | 60 |

With these methods, the extra seeds were also spreaded in the plantation area where the older trees are present and generally the area where natural regeneration of seeds happens.

## 5. Site visit

Before the initiation of mangrove plantation activity, a through pre-project survey was conducted to examine the proposed plantation site. In this survey, the crucial technical factors like land elevation, tidal pattern, physical and chemical properties of soil and water (by laboratory analysis), access to the site, level of protection such as cattle grazing, human disturbance and other potential risks, etc. were observed. This survey helps to decide the suitability of site for mangrove plantation in DPA port limit.

### 5.1. On-site observations

- The indicators of regular flooding of site by tide water was observed in on-site visit. The site area was wet and with plenty of mud which is required for plantation.
- There was no presence of very hard, dried soil surface in the site was observed anywhere.
- The presence of a few natural mangrove (*A. marina*) trees was observed around and in the plantation site which denotes the site is suitable for the plantation.
- The presence of crab holes and mudskippers holes is the indicator that the soil of the site is soft and regularly get wet due to tides.
- The pneumatophores of nearby mangroves were found in the nearby area which indicate that there is no sediment deposition and buried pneumatophores in this area.
- Nearby area also shows the presence of halophytic/ salt marsh plants such as *Sesuvium* and also *Salicornia* nearby creek.
- The *Sesuvium* leaves were green and fresh, also not thicker which represent the good condition of the site.
- The presence of sub-creek system may ensure the availability of tidal water which were be primary need of the plantation.
- A few natural regeneration plants were also observed in the site.
- The presence of the jackal foot marks observed which denotes the overall area have a good ecosystem and where the jackal food (crabs) sources are available.

## 5.2. Analysis of water and sediment samples

### 5.2.1. Water analysis

The water samples were collected from the plantation site in pre-cleaned polyethene bottles and rinsed with sample water, and transported to the laboratory in icebox for further analysis such as pH analysis by pH meter, salinity was determined by refractometer. The pH of water sample was found 7.25 and salinity 18 psu. Although there is no domestic freshwater source, and tidal water salinity generally higher, due to the rainy season the salinity shows lower values. However, the lower salinity is also in favour of germination of mangrove seeds.

### 5.2.2. Sediment/ soil analysis

Sediment samples were collected by using a non-metallic plastic spatula from random locations; three from each transect to cover the whole study area. The collected samples were air-dried at room temperature (Jackson, 1958), homogenized using an agate mortar and pestle, sieved through a standard sieve of 2 mm mesh (Tandon, 2005). The particles with size less than 2mm were retained in pre cleaned plastic bottles for further analysis for various parameters. Total Organic Carbon (TOC), pH, texture, bulk density, etc were analysed.

Texture of sediment: The texture of soil/sediment is one of the key factors when choosing a site for plantation mangroves. Generally, mangrove ecosystems typically have the types of soils which includes muds or clay or sandy mud, etc. The texture of soil significantly impacts the survival and growth of mangroves. The presence of clay texture which makes soil muddy may expected to offer a stable base for mangrove roots to flourish under tidal conditions. Thus, evaluating the soil conditions at the plantation site is crucial before starting mangrove planting activities. Here we collected 3 samples, and all shows good amount of clay percentage in them which may be favourable for the plantation.

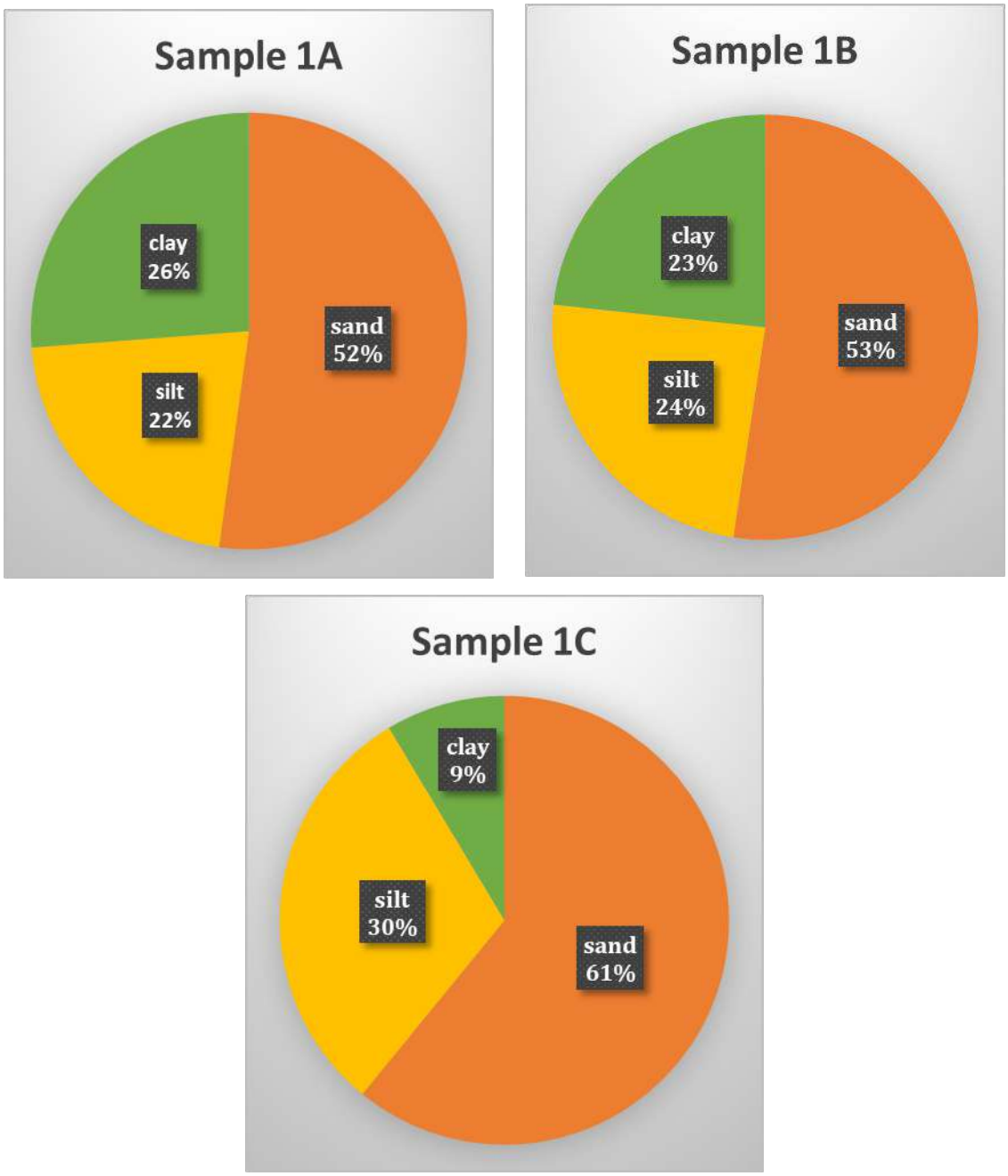



**Figure 2:** Sediment textural composition in the sampling sites

Bulk density of soil: It refers to the amount of soil organic matter within a given volume of soil. This property can vary significantly and is influenced by the soil's texture, structure, and organic matter content. Soils with high organic matter tend to have lower bulk density, while compacted soils exhibit higher bulk density.

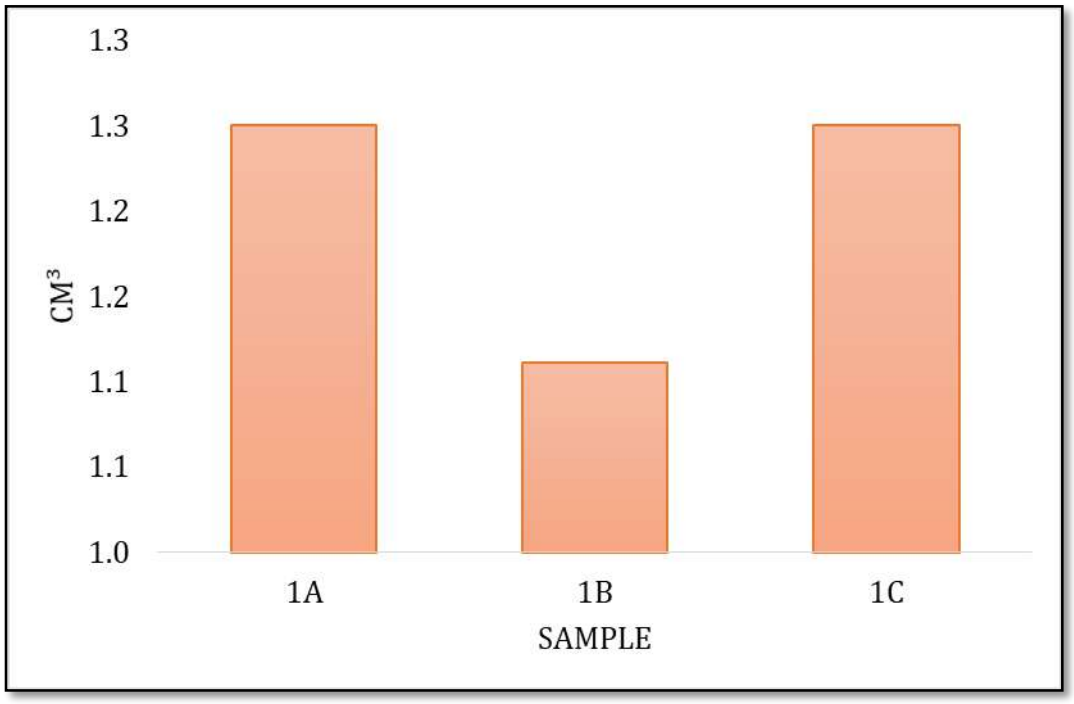



**Figure 3:** Bulk density of sediment samples

Total Organic Carbon: Organic carbon levels are influenced by living organisms, and the diversity of life forms in mudflats affects the total organic carbon (TOC) estimates. In all samples, the TOC percentage was ranged from 2.7 % to 2.85%

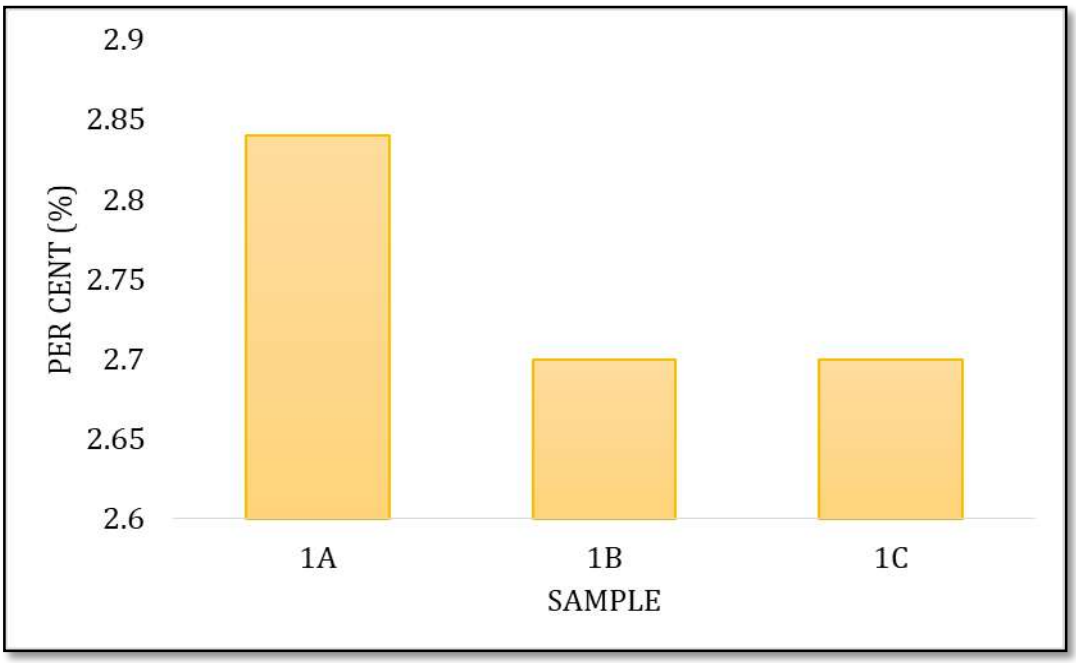



**Figure 4:** Total Organic Carbon content of sediment samples

**Plate 1:** Selection of suitable sites for mangrove plantation in DPA area based on sediment characteristics, tidal pattern, cattle grazing etc

**Plate 2**: Site identification, planning and field observation at mangrove plantation site on July 17th to 31st, 2024

**Plate 3:** Mangrove Seed Collection at Kandla on 1st to 07th August, 2024

**Plate 4:** Team involved in collection and separation of healthy mangrove seeds on 8th to 17th August, 2024

**Plate 5:** Women involved in processing of mangrove seeds on 17th to 25th August, 2024

**Plate 6**: Preparation and filling of bags for submerged Nursery Development Activity on 25th to 30th August, 2024

**Plate 7:** Labour Involvement in filling of bags for nursery preparation at Kandla on 25$^{th}$August to 5$^{th}$ September, 2024

**Plate 8:** Seed sowing of *Avicennia marina* in polybags at nursery at Kandla on 6th to15th September, 2024

**Plate 9:** Site submerged during high tide on 15th September, 2024

**Plate 10:** Germination of *A. marina* seeds in polybags and germination during visit of GUIDE team at Kandla on 15th to 25th September, 2024

**Plate 11:** Nursery of *A. marina* saplings in natural tidal inundation at Kandla on 5th to 25th October, 2024

**Plate 12:** Insect pests and diseases in *A. marina* leaf and stem in saplings during visit of GUIDE team at Kandla on 25th October to 5th November, 2024

**Plate 13:** Labour Involvement in Otla bed raised method at Kandla 1st to 07th September, 2024

**Plate 14:** Seed sowing of *A. marina* in Otla beds at nursery at Kandla on 10th to 25th September, 2024

**Plate 15:** Germination of *A. marina* in Otla beds observed during visit of GUIDE team at Kandla on 5th to 25th October,

**Plate 16:** Mangrove Growth of *A. marina* prior to Transplanting from Nursery to Plantation Site by the GUIDE Team at Kandla on 30th November

**Plate 17:** Labour Participation in Loading Nursery Bags onto Boats for Transportation to Plantation Sites at Kandla on 1st December to 15th December, 2024

**Plate 18:** Labour Involvement plantation the *A. marina* at Kandla on 1st December, 2024 to 31st January, 2025

**Plate 19:** Labour Involvement plantation the *A. marina* at Kandla on 1st December, 2024 to 31st January, 2025

**Plate 20:** Labour Involvement in *A. marina* Plantation during GUIDE Team Visit to Kandla on 15th January, 2025

**Plate 21:** *A. marina* Plantation during GUIDE Team and DPA Team Visit to Kandla on 15th January, 2025

**Plate 22:** Mangrove outplanting, including row establishment and saplings placing inside hole, levelling soil surface at Kandla on 10th February, 2025

## 6. Summary of the Report

The aim of the report is to assess the situation of growing mangrove saplings at DPA Gulf of Kutch. In order to comply with the stipulated condition of the EC & CRZ Clearance dated 1/1/2024 accorded by the MoEF&CC, GoI read with CRZ Recommendation dated 25/8/2022 for "Augmentation of Liquid Cargo Handling capacity from 8 to 23.8 MMTPA through modernization of existing Pipeline network at Oil Jetty area of DPA, Kandla"), DPA assigned work of "Mangrove Plantation in an area of 50 Hectares for Deendayal Port Authority reg.", to GUIDE, Bhuj vide work order dated 10/6/2024.

The DPA has initiated a program for plantation of mangroves to improve these ecosystems within the limits of its port. The general focus of this project is to evaluate mangrove plantation in an area of 50 Hectares for Deendayal Port Authority, site conditions for planting, study the soil and water characteristics, and formulate and execute a site-specific planting plan utilizing nursery grown transplant, otla method and other forms. The objective is to increase the mangrove species, improve the resilience of the ecosystem and provide the local population with valuable resources and services, all while ensuring the sustainability of mangrove cover over the long term. The increased ecological stability and productivity of the region, and provide necessary resources and services to the local and marginalized communities throughout the work in a selected, defined and timetabled manner to observe the speed of the work done. The Mangrove Plantation in an area of 50 Hectares of *Avicennia marina* and *Rhizophora mucronata* at scientifically identified location (Satsaida bet) is completed.

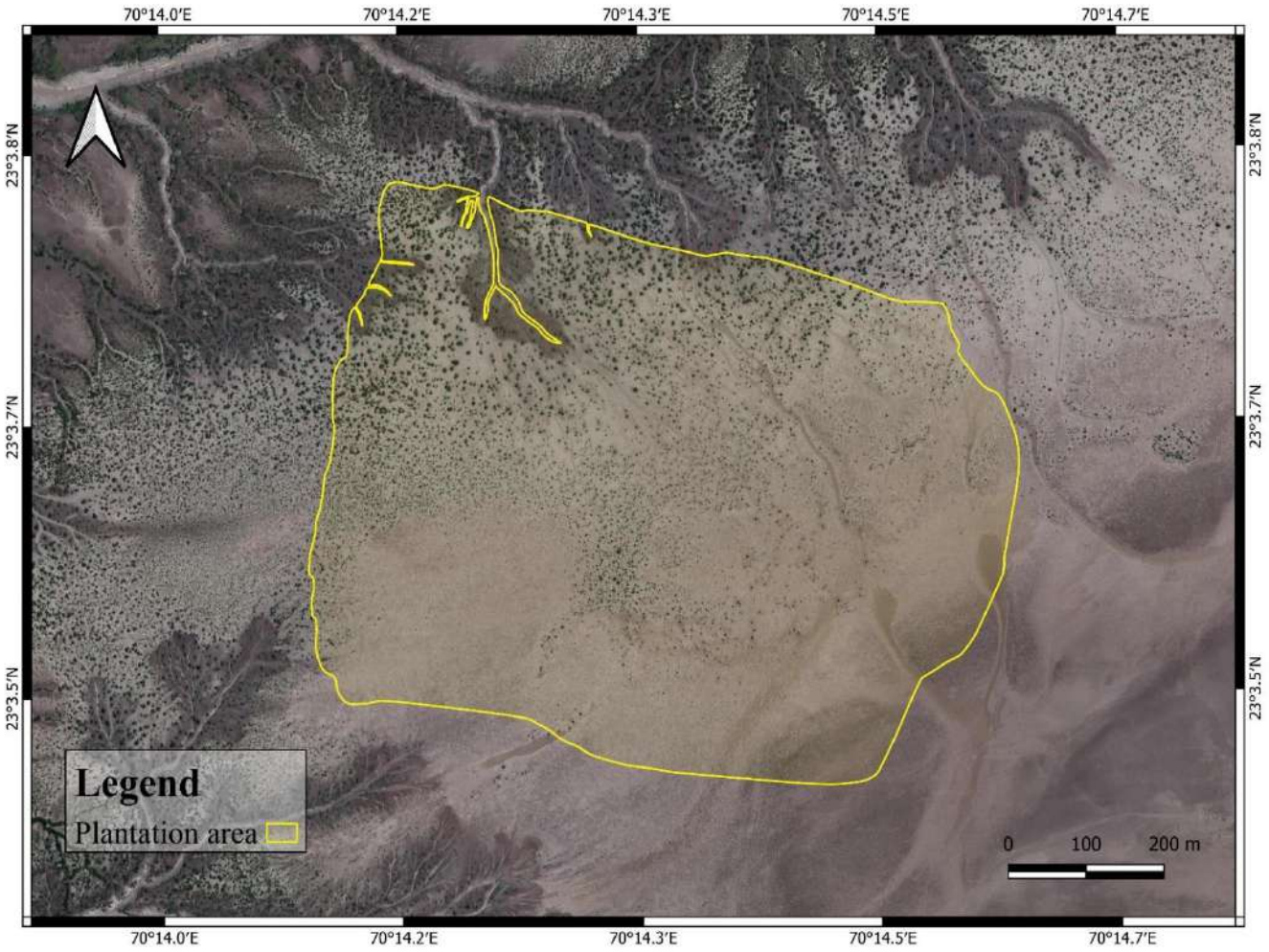



**Figure 5:** Mangrove plantation site area at Kandla, Gujarat, India

**Plate 24:** Growing saplings during GUIDE Team Visit to Kandla on 10th February, 2025

**Plate 25:** Labour Involvement plantation the *Rhizophora mucronata* at Kandla on 31st January to 28th March, 2025

Table: 2 GPS Points of Mangrove Project Site at Kandla, Gujarat, India

| No | Point No. | Longitude | Latitude |
|---|---|---|---|
| **1** | **K-18** | 70.243 | 23.062 |
| **2** | **K-19** | 70.244 | 23.06 |
| **3** | **K-23** | 70.243 | 23.058 |
| **4** | **K-25** | 70.241 | 23.057 |
| **5** | **K-27** | 70.239 | 23.057 |
| **6** | **K-28** | 70.235 | 23.058 |
| **7** | **K-31** | 70.235 | 23.061 |
| **8** | **K-33** | 70.235 | 23.062 |
| **9** | **K-35** | 70.237 | 23.064 |
| **10** | **K-37** | 70.24 | 23.063 |

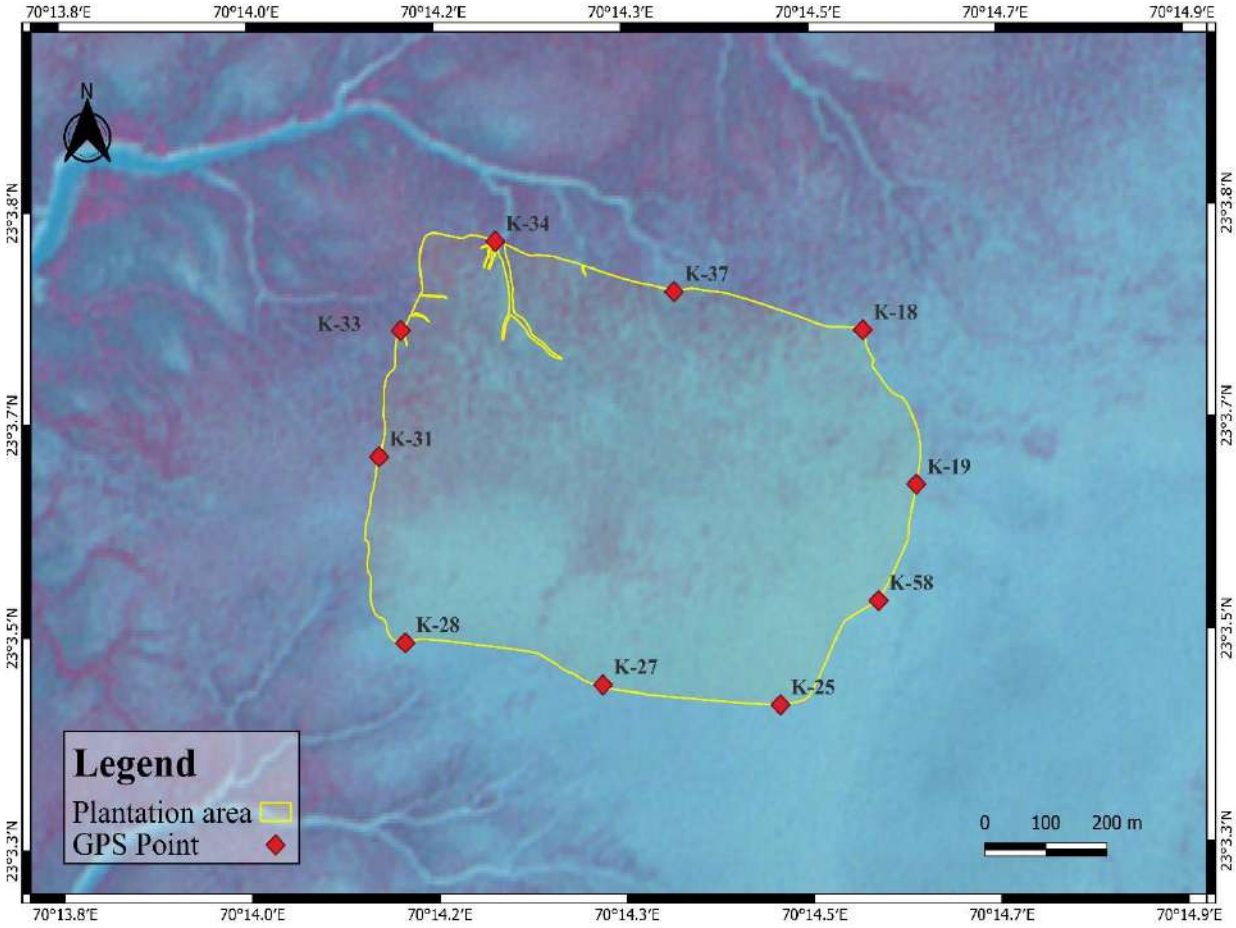



**Figure 6:** Mangrove plantation site area with GPS location points at kandla, Gujarat, India

## 7. Future Considerations for Mangrove Plantation

DPA needs to focus on the mangrove plantation project in Kandla. In ensuring that, this report puts forward the steps that need monitoring for the future.

### 7.1. Carry out regular monitoring of mangrove plantation

The regular monitoring of mangrove plantations is must in the plantation site to ensure growth status of the planted mangroves. It will also help in detection of any signs of disease or damage early. Regular monitoring also helps to understand any threats to mangrove such as potential erosion or grazing etc, also help to protect the local ecosystem and biodiversity. It will useful in the measurement of effectiveness of conservation efforts.

### 7.2. Regular gap filling to be done

Maintenance of the plantation is crucial for its continued success. Regular upkeep is needed, including filling in gaps where plants may have failed to establish. In addition to *Avicennia marina*, it's important to plant a variety of mangrove species to boost biodiversity. This increased diversity enhances the ecosystem's resilience to environmental changes, such as fluctuations in salinity, temperature, and sea level rise. Regular monitoring and management practices ensure the plantation's long-term health and ecological stability, contributing to the protection of coastal areas and marine life habitats.

## 8. References

ISFR (2019) India state of forest report. Ministry of Environment Forest and Climate Change Dehradun

Ragavan P, Saxena A, Jayaraj RSC, Mohan PM, Ravichandran K, Saravanan S, Vijayaraghavan A (2016) A review of the mangrove floristics of India. Taiwania 61(3)

Singh JK (2020) Structural characteristics of mangrove forest in different coastal habitats of Gulf of Khambhat arid region of Gujarat, west coast of India. Heliyon 6(8):e04685. https://doi.org/10.1016/j.heliyon.2020.e04685

Woodroffe CD, Rogers K, McKee KL, Lovelock CE, Mendelssohn IA, Saintilan N (2016) Mangrove sedimentation and response to relative sea-level rise. Annual review of marine science 8(1):243–266

APHA (2017). Standard Methods for the Examination of Water and Wastewater, 23nd edition. American Public Health Association, 1546.

Strickland, J.D.H. and Parsons, T.R. (1972) A Practical Handbook of Seawater Analysis. 2nd edition. Ottawa, Canada, Fisheries Research Board of Canada, 310pp. (Bulletin Fisheries Research Board of Canada, Nr. 167 (2nd ed)). DOI: http://dx.doi.org/10.25607/OBP-1791

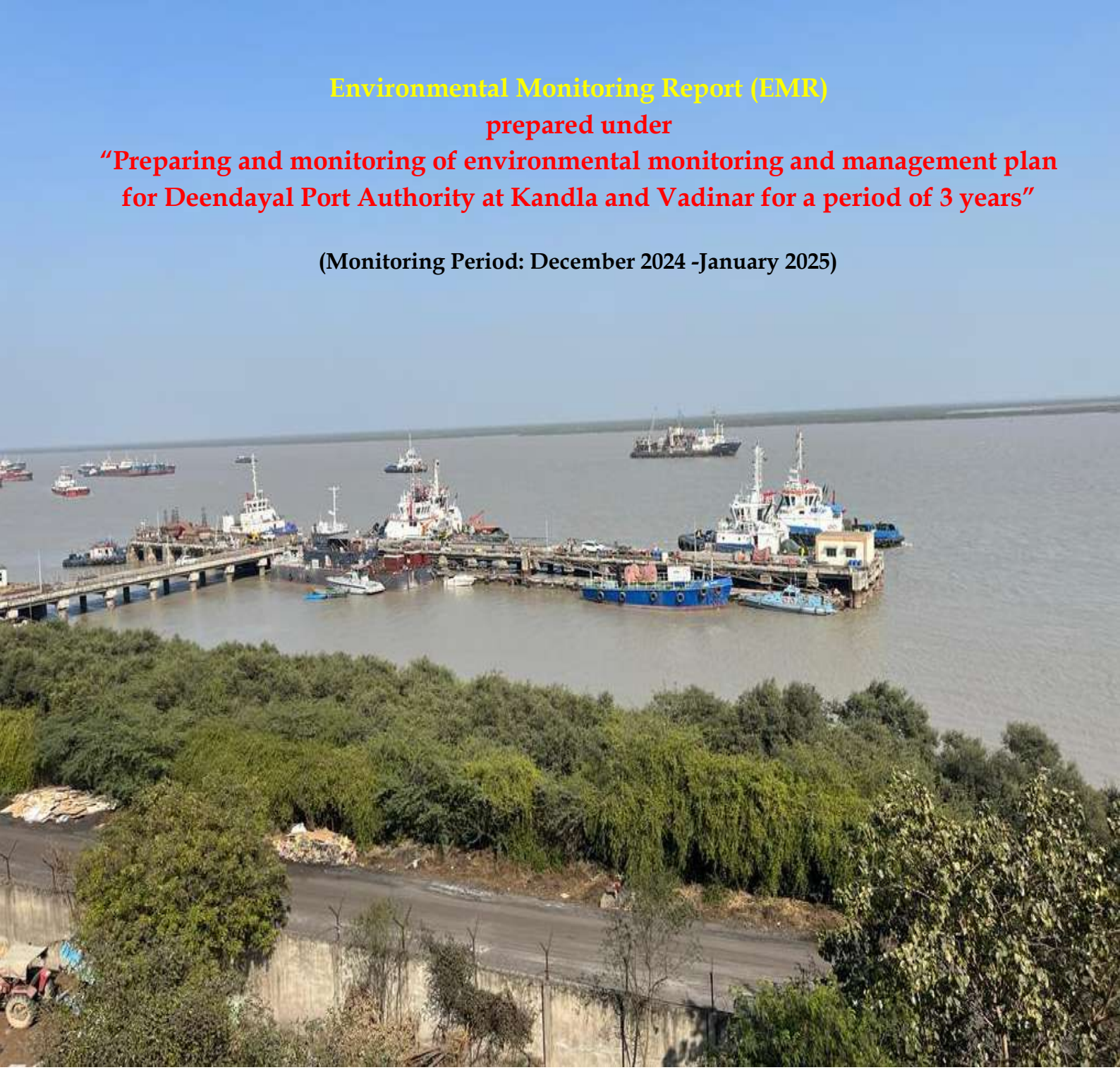
Tandon, V.R. (2005) Medicinal Uses and Biological Activities of Vitex negundo. Natural Product Radiance, 4, 162-165.

Jackson, M.L. (1958) Soil Chemical Analysis. Prentice-Hall Inc., Englewood Cliffs, NJ, 498 p.

# Annexure -C

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

**(Monitoring Period: December 2024 -January 2025)**



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

## Submitted to:

## Deendayal Port Authority (DPA), Kandla


## Gujarat Environment Management Institute (GEMI)

**(An Autonomous Institute of Government of Gujarat)**

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

# Certificate

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

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

S. S. O. & Lab Head

**Authorized Signatory**

# About this Document

Gujarat Environment Management Institute (GEMI) has been assigned with the work of "Preparing and monitoring of Environmental monitoring and Management plan for Deendayal Port Authority (DPA) at Kandla and Vadinar for a period of 3 years" by DPA, Kandla. Under the said project the report titled *"Environment Monitoring Report (Dec-2024-Jan-2025)"* is prepared.

- **Name of the Report:** *Environment Monitoring Report (Dec-2024-Jan-2025)*
- **Date of Issue:** 15/02/2025
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- **Report Ref.:** GEMI/DPA/782(2)(4)/2024-25/165

## Table of Contents

## List of Tables

# List of Maps



# List of Figures



# List of Graphs

# List of Abbreviations

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

# CHAPTER 1: INTRODUCTION

## 1.1 Introduction

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

## 1.2 Green Ports Initiative

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

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

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

## 1.3 Importance of EMP

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

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

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

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

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

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

This document presents the Environmental Monitoring Report (EMR) for Kandla and Vadinar for the environmental monitoring done during the period from 17th December-16th January 2024-2025.

## 1.4 Objectives and scope of the Study

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

The scope of work includes not limited to following:

1. To review the locations/stations of Ambient Air, Ambient Noise, drinking water, and Marine Water, Soil and Sediments monitoring within the impacted region in-and-around DPA establishment, in view of the developmental projects.
2. To assess the Ambient Air quality, quality at 6 stations at Kandla and 2 at Vadinar in terms of gases and particulate matter.
3. To assess the DG stack emissions (gases and particulate matter).
4. To assess Drinking water quality at twenty locations (18 at Kandla and 2 at Vadinar) in terms of Physical, Chemical and Biological parameters viz., Color, Odor, turbidity, conductivity, pH, Total Dissolved Solids, chlorides, Hardness, total iron, sulfate, $NH_4$, $PO_4$, and bacterial count on a monthly basis.
5. To assess the Marine water quality in terms of aquatic Flora and Fauna and Sediment quality in terms of benthic flora and fauna.
6. To assess Marine Water Quality and sediment in term of physical and chemical parameter.
7. To assess the trends of water quality in terms of Marine ecology by comparing the data collected over a specified time period.
8. Weekly sample collection and analysis of inlet & Outlet points of the Sewage Treatment Plant (STP) to check the water quality being discharged by DPA as per the CC&A.
9. Carrying out monthly Noise monitoring; twice a day at the representative stations for a period of 24 hours.
10. Meteorological parameters are very important from air pollution point of view, hence precise and continuous data collection is of utmost importance. Meteorological data on wind speed, wind direction, temperature, relative humidity, solar radiation and

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

11. To suggest mitigation measures, based on the findings of this study and also check compliance with Environmental quality standards, Green Port Initiatives, MIV 2030, and any applicable Statutory Compliance.
12. To recommend Environment Management Plans based on Monitoring programme and findings of the study.

# CHAPTER 2: METHODOLOGY

## 2.1 Study Area

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

### a. Kandla

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

- **Climatic conditions of Kandla**

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

### b. Vadinar

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

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

- **Climatic conditions of Vadinar**

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

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


**Map 1: Locations of Kandla and Vadinar Port**


**Map 2: Locations of Kandla Port**


**Map 3: Locations of Vadinar Port**

## 2.2 Environmental Monitoring at Kandla and Vadinar

Regular monitoring of environmental parameters is of immense importance to assess the status of environment during project operation. With the knowledge of baseline conditions, the monitoring programme will serve as an indicator for identifying any deterioration in environmental conditions, thereby assist in recommending suitable mitigatory steps in time to safeguard the environment. Monitoring is as important as that of control of pollution since the efficiency of control measures can only be determined by a well-defined monitoring program. Environmental Monitoring is vital for monitoring the environmental status of the port for sustainable development. The list of main elements for which Environmental monitoring is to be carried out have been mentioned below:

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

GEMI has been entrusted by DPA to carry out the monitoring of the various aforementioned environmental aspects at the port, so as to verify effectiveness of prevailing Environment Management plan, if it confirms to the statutory and/or legal compliance; and identify any unexpected changes. Standard methods and procedures have been strictly adhered to in the course of this study. QA/QC procedures were strictly followed which covers all aspects of the study, and includes sample collection, handling, laboratory analyses, data coding, statistical analyses, interpretation and communication of results. The analysis was carried out in GEMI's NABL/MoEF accredited/recognized laboratory.

**Methodology adopted for the study**

Methodology is a strictly defined combination of practices, methods and processes to plan, develop and control a project along the continuous process of its implementation and successful completion. The aim of the project management methodology is to allow the control of whole process of management through effective decision-making and problem solving. The methodology adopted for the present study is shown in **Figure 1** as given below:

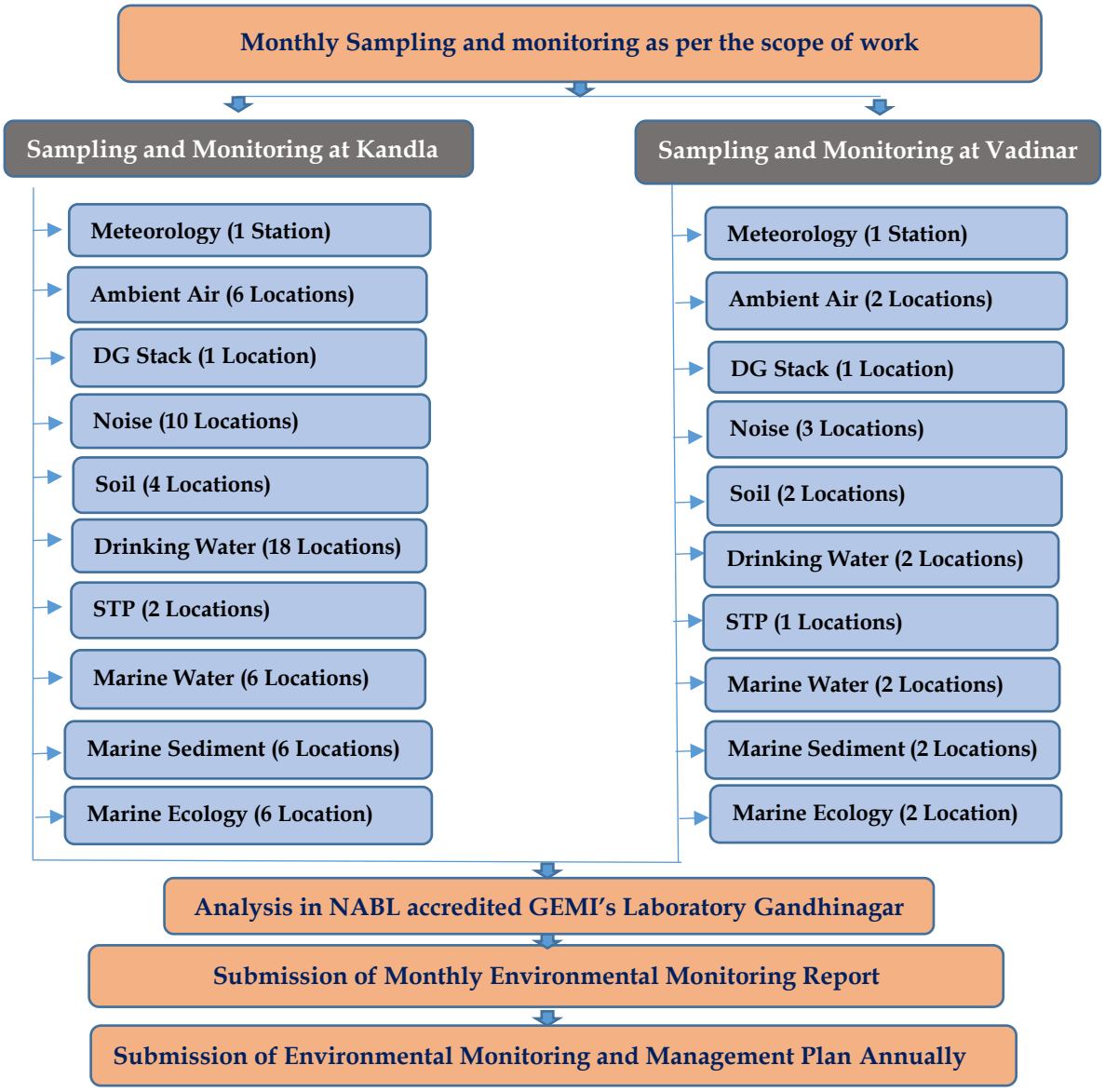



**Figure 1: Methodology flow chart**

The details of various sectors of Environment monitoring are described in subsequent chapters.

# CHAPTER 3: METEOROLOGY MONITORING

## 3.1 Meteorology Monitoring

Meteorological conditions play a crucial role in dispersion of air pollutants as well as in environmental pollution studies particularly in pollutant transport irrespective of their entry into the environment. The wind speed and direction play a major role in dispersion of environment pollutants. In order to determine the prevailing micro-meteorological conditions at the project site an Automatic Weather Monitoring Stations (AWS) of Envirotech make (Model: WM280) were installed at both the sites of Kandla and Vadinar at 10 m above the ground. The details of the AWS installed have been mentioned in **Table 1** as follows:

**Table 1: Details of Automatic Weather Station**

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

**Methodology**

During the study, a continuous automatic weather monitoring station was installed at both the sites to record climatological parameters such as Wind speed, Wind Direction, Relative Humidity, Solar Radiation, Rainfall and Temperature to establish general meteorological regime of the study area. The methodology adopted for monitoring meteorological data shall be as per the standard norms laid down by Bureau of Indian Standards (BIS) and the India Meteorological Department (IMD). The details of Automatic Weather Monitoring Station have been mentioned in **Table 2**.

**Table 2: Automatic Weather Monitoring Station details**

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

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



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

## 3.2 Results and discussion

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

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

| Details of Micro-meteorological data at Kandla Observatory | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Monitoring Period** | **Wind Speed (Km/h)** | | | **Temperature (°C)** | | | **Relative humidity (%)** | | | **Solar Radiation (W/m²)** | **Wind Direction (°)** | **Rainfall (mm)** |
| **Stat.** | **Mean** | **Max.** | **Min** | **Mean** | **Max** | **Min** | **Mean** | **Max** | **Min** | | | |
| **December-January, 2024-2025** | 7.25 | 48 | 3.12 | 20.27 | 34.1 | 13.5 | 52.38 | 78 | 27.8 | 57.19 | South | 0 |
| **Details of Micro-meteorological data at Vadinar Observatory** | | | | | | | | | | | | |
| **Monitoring Period** | **Wind Speed (Km/h)** | | | **Temperature (°C)** | | | **Relative humidity (%)** | | | **Solar Radiation (W/m²)** | **Wind Direction (°)** | **Rainfall (mm)** |
| **Stat.** | **Mean** | **Max.** | **Min** | **Mean** | **Max** | **Min** | **Mean** | **Max.** | **Min** | | | |
| **December-January, 2024-2025** | 7.91 | 74.7 | 2.96 | 20.90 | 27.3 | 14.1 | 60.62 | 104.1 | 29.4 | 69.28 | South-West | 0 |

## 3.3 Data Interpretation and Conclusion

- **Temperature**

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

- **Relative Humidity**

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

- **Rainfall**

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

- **Wind Speed**

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

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

- **Solar Radiation:**

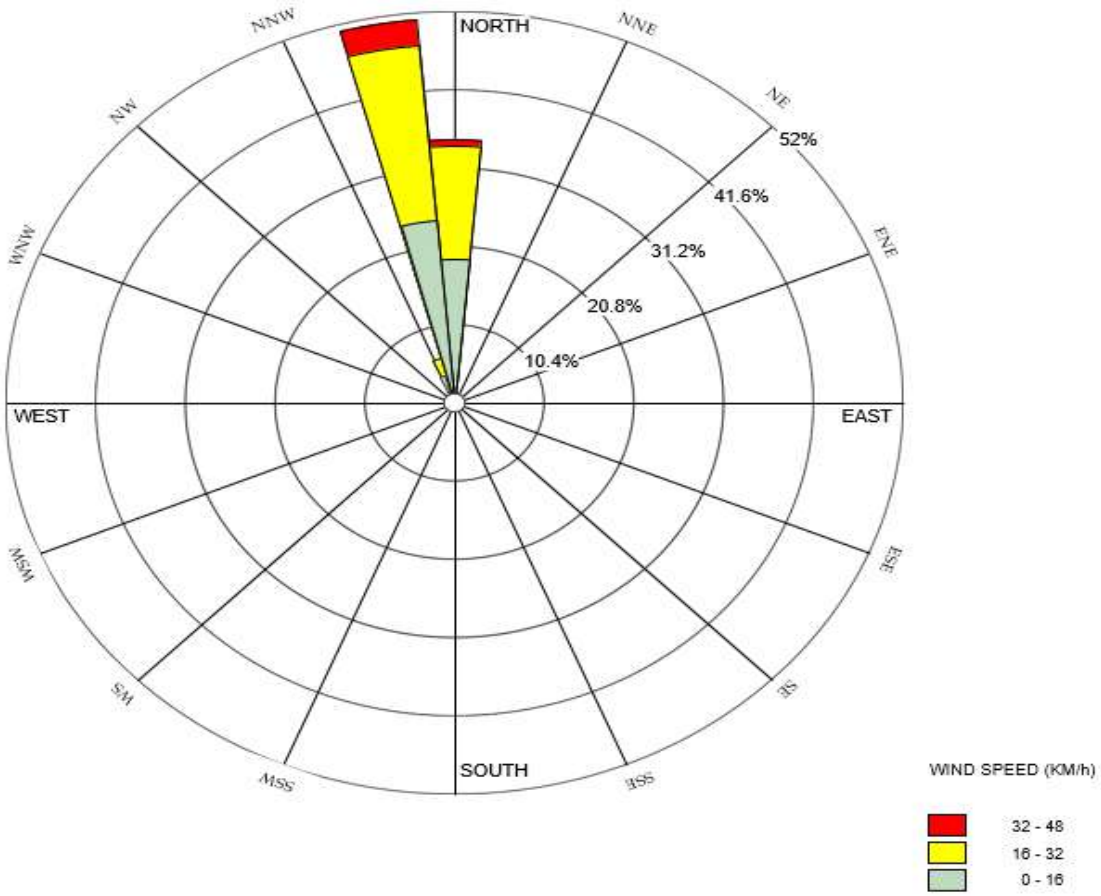
a. **Kandla:** The average Solar Radiation for the monitoring period was recorded as 57.19 W/m$^2$.
b. **Vadinar:** The average Solar Radiation was recorded as 69.28 W/m$^2$.

- **Wind rose diagram -**

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

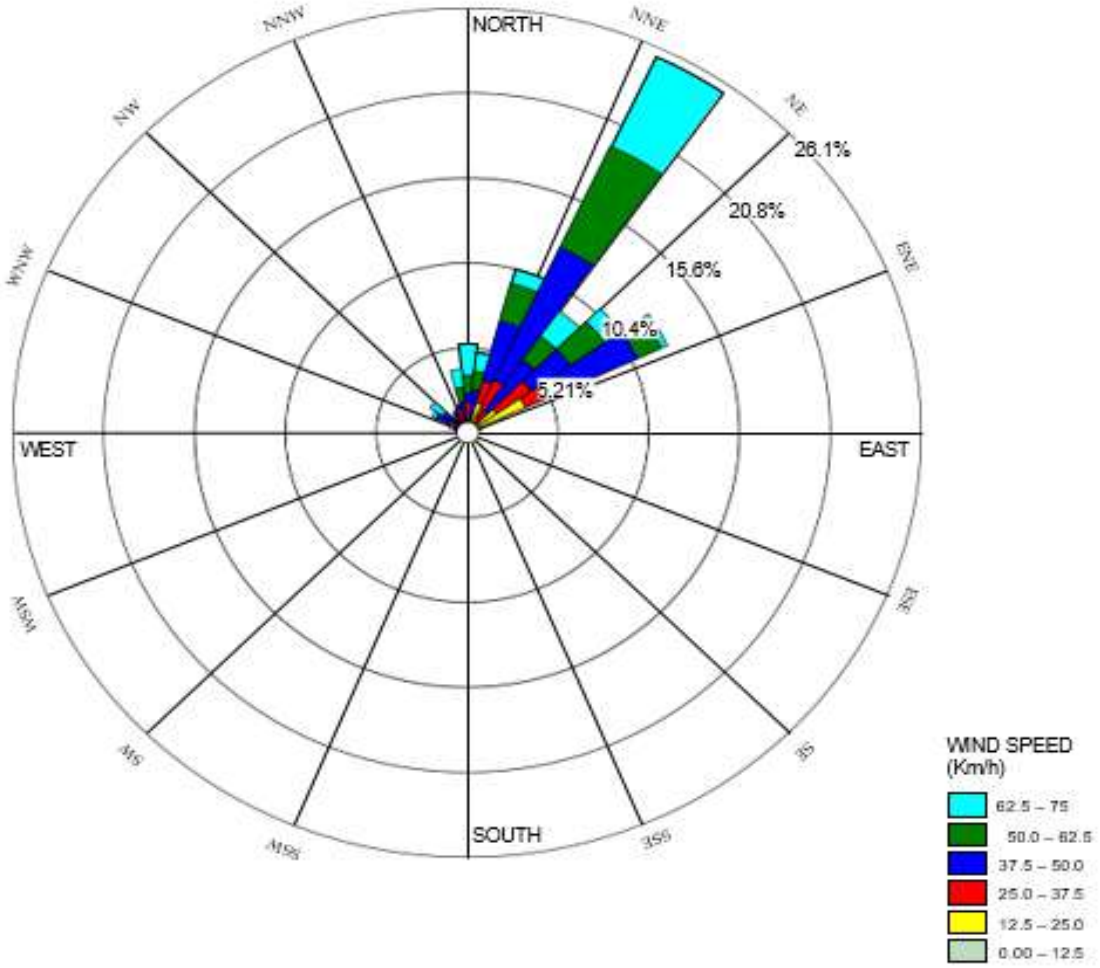
This Wind Rose Diagram reveals that at Kandla and Vadinar, during the monitoring period, the prevailing winds predominantly blow from the West South West direction at Kandla, whereas, high speed winds were also observed to blow from South direction. At Vadinar, the winds were observed to blow from South-West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

| Wind Rose Plot<br>M/s Deendayal Port Authority<br>Site: Kandla Port (Environment Laboratory) | Display: Wind Direction<br>Wind Speed (Km/hr) |
|---|---|




Modeler: Envirotech Instruments Pvt. Ltd. Delhi.

| Wind Rose Plot<br>M/s Deendayal Port Authority<br>Site: Vadinar Port (Canteen Area) | Display: Wind Direction<br>Wind Speed (Km/hr) |
|---|---|




Modeler: Envirotech Instruments Pvt. Ltd. Delhi.

# CHAPTER 4: AMBIENT AIR QUALITY MONITORING

## 4.1 Ambient Air Quality

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

**Methodology**

The study area represents the area occupied by DPA and its associated Port area. The sources of air pollution in the region are mainly vehicular traffic, fuel burning, loading & unloading of dry cargo, fugitive emissions from storage area and dust arising from unpaved village roads. Considering the below factors, under the study, as per the scope specified by DPA eight locations wherein, 6 stations at Kandla and 2 at Vadinar have been finalized within the study area

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

The description of various air quality stations monitored at Kandla and Vadinar have been specified in **Table 4**.

**Table 4: Details of Ambient Air monitoring locations**

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

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

Ambient Air monitoring photos

**Kandla**

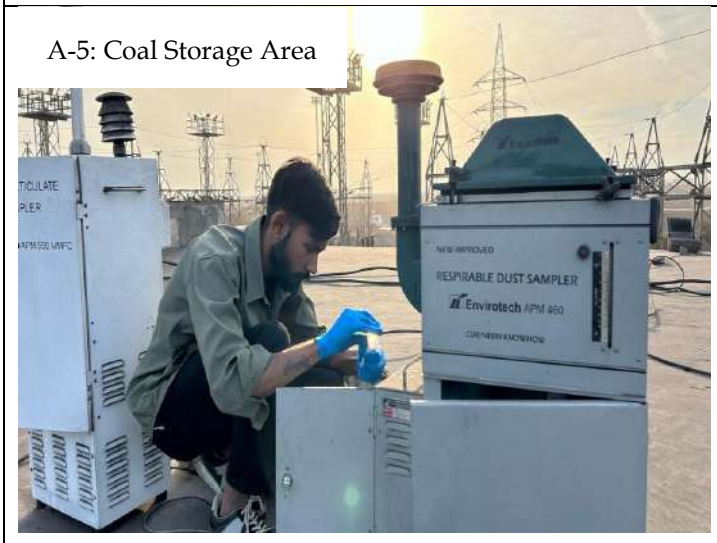
A-1: Oil Jetty No. 1

A-2: Oil Jetty No. 7

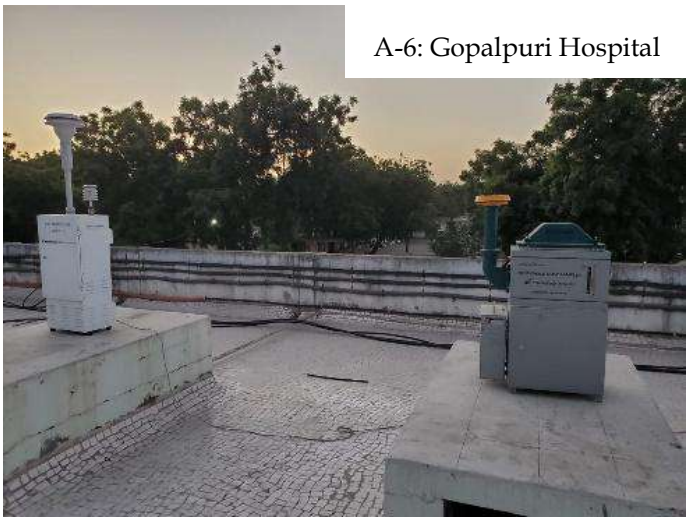
A-3: Kandla Port Colony

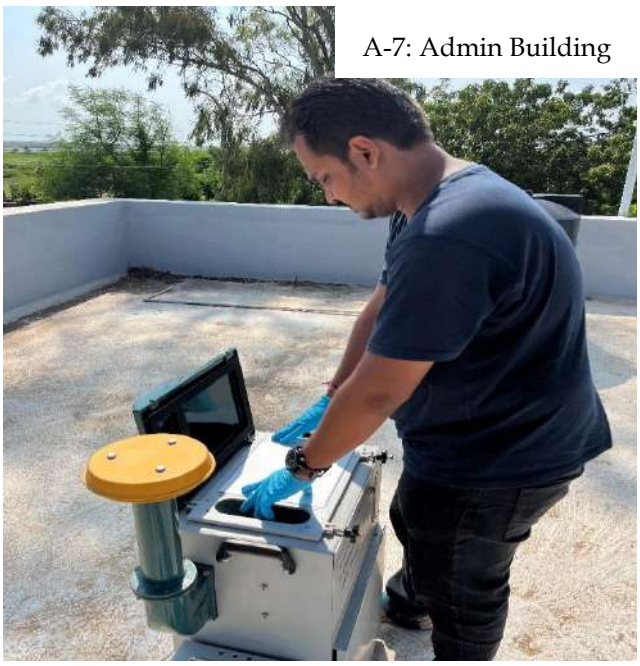
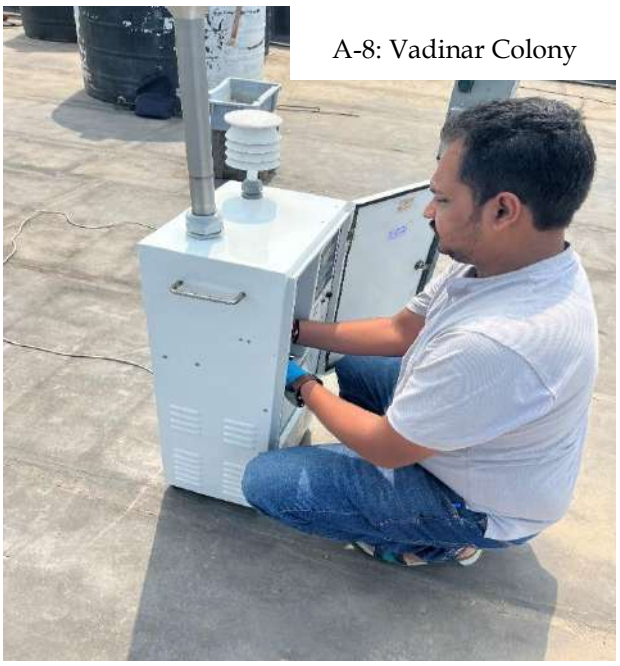
A-4: Marine Bhavan

A-5: Coal Storage Area

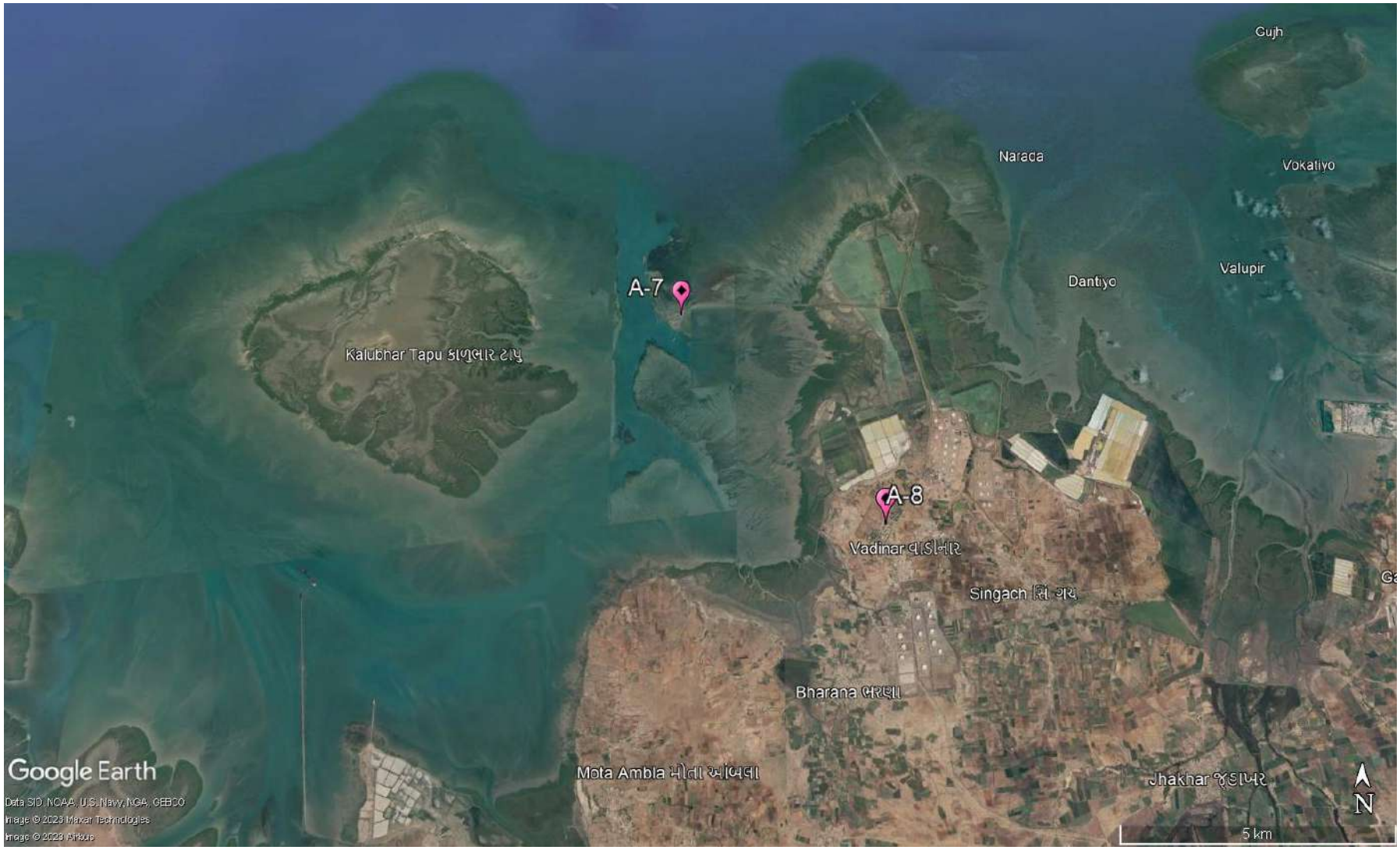



A-6: Gopalpuri Hospital



| Vadinar | |
|---|---|
|  A-7: Admin Building |  A-8: Vadinar Colony |


**Map 4: Locations for Ambient Air Monitoring at Kandla**




**Map 5: Locations for Ambient Air Monitoring at Vadinar**

**Frequency**

The sampling for Particulate matter i.e. $PM_{10}$ and $PM_{2.5}$ and the gaseous components like $SO_x$, $NO_x$, CO as well as the Total VOCs were monitored twice in a week for a period of 24 hours a day. Whereas, the sampling for the components of PAH, Benzene and non-Methane VOCs was conducted on monthly basis.

**Sampling and Analysis**

The Sampling of the Ambient Air Quality parameters and analysis is conducted as per the CPCB guidelines of National Ambient Air Quality Monitoring. The sampling was performed at a height of 3.5 m (approximately) from the ground level. For the sampling of $PM_{10}$, calibrated 'Respirable Dust Samplers' were used, where Whatman GF/A microfiber filter paper of size 8"x 10" were utilized, where the Gaseous attachment of the make Envirotech instrument was attached with Respirable Dust Sampler for the measurement of $SO_x$ and $NO_x$. The Fine Particulate Sampler for collection of $PM_{2.5}$ was utilized for the particulate matter of size <2.5 microns. A known volume of ambient air is passed through the cyclone to the initially pre-processed filter paper. The centrifugal force in cyclone acts on particulate matter to separate them into two parts and collected as following:

- Particles <10 µ size (Respirable): GF/A Filter Paper
- Particles <2.5 µ size (Respirable): Polytetrafluoroethylene (PTFE)

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

Data has been compiled for $PM_{10}$, $PM_{2.5}$, $SO_x$ and $NO_x$ samples of 24-hour carried out twice a week. In case of CO, one hourly sample were taken on selected monitoring days using the sensor-based CO Meter. For the parameters Benzene, Methane & Non-methane and Volatile Organic Carbons (VOCs), the Low Volume Sampler is used, where the charcoal tubes are used as sampling media. The sampling in the Low Volume Sampler (LVS) is carried out as per IS 5182 (Part 11): 2006 RA: 2017, where the ambient air flow rate is maintained at 200 cc/min, the volume of air that passes through the LVS during two hours monitoring is approx. 24 L.

The sampling of PAHs is carried out as per IS: 5182 (Part 12): 2004. Where, the EPM 2000 Filter papers are utilized in the Respirable Dust Sampler (RDS). For the parameters, Benzene, PAH & Non-methane VOC's, monthly monitoring is carried out. The details of the parameters with their frequency monitored are mentioned in **Table 5:**

**Table 5: Parameters for Ambient Air Quality Monitoring**

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

## 4.2 Result and Discussion

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

**Table 6: Summarized results of $PM_{10}$, $PM_{2.5}$, $SO_2$, $NO_x$, VOC and CO for Ambient Air quality monitoring**

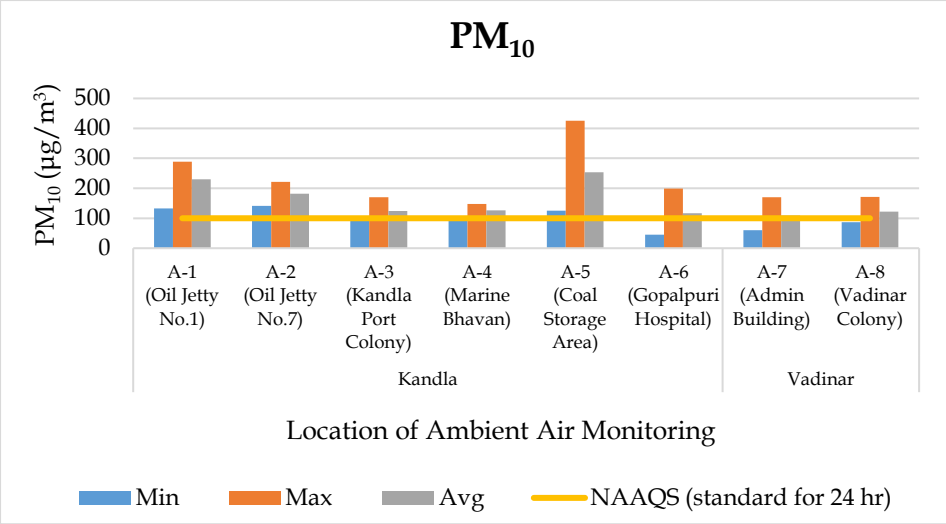
| Station Code & Name | Unit of Average Concentration | Average Pollutant Concentration | | | | | |
|---|---|---|---|---|---|---|---|
| | **Pollutants** | **$PM_{10}$ (µg/m³)** | **$PM_{2.5}$ (µg/m³)** | **$SO_2$ (µg/m³)** | **$NO_X$ (µg/m³)** | **VOC (µg/m³)** | **CO (mg/m³)** |
| | **Duration** | **(24 hr)** | | | | **(2 hr)** | **(1 hr)** |
| | **NAAQS by CPCB** / **Monitoring days** | **100** | **60** | **80** | **80** | **-** | **2** |
| **A-1:** Oil Jetty No.1, Kandla | 16-12-2024 | 288.45 | 59.98 | 53.31 | 33.23 | 0.05 | 0.88 |
| | 18-12-2024 | 284.13 | 76.86 | 50.42 | 24.14 | 0.06 | 0.63 |
| | 23-12-2024 | 285.33 | 68.85 | 13.09 | 21.12 | 0.12 | 0.83 |
| | 26-12-2024 | 132.58 | 23.08 | 9.45 | 10.48 | 0.17 | 0.79 |
| | 30-12-2024 | 154.79 | 62.87 | 16.62 | 21.43 | 0.1 | 0.82 |

| Station Code & Name | Unit of Average Concentration | Average Pollutant Concentration | | | | | |
|---|---|---|---|---|---|---|---|
| | Pollutants | $PM_{10}$ (µg/m³) | $PM_{2.5}$ (µg/m³) | $SO_2$ (µg/m³) | $NO_X$ (µg/m³) | VOC (µg/m³) | CO (mg/m³) |
| | Duration | (24 hr) | | | | (2 hr) | (1 hr) |
| | NAAQS by CPCB / Monitoring days | 100 | 60 | 80 | 80 | - | 2 |
| | 02-01-2025 | 260.09 | 80.83 | 20.07 | 27.43 | 0.12 | 0.81 |
| | 06-01-2025 | 210.54 | 60.52 | 13.86 | 18.97 | 0.2 | 0.82 |
| | 07-01-2025 | 221.02 | 56.07 | 14.78 | 23.16 | 0.21 | 0.81 |
| | **Minimum** | **132.58** | **23.08** | **9.45** | **10.48** | **0.05** | **0.63** |
| | **Maximum** | **288.45** | **80.83** | **53.31** | **33.23** | **0.21** | **0.88** |
| | **Average** | **229.62** | **61.13** | **23.95** | **22.50** | **0.13** | **0.80** |
| | **Std. Deviation** | **60.85** | **17.62** | **17.51** | **6.57** | **0.06** | **0.07** |
| **A-2:** Oil Jetty No.7, Kandla | 16-12-2024 | 157.04 | 47.49 | 14.12 | 18.32 | 0.16 | 0.84 |
| | 18-12-2024 | 190.54 | 74.27 | 12.34 | 12.52 | 0.20 | 0.88 |
| | 23-12-2024 | 208.91 | 80.64 | 28.18 | 20.47 | 0.19 | 0.89 |
| | 26-12-2024 | 158.75 | 23.69 | 8.56 | 14.75 | 0.14 | 0.81 |
| | 30-12-2024 | 221.71 | 60.32 | 14.96 | 11.16 | 0.07 | 0.84 |
| | 02-01-2025 | 141.48 | 67.90 | 17.16 | 13.84 | 0.13 | 0.84 |
| | 06-01-2025 | 187.49 | 51.67 | 16.66 | 32.53 | 0.11 | 0.85 |
| | 07-01-2025 | 186.94 | 44.70 | 13.05 | 7.47 | 0.09 | 0.88 |
| | **Minimum** | **141.48** | **23.69** | **8.56** | **7.47** | **0.07** | **0.81** |
| | **Maximum** | **221.71** | **80.64** | **28.18** | **32.53** | **0.20** | **0.89** |
| | **Average** | **181.61** | **56.34** | **15.63** | **16.38** | **0.14** | **0.85** |
| | **Std. Deviation** | **27.34** | **18.37** | **5.75** | **7.67** | **0.05** | **0.03** |
| **A-3:** Kandla Port Colony, Kandla | 16-12-2024 | 103.64 | 26.50 | 10.26 | 27.56 | 0.25 | 0.76 |
| | 18-12-2024 | 115.94 | 30.87 | 14.83 | 20.56 | 0.10 | 0.79 |
| | 23-12-2024 | 142.12 | 24.10 | 28.78 | 10.32 | 0.06 | 0.82 |
| | 26-12-2024 | 136.52 | 24.26 | 12.69 | 15.27 | 0.14 | 0.86 |
| | 30-12-2024 | 127.02 | 15.86 | 11.58 | 17.60 | 0.18 | 0.87 |
| | 02-01-2025 | 169.82 | 21.33 | 20.57 | 12.37 | 0.20 | 0.81 |
| | 06-01-2025 | 100.35 | 33.68 | 13.54 | 8.53 | 0.24 | 0.85 |
| | 07-01-2025 | 101.56 | 21.41 | 24.56 | 11.30 | 0.16 | 0.77 |
| | **Minimum** | **100.35** | **15.86** | **10.26** | **8.53** | **0.06** | **0.76** |
| | **Maximum** | **169.82** | **33.68** | **28.78** | **27.56** | **0.25** | **0.87** |
| | **Average** | **124.62** | **24.75** | **17.10** | **15.44** | **0.17** | **0.82** |
| | **Std. Deviation** | **24.30** | **5.64** | **6.75** | **6.31** | **0.07** | **0.04** |
| **A-4:** Marine Bhavan, Kandla | 16-12-2024 | 112.54 | 27.08 | 9.54 | 8.76 | 0.14 | 0.79 |
| | 18-12-2024 | 106.87 | 13.67 | 15.68 | 11.74 | 0.21 | 0.83 |
| | 23-12-2024 | 126.95 | 25.34 | 12.45 | 10.37 | 0.18 | 0.89 |
| | 26-12-2024 | 145.50 | 15.98 | 21.89 | 11.52 | 0.11 | 0.76 |
| | 30-12-2024 | 135.26 | 19.57 | 22.42 | 13.90 | 0.08 | 0.81 |
| | 02-01-2025 | 125.63 | 24.68 | 16.74 | 12.39 | 0.07 | 0.88 |
| | 06-01-2025 | 110.25 | 18.76 | 19.85 | 5.75 | 0.10 | 0.81 |
| | 07-01-2025 | 147.32 | 15.48 | 11.02 | 18.20 | 0.12 | 0.86 |
| | **Minimum** | **106.87** | **13.67** | **9.54** | **5.75** | **0.07** | **0.76** |
| | **Maximum** | **147.32** | **27.08** | **22.42** | **18.20** | **0.21** | **0.89** |
| | **Average** | **126.29** | **20.07** | **16.20** | **11.58** | **0.13** | **0.83** |
| | **Std. Deviation** | **15.66** | **5.06** | **4.93** | **3.65** | **0.05** | **0.05** |

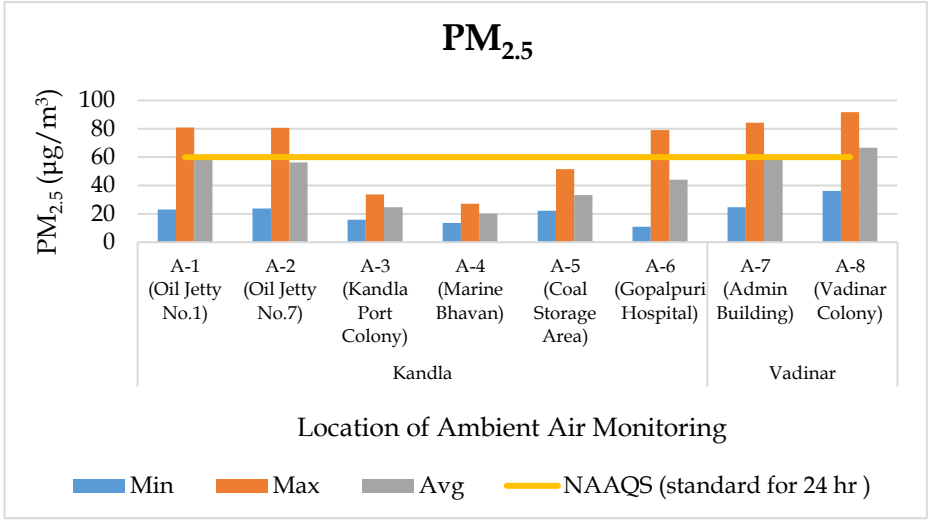
| Station Code & Name | Unit of Average Concentration | Average Pollutant Concentration | | | | | |
|---|---|---|---|---|---|---|---|
| | Pollutants | $PM_{10}$ (µg/m³) | $PM_{2.5}$ (µg/m³) | $SO_2$ (µg/m³) | $NO_X$ (µg/m³) | VOC (µg/m³) | CO (mg/m³) |
| | Duration | (24 hr) | | | | (2 hr) | (1 hr) |
| | NAAQS by CPCB / Monitoring days | 100 | 60 | 80 | 80 | - | 2 |
| **A-5:** Coal Storage Area, Kandla | 16-12-2024 | 159.63 | 36.38 | 26.58 | 8.84 | 0.29 | 0.93 |
| | 18-12-2024 | 125.48 | 29.31 | 14.67 | 9.78 | 0.07 | 0.98 |
| | 23-12-2024 | 169.84 | 40.28 | 13.52 | 30.62 | 0.23 | 1.02 |
| | 26-12-2024 | 415.26 | 22.13 | 19.64 | 11.40 | 0.16 | 0.97 |
| | 30-12-2024 | 425.68 | 51.64 | 20.15 | 28.51 | 0.17 | 0.88 |
| | 02-01-2025 | 348.61 | 27.88 | 12.06 | 19.77 | 0.19 | 0.92 |
| | 06-01-2025 | 228.78 | 24.65 | 8.4 | 24.39 | 0.13 | 0.96 |
| | 07-01-2025 | 157.62 | 34.58 | 26.87 | 13.28 | 0.10 | 0.99 |
| | **Minimum** | **125.48** | **22.13** | **8.40** | **8.84** | **0.07** | **0.88** |
| | **Maximum** | **425.68** | **51.64** | **26.87** | **30.62** | **0.29** | **1.02** |
| | **Average** | **253.86** | **33.36** | **17.74** | **18.32** | **0.17** | **0.96** |
| | **Std. Deviation** | **123.55** | **9.57** | **6.74** | **8.70** | **0.07** | **0.04** |
| **A-6:** Gopalpuri Hospital, Kandla | 16-12-2024 | 56.81 | 16.60 | 4.94 | 15.15 | 0.05 | 0.75 |
| | 18-12-2024 | 45.26 | 21.16 | 36.41 | 14.27 | 0.09 | 0.70 |
| | 23-12-2024 | 112.63 | 10.92 | 4.87 | 10.10 | 0.10 | 0.69 |
| | 26-12-2024 | 154.21 | 18.61 | 4.37 | 7.73 | 0.19 | 0.68 |
| | 30-12-2024 | 199.56 | 79.04 | 13.01 | <6 | 0.13 | 0.64 |
| | 02-01-2025 | 183.59 | 73.01 | 21.16 | 27.47 | 0.17 | 0.61 |
| | 06-01-2025 | 104.11 | 66.03 | 13.01 | 6.42 | 0.07 | 0.62 |
| | 07-01-2025 | 76.55 | 67.61 | 13.51 | 27.9 | 0.17 | 0.6 |
| | **Minimum** | **45.26** | **10.92** | **4.37** | **6.42** | **0.05** | **0.60** |
| | **Maximum** | **199.56** | **79.04** | **36.41** | **27.90** | **0.19** | **0.75** |
| | **Average** | **116.59** | **44.12** | **13.91** | **15.58** | **0.12** | **0.66** |
| | **Std. Deviation** | **57.60** | **29.58** | **10.78** | **8.86** | **0.05** | **0.05** |
| **A-7:** Admin Building, Vadinar | 16-12-2024 | 60.52 | 24.61 | 12.03 | 6.12 | 0.08 | 0.70 |
| | 18-12-2024 | 92.96 | 54.94 | 11.45 | <6 | 0.19 | 0.60 |
| | 23-12-2024 | 160.57 | 79.35 | 11.37 | 17.11 | 0.15 | 0.62 |
| | 26-12-2024 | 169.87 | 82.15 | 12.66 | 6.65 | 0.16 | 0.62 |
| | 30-12-2024 | 86.86 | 46.73 | 12.67 | <6 | 0.14 | 0.63 |
| | 02-01-2025 | 82.64 | 69.48 | 45.56 | 12.19 | 0.17 | 0.62 |
| | 06-01-2025 | 91.27 | 29.82 | 14.91 | <6 | 0.16 | 0.56 |
| | 07-01-2025 | 125.49 | 84.19 | 26.28 | 7.01 | 0.13 | 0.72 |
| | **Minimum** | **60.52** | **24.61** | **11.37** | **6.12** | **0.08** | **0.56** |
| | **Maximum** | **169.87** | **84.19** | **45.56** | **17.11** | **0.19** | **0.72** |
| | **Average** | **108.77** | **58.91** | **18.37** | **9.82** | **0.15** | **0.63** |
| | **Std. Deviation** | **39.18** | **23.59** | **12.05** | **4.75** | **0.03** | **0.05** |
| **A-8**: Vadinar Colony, Vadinar | 16-12-2024 | 87.32 | 36.57 | 11.71 | <6 | 0.20 | 0.65 |
| | 18-12-2024 | 120.29 | 65.04 | 10.78 | <6 | 0.14 | 0.55 |
| | 23-12-2024 | 149.90 | 81.26 | 10.73 | <6 | 0.20 | 0.55 |
| | 26-12-2024 | 171.58 | 76.15 | 12.81 | 6.02 | 0.15 | 0.58 |
| | 30-12-2024 | 116.51 | 60.18 | 12.99 | <6 | 0.18 | 0.55 |
| | 02-01-2025 | 109.79 | 91.70 | 40.11 | 12.07 | 0.13 | 0.56 |

| Station Code & Name | Unit of Average Concentration | Average Pollutant Concentration | | | | | |
|---|---|---|---|---|---|---|---|
| | Pollutants | $PM_{10}$ (µg/m³) | $PM_{2.5}$ (µg/m³) | $SO_2$ (µg/m³) | $NO_X$ (µg/m³) | VOC (µg/m³) | CO (mg/m³) |
| | Duration | (24 hr) | | | | (2 hr) | (1 hr) |
| | NAAQS by CPCB / Monitoring days | 100 | 60 | 80 | 80 | - | 2 |
| | 06-01-2025 | 111.08 | 36.25 | 11.96 | 7.14 | 0.17 | 0.63 |
| | 07-01-2025 | 112.69 | 85.93 | 18.23 | 9.60 | 0.08 | 0.65 |
| | **Minimum** | **87.32** | **36.25** | **10.73** | **6.02** | **0.08** | **0.55** |
| | **Maximum** | **171.58** | **91.70** | **40.11** | **12.07** | **0.20** | **0.65** |
| | **Average** | **122.40** | **66.64** | **16.17** | **8.71** | **0.16** | **0.59** |
| | **Std. Deviation** | **26.26** | **21.30** | **9.96** | **2.69** | **0.04** | **0.05** |

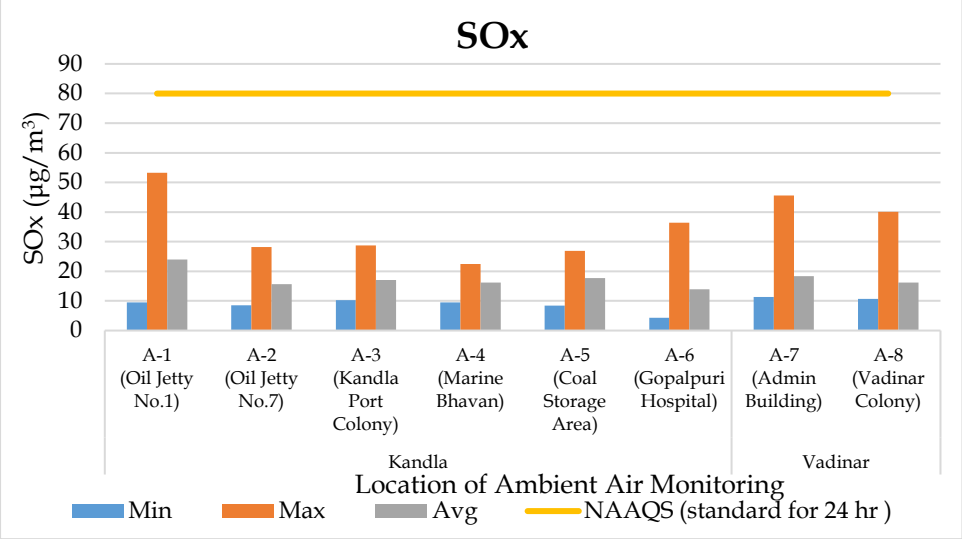
**Graphs 1-6** shows spatial trend of ambient air parameter at all the eight-monitoring location (six at Kandla and 2 at Vadinar



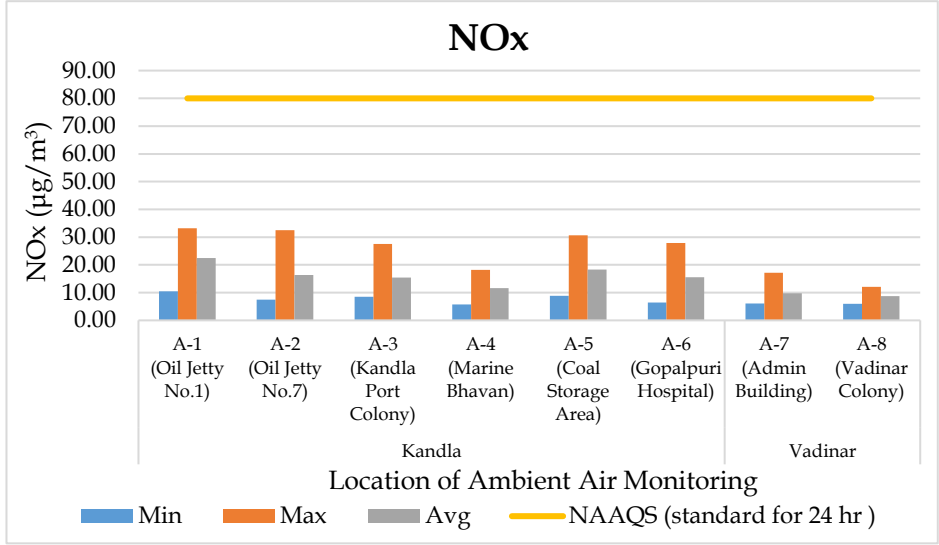

**Graph 1: Spatial trend in Ambient $PM_{10}$ Concentration**



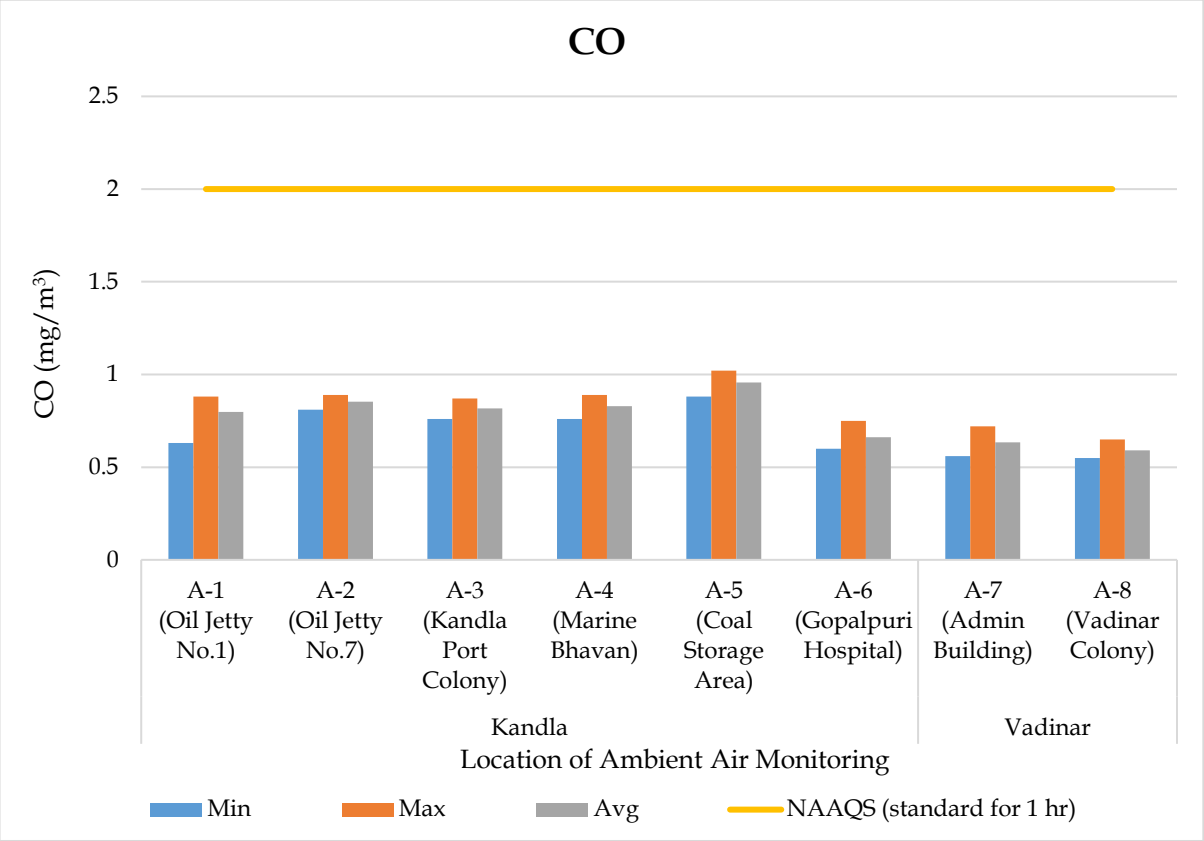

**Graph 2: Spatial trend in Ambient $PM_{2.5}$ Concentration**



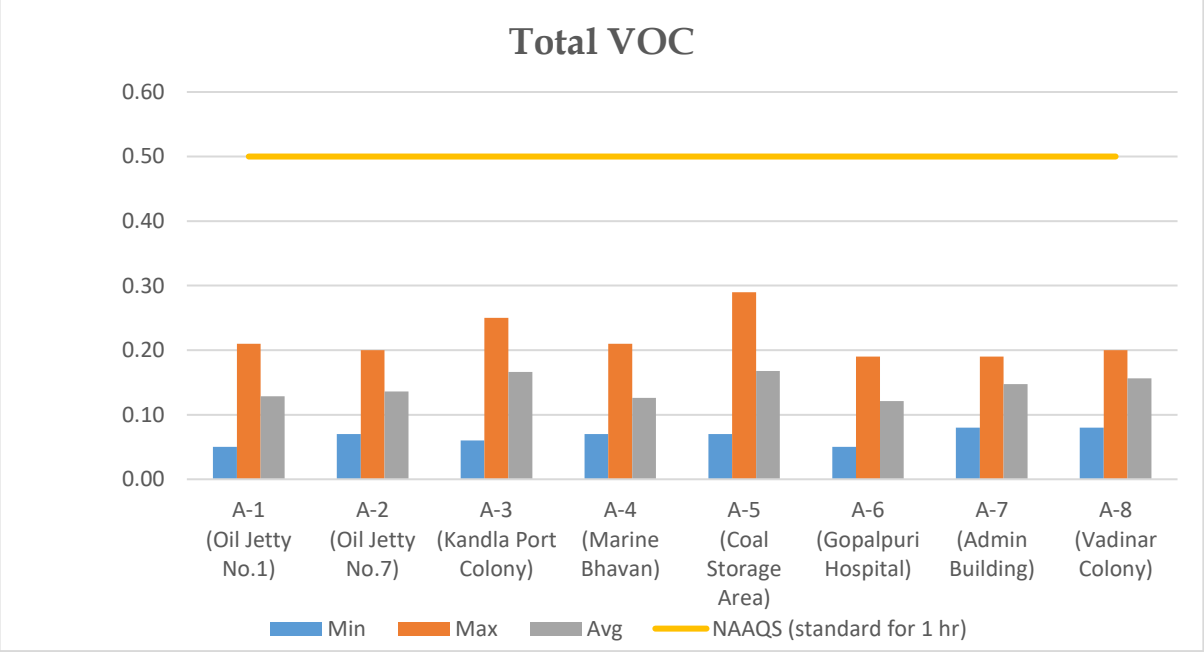

**Graph 3: Spatial Trend in Ambient SOx Concentration**




**Graph 4: Spatial trend in Ambient Nox Concentration**




**Graph 5: Spatial trend in Ambient CO Concentration**




**Graph 6: Spatial trend in Ambient Total VOCs**

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

| Benzene (µg/m³) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Sr. No | Kandla | | | | | | Vadinar | | NAAQS standards (24 hr) |
| | A-1 | A-2 | A-3 | A-4 | A-5 | A-6 | A-7 | A-8 | |
| 1 | 0.05 | 0.02 | 0.04 | 0.01 | 0.08 | 0 | 0 | 0 | 5 µg/m³ |

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

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

**Table 9: Summarized results of Non-methane VOC**

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

## 4.3 Data Interpretation and Conclusion

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

- The concentration of $PM_{10}$ at Kandla varies in the range of **45.26 to 425.68 µg/m³** with an average value of **172.10 µg/m³**. $PM_{10}$ exceeded NAAQS of all the monitoring locations in Kandla. Whereas, at Vadinar, the concentration varies from **60.52 to 171.58 µg/m³**, with an average value of **115.68 µg/m³**, and complies with the stipulated norm (100 µg/m³).

- The elevated $PM_{10}$ concentration at location A-5, the Coal Storage Area, can be attributed to several factors. Heavy vehicular traffic in upwind areas significantly contributes to the dispersion of particulate matter into the ambient air. The process of unloading coal directly onto trucks using grabs leads to the emission of coal dust into the air and its subsequent settling on the ground. This settled dust is re-entrained into the atmosphere as trucks travel through the area. Additionally, coal-loaded trucks are often not adequately covered with tarpaulin sheets, which exacerbates the suspension of coal particles during transit from vessels to the storage yard or site. These factors collectively contribute to increased $PM_{10}$ levels in and around the Coal Storage Area and Marine.
- The **$PM_{2.5}$** concentrations at Kandla varies from **10.92 to 80.83 µg/m³** with average **39.96 µg/m³**. The **$PM_{2.5}$** concentration falls within the NAAQS limit for all locations of Kandla. Whereas, at Vadinar its concentration varies from **24.61 to 91.70 µg/m³** with average **62.77 µg/m³**. During winter, the concentrations of particulate matter (PM10 & PM2.5) are seen to increase. Also due to construction and demolition all around the port contributing in increased particulate matter levels.
- The concentration of **$SO_x$** varies from **4.37 to 53.31 µg/m³** with average concentration as **17.42 µg/m³** at Kandla and **10.73 to 45.56 µg/m³** with average as **17.27 µg/m³** at Vadinar. The average concentration of $SO_x$ complies with the prescribed limit of NAAQS (80 µg/m³) for both the monitoring site.
- The concentration of **$NO_x$** varies from **5.75 to 33.23 µg/m³** with average **16.63 µg/m³** at Kandla and **6.02 to 17.11 µg/m³** with average **9.26 µg/m³** at Vadinar. The concentration of **$NO_x$** falls within the prescribed limit of NAAQS i.e. 80 µg/m³ at both the monitoring site of Kandla and Vadinar.
- The concentration of **CO** varies from **0.60 to 1.02 µg/m³** with average **0.82 µg/**m³ at Kandla and **0.55 to 0.72 µg/m³** with average **0.61 µg/m³** at Vadinar. The concentration falls within the norm of 2 mg/m³ specified by NAAQS at both the monitoring sites
- The concentration of **Total VOCs** levels was recorded in range of **0.05 to 0.29 µg/m³** at Kandla and **in range of 0.08 to 0.20 µg/m³** at the location of Vadinar respectively. The main source of VOCs in the ambient air may be attributed to the burning of Gasoline and Natural gas in Vehicle exhaust and burning fossil fuels, and garbage that release VOCs into the atmosphere. During the monitoring period, the wind flows towards South direction at Kandla, and hence the wind direction and speed also contribute to increased dispersion of pollutants from the upward areas towards the downward areas.
- **Benzene** was detected on the location of Kandla in the range of **0 to 0.08 (µg/m3)** whereas not detected on the location of Vadinar.
- **Polycyclic Aromatic Hydrocarbons (PAHs)** are ubiquitous pollutants in urban atmospheres. Anthropogenic sources of total PAHs in ambient air emissions are greater than those that come from natural events. These locations are commercial areas where Vehicular activity and dust emission is common. PAHs are a class of chemicals that occur naturally in coal, crude oil, and gasoline. The higher

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

- The Ambient air Monitoring location of Kandla recorded the **Non-methane VOC** (NM-VOC) concentration in the range of **0.92 to 1.56 µg/m³**. While at Vadinar, the concentration of NM-VOC falls is found to be **1.12 to 1.45 mg/m³** at both the location.

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

1. **Port Machinery:** Port activities involve the use of various machinery and equipment, including cranes, for lifts, tugboats, and cargo handling equipment. These machines often rely on diesel engines, which can emit pollutants such as $NO_x$, Particulate matter, and CO. Older or poorly maintained equipment tends to generate higher emissions.
2. **Port Vehicles:** Trucks and other vehicles operating within port and port area contributes to air pollution. Similar to port machinery, diesel-powered vehicles can emit $NO_x$, PM, CO, and other pollutants such as PAH, VOCs etc. Vehicle traffic and congestion in and around port areas can exacerbate the air quality issues.
3. Apart from that, construction and demolition activities majorly contribute to particulate matter pollution.

## 4.4 Remedial Measures:

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

- Practice should be initiated for using mask as preventative measure, to avoid Inhalation of dust particle-Mask advised in sensitive areas. Covering vehicles with tarpaulin during transportation will help to reduce the suspension of pollutants in air.
- Frequent water sprinkling on roads to reduce dust suspension due to vehicular movement, this can be use during transporting coal to avoid suspension of coal dust.
- Use of proper transport methods, such as a conveyor belt, for excavated material and screens around the construction site.
- Temporary pavement of roads in construction site could considerably reduce dust emission. Prohibition of use of heavy diesel oil as fuel could be possibly reduce

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

- Investing in infrastructure for cold ironing allows ships to connect to the electrical grid while docked, reducing the need for auxiliary engines and associated emissions.
- Implementing efficient cargo-handling processes, optimizing logistics to reduce congestion and idling times, and encouraging use of cleaner port machinery and vehicles can all contribute to reducing air pollution in port areas.

# CHAPTER 5: DG STACK MONITORING

## 5.1 DG Stack Monitoring

A diesel generator is a mechanical-electrical machine that produces electrical energy (electricity) from diesel fuel. They are used by the residential, commercial, charitable and governmental sectors to provide power in the event of interruption to the main power, or as the main power source. Diesel generating (DG) sets are generally used in places without connection to a power grid, or as an emergency power supply if the grid fails. These DG sets utilize diesel as fuel and generate and emit the air pollutants such as Suspended Particulate Matter, $SO_2$, $NO_x$, CO, etc. from the stack during its functioning. The purpose of stack sampling is to determine emission levels from plant processes to ensure they are in compliance with any emission limits set by regulatory authorities to prevent macro environmental pollution. The stack is nothing but chimney which is used to disperse the hot air at a great height, emissions & particulate matters that are emitted. Hence, monitoring of these stacks attached to DG Sets is necessary in order to quantify the emissions generated from it.

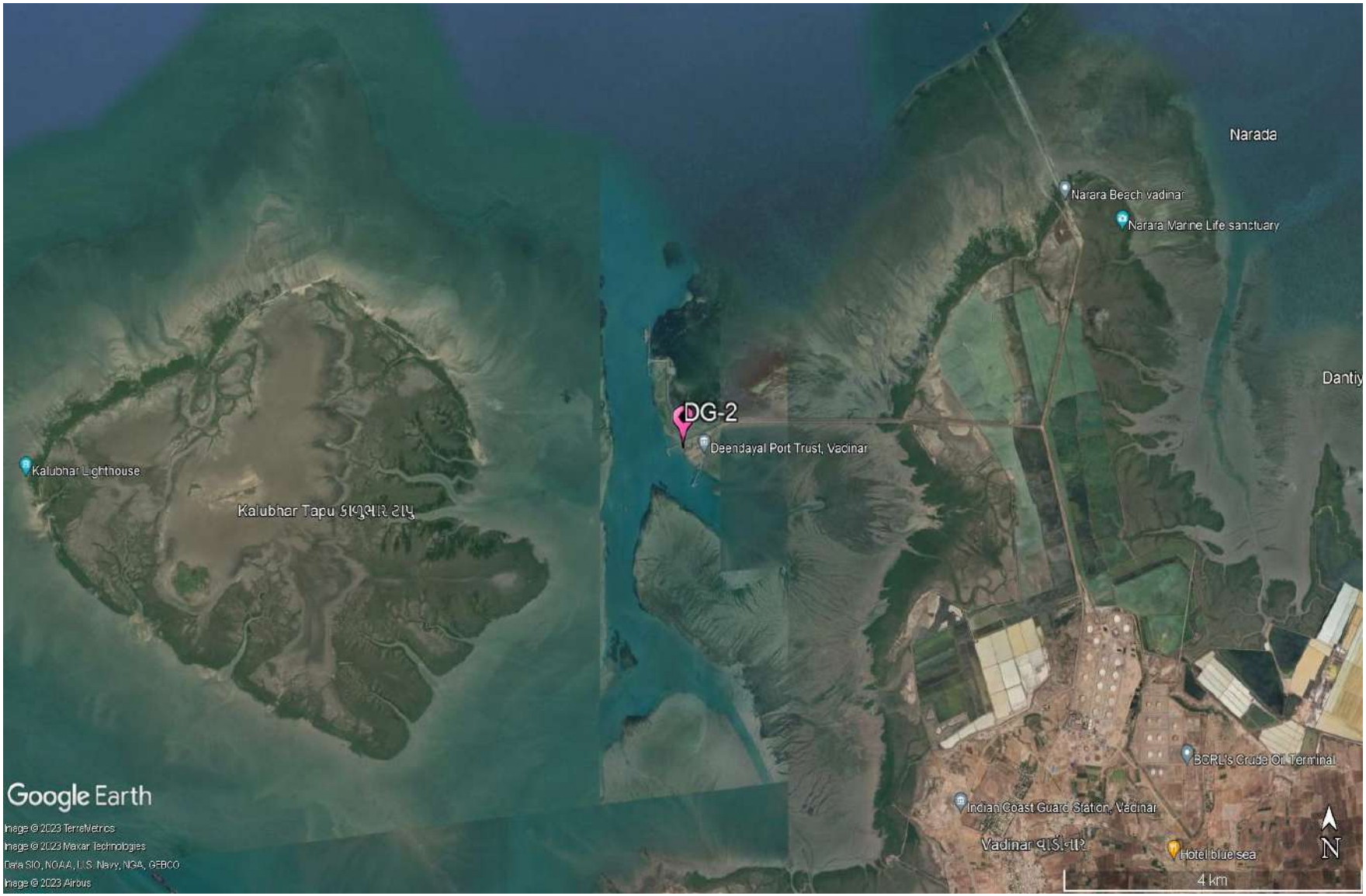
As defined in scope by DPA, the monitoring of DG Stack shall be carried out at two locations, one at Kandla and one at Vadinar. The details of the DG Sets at Kandla and Vadinar have been mentioned in **Table 10** as follows:

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

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

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


**Map 6: Locations for DG Stack monitoring at Kandla**




**Map 7: Locations for DG Stack monitoring at Vadinar**

### Methodology:

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

**Table 11: DG stack parameters**

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

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

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

**Frequency**

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

## 5.2 Result and Discussion

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

**Table 12: DG monitoring data**

| Sr. No. | Stack Monitoring Parameters for DG Sets | Stack Monitoring Limits / Standards As per CPCB | DG- 1 (Kandla) | DG-2 (Vadinar) |
|---|---|---|---|---|
| 1. | Suspended Particulate Matter (SPM) (mg/Nm$^3$) | 150 | 71.45 | 37.48 |
| 2. | Sulphur Dioxide ($SO_2$) (PPM) | 100 | 1.17 | N.D. |
| 3. | Oxides of Nitrogen ($NO_x$) (PPM) | 50 | 25.49 | 9.04 |
| 4. | Carbon Monoxide (CO) (%) | 1 | 0.15 | 0.011 |
| 5. | Carbon Dioxide ($CO_2$) (%) | - | 1.19 | 1.41 |

## 5.3 Data Interpretation and Conclusion

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

# CHAPTER 6: NOISE MONITORING

## 6.1 Noise Monitoring

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

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

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

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


**Map 8: Locations for Noise Monitoring at Kandla**


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

**Methodology:**

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

**Frequency**

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

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

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

**Standard for Noise**

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

**Table 15: Ambient Air Quality norms in respect of Noise**

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

## 6.2 Result and Discussion

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

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

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

## 6.3 Data Interpretation and Conclusion

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

## 6.4 Remedial Measures

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

# CHAPTER 7: SOIL MONITORING

## 7.1 Soil Quality Monitoring:

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

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

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

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

### Methodology

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

The samples of soil collected from the locations of Kandla and Vadinar and analyzed for the various physico-chemical parameter. Collection and analysis of these samples was carried out as per established standard methods and procedures. The samples were analyzed for selected parameters to get the present soil quality status and environmental risks associated with various practices prevalent at the location. GEMI has framed its own guidelines for collection of soil samples titled as ***'Soil Sampling Manual'***. Soil samples were collected from 30 cm depth below the surface using scrapper, filled in polythene bags, labelled on-site with specific location code and name and sent to GEMI's laboratory, Gandhinagar for further detailed analysis. The samples collected from all locations are homogeneous representative of each location. The list of parameters to be monitored under the projects for the Soil Quality Monitoring been mentioned in **Table 18** as follows:

### Frequency

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

**Table 18: Soil parameters**

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

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


**Map 10: Locations for Soil Quality Monitoring at Kandla**


**Map 11: Locations for Soil Quality Monitoring at Vadinar**

## 7.2 Result and Discussion

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

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

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

## 7.3 Data Interpretation and Conclusion

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

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

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

- At entire monitoring locations of Kandla the value of **Electrical Conductivity** ranges from **2630-15690 µs/cm**, highest at location S-4 (Nakti Creek) with the average as **11077.5 µs/cm**. Whereas, at Vadinar the range of conductivity was between the range of **231 to 271 µs/cm** with an average value of **251 µs/cm**.

- At Kandla, the concentration of **Inorganic Phosphate** varied from **0.68-1.94 Kg/ha**, with average **1.38 Kg/ha**. Whereas, at the locations of Vadinar, the Inorganic Phosphate was observed at S-5 i.e., Near SPM (**0.87 Kg/ha**) and detected at S-6 i.e., near Jetty Area (**0.86 Kg/ha**). The phosphorus availability in soil solution is influenced by a number of factors such as Organic matter, clay content, pH, temperature, etc.

- The concentration of **Total Organic Carbon** ranges from **0.30-0.78**% while the average TOC at Kandla was detected as **0.47%.** Whereas, at Vadinar the average TOC was found to be **0.58**% where the observed TOC value found at S-5 i.e. Near SPM (**0.35**%) and S-6 i.e. near Jetty Area to be **0.82** % and below quantification limit respectively.

- The concentration of **Water Holding Capacity** in the soil samples of Kandla and Vadinar varies from **47.2-60**% and **47.2-65.59**% respectively.

- The concentration of **Sodium Adsorption Ratio** ranges from **1.31-18.31 meq/L** with an average value **11.28 meq/L** at Kandla. Whereas, at Vadinar, the average SAR was found to be **0.11 meq/L**. A component of conductivity is the SAR. A high SAR indicates a large concentration of sodium ions in the soil, which raises conductivity.

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

**Heavy Metals**

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

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

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

- The concentration of **Zinc** varied from **61.84 to 95.08 mg/kg** at Kandla and **62.67 to 63.70 mg/kg** at Vadinar and the average value was observed to be **73.59 and 63.18 mg/kg** at Kandla and Vadinar monitoring station, respectively

- The concentration of **copper** varied from **24.96 to 85.80 mg/kg** at Kandla and **76.23 to 89.51 mg/kg** at Vadinar and the average value was observed to be **64.66 and 82.87 mg/kg** at Kandla and Vadinar monitoring station, respectively.

- The concentration of **Arsenic** varied from **0.93 to 3.86 mg/kg** at Kandla and the average value was observed to be **2.01** at Kandla Vadinar and the average value was observed to be **0.35 and 0.72 mg/kg** at Kandla and Vadinar monitoring station.

- While other heavy metals in the Soil i.e., **Mercury, Lead and Cadmium** were observed "Below Quantification Limit" for majority of the soil samples collected at Kandla and Vadinar.

# CHAPTER 8: DRINKING WATER MONITORING

## 8.1 Drinking Water Monitoring

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

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

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

| Sr. No. | Location Code | | Location Name | Latitude/ Longitude |
|---|---|---|---|---|
| 1. | Kandla | DW-1 | Oil Jetty 7 | 23.043527N 70.218456E |
| 2. | | DW-2 | Shramdeep | 23.009631N, 70.220877E |
| 3. | | DW-3 | North Gate | 23.007938N 70.222411E |
| 4. | | DW-4 | Workshop | 23.009372N 70.222236E |
| 5. | | DW-5 | Canteen Area | 23.003707N 70.221331E |
| 6. | | DW-6 | West Gate 1 | 23.006771N 70.217340E |
| 7. | | DW-7 | Sewa Sadan -3 | 23.009779N 70.221838E |
| 8. | | DW-8 | Nirman Building | 23.009642N 70.220623E |
| 9. | | DW-9 | Custom Building | 23.018930N 70.214478E |
| 10. | | DW-10 | Port Colony Kandla | 23.019392N 70.212619E |
| 11. | | DW-11 | Wharf Area/ Jetty | 22.997833N 70.223042E |
| 12. | | DW-12 | Hospital Kandla | 23.018061N 70.212328E |
| 13. | | DW-13 | A.O. Building | 23.061914N 70.144861E |
| 14. | | DW-14 | School Gopalpuri | 23.083619N 70.132061E |
| 15. | | DW-15 | Guest House | 23.078830N 70.131008E |
| 16. | | DW-16 | E- Type Quarter | 23.083306N 70.132422E |
| 17. | | DW-17 | F- Type Quarter | 23.077347N 70.135731E |
| 18. | | DW-18 | Hospital Gopalpuri | 23.081850N 70.135347E |
| 19. | Vadinar | DW-19 | Near Vadinar Jetty | 22.440759N 69.675210E |
| 20. | | DW-20 | Near Port Colony | 22.401619N 69.716822E |


**Map 12: Locations for Drinking Water Monitoring at Kandla**


**Map 13: Locations for Drinking Water Monitoring at Vadinar**

## Methodology

The water samples were collected from the finalized sampling locations and analyzed for physico-chemical and microbiological parameter, for which the analysis was carried out as per APHA, 23rd Edition and Indian Standard method in GEMI's NABL Accredited Laboratory, Gandhinagar. GEMI has followed the CPCB guideline as well as framed its own guidelines for the collection of water/wastewater samples, under the provision of Water (Preservation and Control of Pollution) Act 1974, titled as '**Sampling Protocol for Water & Wastewater**'; approved by the Government of Gujarat vide letter no. ENV-102013-299-E dated 24-04-2014. The samples under the study were collected and preserved as per the said Protocol. The parameters finalized to assess the drinking water quality have been mentioned in **Table 21** as follows:

**Table 21: List of parameters for Drinking Water Quality monitoring**

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

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

## 8.2 Result and Discussion

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

**Table 22: Summarized results of Drinking Water quality**

| Sr. No. | Parameters | Units | Standard values as per IS | | Kandla | | | | | | | | | | | | | | | | | Vadinar | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | P | DW-1 | DW-2 | DW-3 | DW-4 | DW-5 | DW-6 | DW-7 | DW-8 | DW-9 | DW-10 | DW-11 | DW-12 | DW-13 | DW-14 | DW-15 | DW-16 | DW-17 | DW-18 | DW-19 | DW-20 |
| 1. | pH | - | 6.5-8.5 | - | 8.40 | 7.20 | 7.54 | 7.41 | 7.02 | 7.99 | 7.36 | 7.16 | 6.91 | 6.93 | 7.99 | 7.15 | 7.50 | 6.96 | 6.99 | 7.10 | 7.08 | 6.76 | 6.90 | 6.79 |
| 2. | Colour | Hazen | 5 | 15 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 3. | EC | µS/ cm | - | - | 125.5 | 279 | 23.1 | 43.9 | 50 | 149 | 23 | 25.4 | 61.4 | 217 | 138 | 212 | 65.4 | 203 | 174.4 | 49.2 | 29.7 | 126.8 | 165.3 | 105.6 |
| 4. | Salinity | PSU | - | - | 0.06 | 0.13 | 0.02 | 0.03 | 0.03 | 0.06 | 0.02 | 0.02 | 0.03 | 0.11 | 0.09 | 0.10 | 0.04 | 0.10 | 0.09 | 0.03 | 0.02 | 0.06 | 0.08 | 0.05 |
| 5. | Turbidity | NTU | 1 | 5 | 0.59 | 0.64 | 0.56 | 0.71 | 0.64 | 0.65 | 0.65 | 0.69 | 0.73 | BQL | 0.98 | BQL | 0.52 | 0.71 | BQL | BQL | 0.63 | 0.83 | BQL | BQL |
| 6. | Chloride | mg/L | 250 | 1000 | 28.58 | 60.12 | 7.88 | 13.80 | 11.50 | 111.97 | 7.88 | 7.88 | 16.75 | 45.33 | 109.97 | 45.33 | 17.74 | 48.29 | 43.36 | 15.77 | 9.86 | 35.48 | 20.70 | 13.80 |
| 7. | Total Hardness | mg/L | 200 | 600 | 16 | 40 | 2 | 2 | 5 | 180 | 2 | 2.5 | 7 | 42 | 160 | 34 | 8 | 26 | 10 | 4 | 2 | 6 | 54 | 22 |
| 8. | Ca Hardness | mg/L | - | - | 8 | 18 | 1.5 | 1.5 | 3 | 100 | 1.5 | 2 | 4 | 24 | 90 | 18 | 2 | 12 | 8 | 2.5 | 1.5 | 4 | 26 | 12 |
| 9. | Mg Hardness | mg/L | - | - | 8 | 22 | BQL | BQL | 2 | 80 | BQL | BQL | 3 | 18 | 70 | 16 | 6 | 14 | 2 | 1.5 | BQL | 2 | 28 | 10 |
| 10. | Free Residual Chlorine | mg/L | 0.2 | 1 | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 11. | TDS | mg/L | 500 | 2000 | 66 | 92 | 12 | 22 | 26 | 342 | 12 | 14 | 32 | 112 | 346 | 108 | 34 | 106 | 90 | 26 | 16 | 66 | 84 | 54 |
| 12. | TSS | mg/L | - | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 13. | Fluoride | mg/L | 1.0 | 1.5 | BQL | BQL | BQL | 0.62 | BQL | 0.435 | BQL | BQL | BQL | BQL | 0.349 | BQL | BQL | BQL | 0.35 | BQL | BQL | BQL | BQL | BQL |
| 14. | Sulphate | mg/L | 200 | 400 | BQL | 15.25 | BQL | BQL | BQL | 36.66 | BQL | BQL | BQL | 11.59 | 35.50 | 10.59 | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 15. | Nitrate | mg/L | 45 | - | BQL | 1.635 | BQL | BQL | 1.040 | 5.851 | BQL | BQL | BQL | 1.236 | 5.470 | 1.246 | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 16. | Nitrite | mg/L | - | - | BQL | BQL | BQL | BQL | BQL | 0.033 | BQL | BQL | BQL | BQL | 0.263 | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 17. | Sodium | mg/L | - | - | 19.91 | 30.35 | BQL | BQL | 7.26 | 76.79 | BQL | BQL | BQL | 17.55 | 71.89 | 16.59 | 5.08 | 19.27 | 16.79 | BQL | BQL | 5.25 | 8.67 | 5.06 |
| 18. | Potassium | mg/L | - | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |

| Sr. No. | Parameters | Units | Standard values as per IS | | Kandla | | | | | | | | | | | | | | | | | Vadinar | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | P | DW-1 | DW-2 | DW-3 | DW-4 | DW-5 | DW-6 | DW-7 | DW-8 | DW-9 | DW-10 | DW-11 | DW-12 | DW-13 | DW-14 | DW-15 | DW-16 | DW-17 | DW-18 | DW-19 | DW-20 |
| 19. | Hexavalent Chromium | mg/L | - | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 20. | Odour | TON | Agreeable | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 21. | Arsenic | mg/L | 0.01 | 0.05 | BQL | BQL | BQL | BQL | BQL | 9.792 | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 22. | Cadmium | mg/L | 0.003 | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 23. | Copper | mg/L | 0.05 | 1.5 | BQL | BQL | BQL | BQL | 0.0072 | BQL | BQL | BQL | 0.0080 | 0.0062 | BQL | 0.0058 | BQL | BQL | BQL | BQL | BQL | BQL | BQL | 0.0086 |
| 24. | Iron | mg/L | 0.3 | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | 0.139 | BQL | BQL |
| 25. | Lead | mg/L | 0.01 | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | 0.00335 | BQL |
| 26. | Manganese | mg/L | 0.1 | 0.3 | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 27. | Mercury | mg/L | 0.001 | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 28. | Total Chromium | mg/L | 0.05 | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 29. | Zinc | mg/L | 5 | 15 | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 30. | Total Coliform* | MPN/ 100ml | Shall not be detected | | 150 | BQL | BQL | BQL | BQL | BQL | BQL | 10 | BQL | BQL | 85 | BQL | 65 | 40 | 110 | 20 | BQL | 170 | 235 | BQL |

A: Acceptable, P:Permissible, BQL: Below Quantification limit; Turbidity (QL=0.5 NTU), Free Residual Chlorine (QL=2 mg/L), Total Suspended Solids (QL=2 mg/L), Fluoride (QL=0.3 mg/L), Sulphate (QL=10 mg/L), Nitrate as $NO_3$ (QL=1 mg/L), Nitrite as $NO_2$ (QL=0.1mg/L), Sodium as Na (QL=5mg/L), Potassium as K (QL=5mg/L), Hexavalent Chromium (QL=0.01 mg/L), Arsenic (QL=0.005 mg/L), Cadmium (QL=0.002 mg/L), Copper (QL=0.005 mg/L), Iron (QL=0.1mg/L), Lead (QL=0.002 mg/L), Manganese (QL=0.04 mg/L), Mercury (QL=0.0005 mg/L), Total Chromium (QL=0.005 mg/L), Zinc (QL=0.5 mg/L), Total Coliforms (QL=1 MPN/ 100ml)

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

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

## 8.3 Data Interpretation and Conclusion

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

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

  It is important to note that the TDS concentrations in both Kandla and Vadinar fall well within the acceptable limit of 500 mg/L.
- **Electrical Conductivity (EC):** It is a measure of the ability of a solution to conduct electric current, and it is often used as an indicator of the concentration of dissolved solids in water. During the monitoring period, the EC values for samples collected in Kandla were observed to range from **23 to 279 µS/cm**, with an average value of **110.87 µS/cm**. In Vadinar, the EC values showed variation from **105.6 to 165.3 µS/cm,** with an average value of **135.45 µS/cm**. It's important to regularly monitor EC levels in drinking water as it can provide valuable information about water quality and presence of dissolved substances.
- **Chlorides:** The concentrations in the drinking water samples collected from Kandla and Vadinar were within acceptable limits, as specified by the BIS. The chloride in Kandla varied from **7.88 to 111.97 mg/L**, with an average value of **35.41 mg/L**. In Vadinar, it ranged from **13.80 to 20.70 mg/L**, with an average value of **17.25 mg/L.** It's important to note that all the recorded chloride concentrations in both Kandla and Vadinar were well below the acceptable limit of 250 mg/L except for location DW-5, DW-11.
- **Total Hardness (TH):** Total Hardness varied from **2 to 180 mg/L**, with the average value as **30.47 mg/L**. While at Vadinar, the variation was observed from **22 to 54 mg/L**; with the average conc. At **38 mg/L**. It's important to note that all the recorded chloride concentrations in both Kandla and Vadinar were well below the acceptable limit of 200 mg/L.

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

## 8.4 Remedial Measures

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

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

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

# CHAPTER 9: SEWAGE TREATMENT PLANT MONITORING

## 9.1 Sewage Treatment Plant (STP) Monitoring:

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

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

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

The Consolidated Consent and Authorization (CC&A) issued by the GPCB were referred for the details of the STP for Kandla and Gopalpuri. The CC&A of Kandla and Gopalpuri entails that the treated domestic sewage should conform to the norms specified in **Table 24**. The treated effluent conforming to the norms shall be discharged on the land within the premises strictly for the gardening and plantation purpose. Whereas, no sewage shall be disposed outside the premises in any manner.

**Table 24: Treated effluent Standards (as per CC&A of Kandla STP)**

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

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

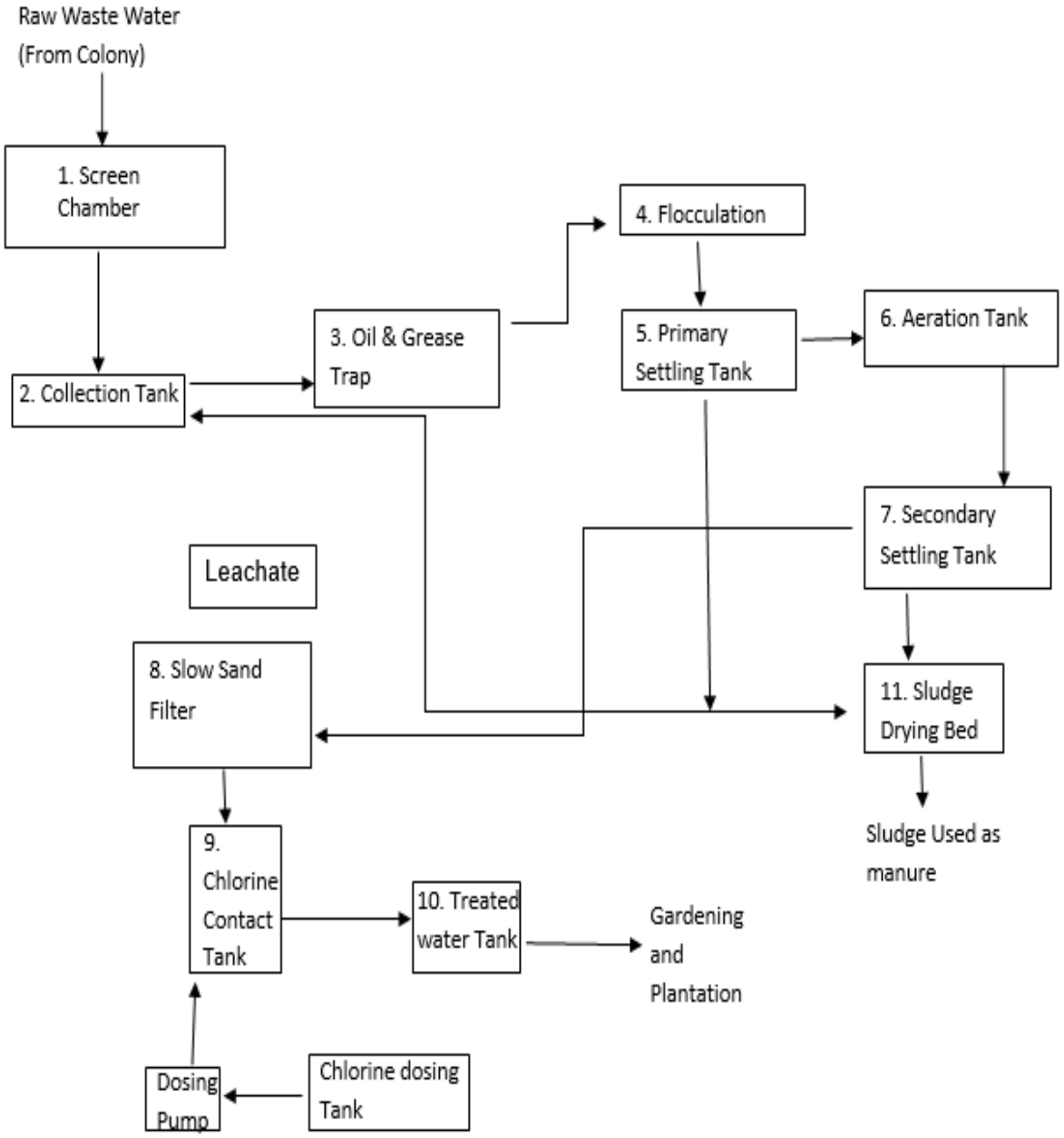



**Figure 3: Process flow diagram of STP at Kandla**

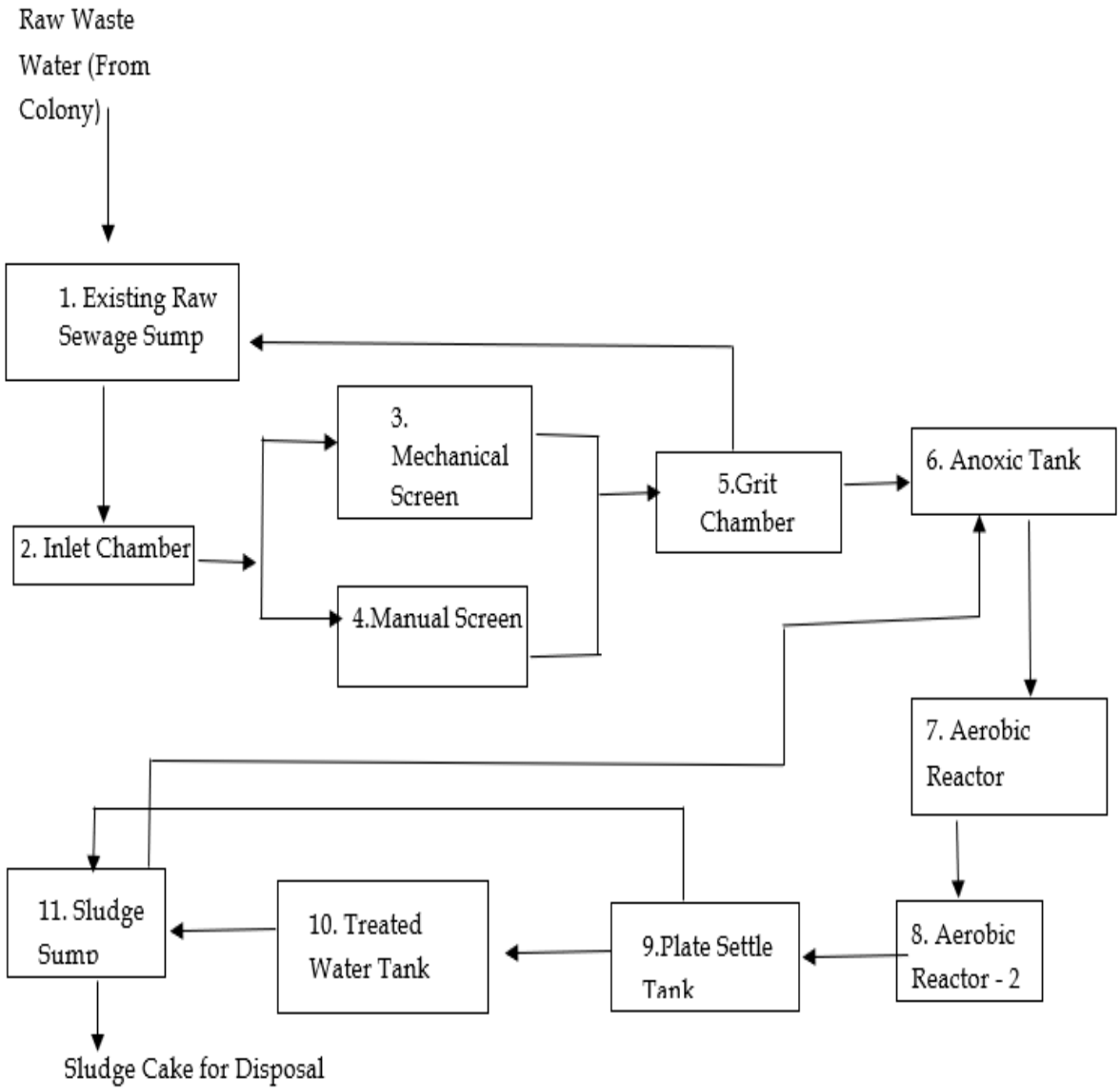



**Figure 4: Process flow diagram of STP at Gopalpuri**

**STP at Vadinar**

The STP at Vadinar has been built with a treatment capacity of 450 KLD/day. The Consolidated Consent and Authorization (CC&A) issued by the GPCB has been referred for the details of the said STP. The CC&A of the Vadinar STP suggests that the domestic effluent generated shall be treated as per the norms specified in **Table 25**. The treated effluent conforming to the norms shall be discharged on the land within the premises strictly for the gardening and plantation purpose. Whereas, no sewage shall be disposed outside the premises in any manner.

**Table 25: Norms of treated effluent as per CC&A of Vadinar STP**

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

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

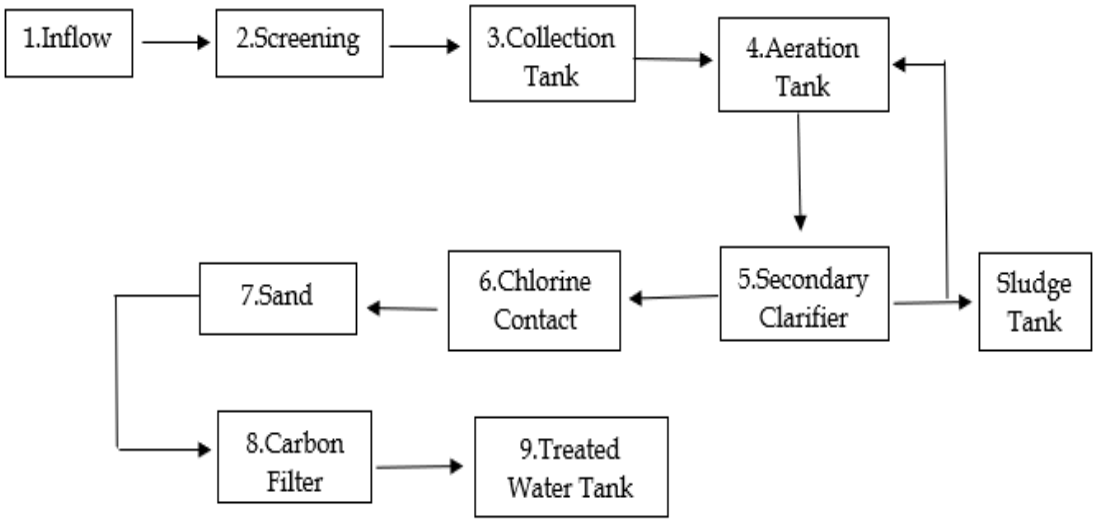
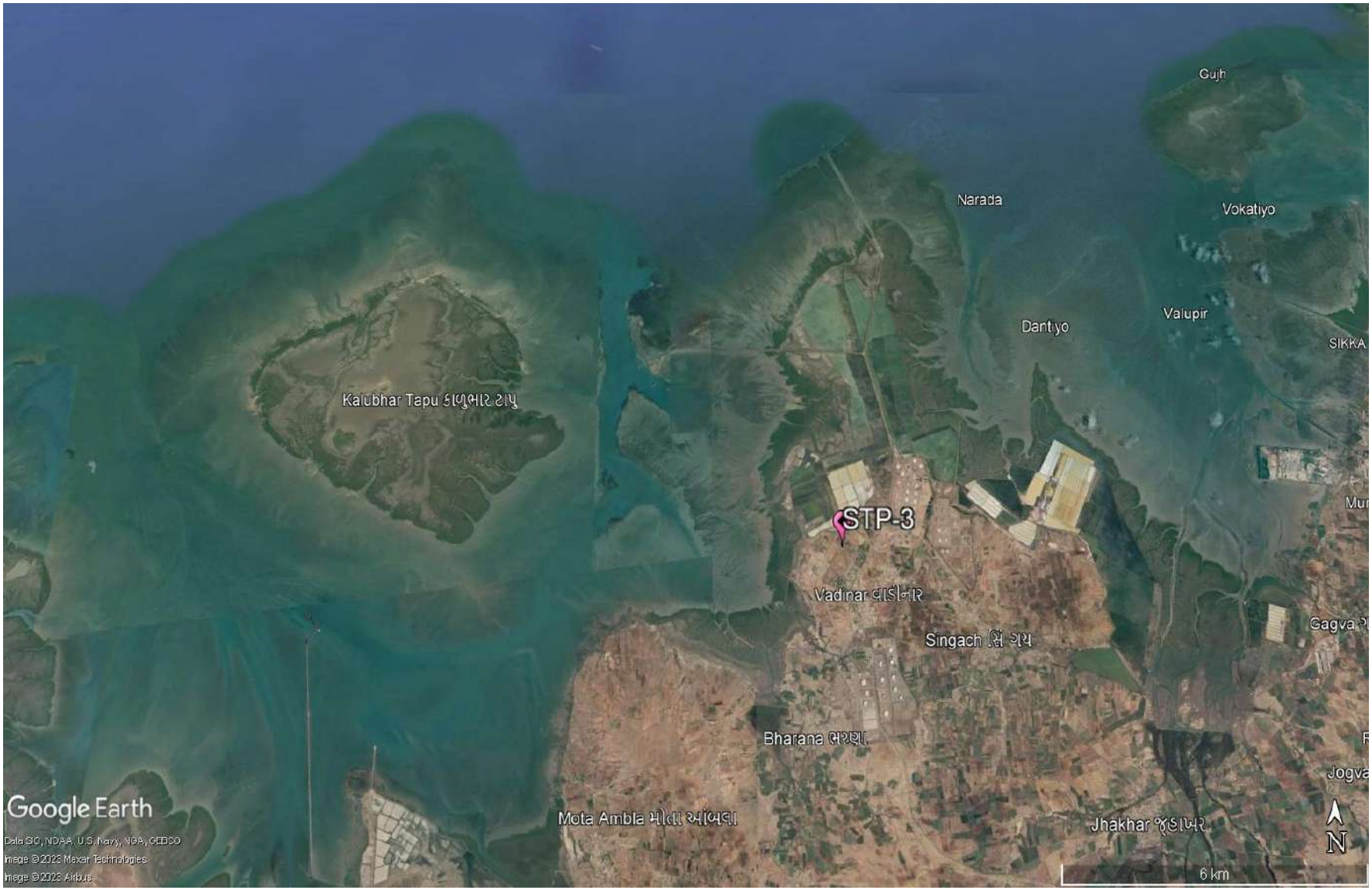



**Figure 5: Process flowchart for the STP at Vadinar**

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


**Map 14: Locations for STP Monitoring at Kandla**




**Map 15: Locations for STP Monitoring at Vadinar**

### Methodology

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

The water samples were collected from inlet and the outlet of the STP's and analyzed for physico-chemical and microbiological parameter. Collection and analysis of these samples was carried out as per established standard methods and procedures for the examination of water. The samples were analyzed for selected parameters to establish the existing water quality of the inlet and outlet points of the STP. GEMI has framed its own guidelines for collection of water/wastewater samples titled as 'Sampling Protocol for Water & Wastewater'; which has been approved by the Government of Gujarat vide letter no. ENV-102013-299-E dated 24-04-2014 under the provision of Water (Preservation and Control of Pollution) Act 1974. The sample collection and preservation are done as per the said Protocol. Under the project, the list of parameters to be monitored for the STP have been mentioned in **Table 26** as follows:

### Frequency

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

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

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

## 9.2 Result and Discussion

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

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

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

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

| Sr No. | Parameter | Units | GPCB Norms (Vadinar) | Week 3 of December | | Week 4 of December | | Week 1 of January | | Week 2 of January | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | STP-3 (Inlet) | STP-3 (Outlet) | STP-3 (Inlet) | STP-3 (Outlet) | STP-3 (Inlet) | STP-3 (Outlet) | STP-3 (Inlet) | STP-3 (Outlet) |
| **1.** | pH | - | **6.5-8.5** | 7.28 | 7.44 | 7.15 | 7.20 | 6.52 | 7.12 | 7.03 | 7.16 |
| **2.** | TDS | mg/L | - | 408 | 382 | 488 | 374 | 418 | 362 | 424 | 358 |
| **3.** | TSS | mg/L | **20** | 8 | 4 | 72 | 10 | 90 | 6 | 38 | 4 |
| **4.** | COD | mg/L | **50** | 168.0 | 56.0 | 293.2 | 52.2 | 498.0 | 32.4 | 196.8 | 36.1 |
| **5.** | DO | mg/L | - | 1.2 | 8.4 | 0.7 | 7.0 | BQL | 6.0 | 1.5 | 6.9 |
| **6.** | BOD | mg/L | **10** | 50.40 | 5.60 | 91.63 | 6.53 | 149.40 | 3.24 | 59.04 | 3.61 |
| **7.** | SAR | meq/L | - | 2.21 | 2.60 | 1.37 | 2.31 | 2.13 | 2.21 | 2.45 | 1.96 |
| **8.** | Total Coliforms | MPN/100ml | **100-230** | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 |

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

## 9.3 Data Interpretation and Conclusion

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

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

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

## 9.4 Remedial Measures:

- The quantum of raw sewage (influent) entering the STP should be monitored by installation of the flow meter. If the quantity of the sewage exceeds the treatment capacity of the treatment plant, then provision of additional capacity of collection sump should be provided.
- The adequacy and efficacy of the stages of Sewage treatment units shall be conducted.
- The results show the presence of total coliforms; hence the method of disinfection (Chlorination) sodium or calcium Hypochlorite can be used.
- Effectiveness of any technology depends on factors such as the specific pollutants in the wastewater, plant size, local regulations, and available resources. There are several processes that may be implemented such as - Advanced oxidation process involve using strong oxidants to break down complex organic compounds. Methods like Fenton's reagent (hydrogen peroxide and iron catalyst) and UV/$H_2O_2$ treatment can help in reducing COD through oxidation.

- Electrochemical processes like Electrocoagulation (EC) and Electrooxidation (EO) that involve the application of an electric current to facilitate the removal of pollutants through coagulation, flocculation, and oxidation. These methods can be useful for treating sewage containing various pollutants.

# CHAPTER 10: MARINE WATER QUALITY MONITORING

## 10.1 Marine Water

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

Major water quality concerns at ports include wastewater and leakage of toxic substances from ships, stormwater runoff, etc. This discharge of wastewater, combined with other ship wastes which includes sewage and wastewater from other on-board uses, is a serious threat to the water quality as well as to the marine life. As defined in the scope by DPA, the Marine Water sampling and analysis has to be carried out at a total of eight locations, six at Kandla and two at Vadinar. The marine water sampling has been carried out with the help of Niskin Sampler with a capacity of 5L. The Niskin Sampler is a device used to take water samples at a desired depth without the danger of mixing with water from other depths. Details of the locations to be monitored have been mentioned in **Table 29:**

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

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

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


**Map 16: Locations for Marine Water Monitoring at Kandla**


**Map 17: Locations for Marine Water Monitoring at Vadinar**

## Methodology

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

**Frequency:**

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

**Table 30: List of parameters monitored for Marine Water**

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

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

## 10.2 Result and Discussion

The quality of the Marine water samples collected from the locations of Kandla and Vadinar during the monitoring period has been summarized in the **Table 31**. The said water quality has been represented in comparison with the standard values as stipulated by CPCB for Class SW-IV Waters.

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

| Sr. No. | Parameters | Unit | Primary Water Quality Criteria for Class SW-IV Waters | Kandla | | | | | | Vadinar | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MW-1 | MW-2 | MW-3 | MW-4 | MW-5 | MW-6 | MW-7 | MW-8 |
| 1. | Density | kg/m³ | - | 1.021 | 1.02 | 1.02 | 1.021 | 1.022 | 1.021 | 1.02 | 1.021 |
| 2. | pH | - | 6.5-9.0 | 8.13 | 8.11 | 8.19 | 8.24 | 8.12 | 8.2 | 8.19 | 8.24 |
| 3. | Color | Hazen | No Noticeable | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 4. | EC | µS/cm | - | 51,500 | 52,300 | 54,100 | 54,300 | 52,400 | 51,800 | 54,100 | 54,300 |
| 5. | Turbidity | NTU | - | 97 | 125 | 4.12 | 3.42 | 131 | 112 | 4.12 | 3.42 |
| 6. | TDS | mg/L | - | 33,326 | 37,182 | 32,478 | 33,142 | 34,109 | 33,806 | 32,478 | 33,142 |
| 7. | TSS | mg/L | - | 347 | 421 | 115 | 195 | 332 | 411 | 115 | 195 |
| 8. | COD | mg/L | - | 32.7 | 30.9 | 47.89 | 51.26 | 31.56 | 33.11 | 47.89 | 51.26 |
| 9. | DO | mg/L | 3.0 mg/L | 5.9 | 6.3 | 6.1 | 5.7 | 6.1 | 5.8 | 6.1 | 5.7 |
| 10. | BOD | mg/L | 5.0 mg/L | 8.15 | 8.3 | 7.42 | 7.13 | 10.2 | 9.92 | 7.42 | 7.13 |
| 11. | Oil & Grease | mg/L | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 12. | Sulphate | mg/L | - | 2364.6 | 2684.7 | 2897.4 | 3157.3 | 2739.8 | 2457.3 | 2897.4 | 3157.3 |
| 13. | Nitrate | mg/L | - | 4.63 | 3.48 | 3.41 | 2.980 | 3.86 | 4.12 | 3.41 | 2.980 |
| 14. | Nitrite | mg/L | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 15. | Phosphate | mg/L | | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 16. | Silica | mg/L | - | 3.01 | 2.71 | 0.93 | 0.79 | 3.83 | 2.76 | 0.93 | 0.79 |
| 17. | Sodium | mg/L | - | 9485 | 9206 | 9,827 | 9,541 | 9642 | 9468 | 9,827 | 9,541 |
| 18. | Potassium | mg/L | - | 360.21 | 320 | 421.7 | 391.40 | 347.60 | 247.67 | 421.7 | 391.40 |
| 19. | Hexavalent Chromium | mg/L | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 20. | Odour | - | - | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 21. | Arsenic | mg/L | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 22. | Cadmium | mg/L | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 23. | Copper | mg/L | - | BQL | 6.22 | BQL | BQL | 6.68 | BQL | BQL | BQL |
| 24. | Iron | mg/L | - | 1.831 | 2.281 | 0.586 | 0.378 | 1.819 | 2.192 | 0.586 | 0.378 |
| 25. | Lead | mg/L | - | 3.16 | 3.22 | 2.412 | 2.984 | 2.41 | 3.36 | 2.412 | 2.984 |
| 26. | Manganese | mg/L | - | 92.18 | 134.29 | 42.57 | BQL | 92.74 | 116.68 | 42.57 | BQL |
| 27. | Total Chromium | mg/L | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 28. | Zinc | mg/L | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 29. | Mercury | mg/L | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 30. | Particulate Organic Carbon | mg/L | - | 1.08 | 0.68 | 0.55 | 0.72 | 0.98 | 1.18 | 0.65 | 0.72 |
| 31. | Total Coliforms | MPN/ 100ml | 500/100 ml | 16 | 15 | 10 | 24 | 10 | 15 | 10 | 24 |

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

## 10.3 Data Interpretation and Conclusion

The Marine water quality of Deendayal Port Harbor waters at Kandla and Vadinar has been monitored for various physico-chemical and biological parameters during the monitoring period. The detailed interpretation of the parameters in comparison to the Class SW-IV for Harbour Waters is as follows:

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

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

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

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

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

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

# CHAPTER 11: MARINE SEDIMENT QUALITY MONITORING

## 11.1 Marine Sediment Monitoring

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

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

### Methodology

As defined in the scope by DPA, the Marine Sediment sampling is required to be carried out once in a month at total eight locations, i.e., six at Kandla and two at Vadinar. The sampling of the Marine Sediment is carried out using the Van Veen Grab Sampler (make Holy Scientific Instruments Pvt. Ltd). The Van Veen Grab sampler is an instrument to sample (disturbed) sediment up to a depth of 20-30 cm into the sea bed. While letting the instrument down on the seafloor, sediment can be extracted. The details of locations of Marine Sediment to be monitored under the study are mentioned in **Table 32** as follows:

**Table 32: Details of the sampling locations for Marine Sediment**

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

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


**Map 18: Location of Marine Sediment Monitoring at Kandla**


**Map 19: Locations of Marine Sediment Monitoring at Vadinar**

The list of parameters to be monitored under the projects for the Marine Sediment sampling been mentioned in **Table 33** as follows:

**Table 33: List of parameters to be monitored for Sediments at Kandla and Vadinar**

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

## 11.2 Result and Discussion

The quality of Marine Sediment samples collected from the locations of Kandla and Vadinar during the monitoring period has been summarized in the **Table 34.**

**Table 34: Summarized result of Marine Sediment Quality**

| Sr No. | Parameters | Unit | Kandla | | | | | | Vadinar | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | MS-1 | MS-2 | MS-3 | MS-4 | MS-5 | MS-6 | MS-7 | MS-8 |
| 1. | Inorganic Phosphate | kg/ ha | 4.41 | 10.27 | 22.43 | 8.63 | 15.6 | 14.5 | 3.16 | 2.17 |
| 2. | Phosphate | mg/Kg | 1055.2 | 1862.2 | 1586.7 | 653.7 | 816.3 | 667.1 | 203.5 | 247.4 |
| 3. | Organic Matter | % | 0.81 | 0.31 | 0.27 | 0.51 | 0.73 | 0.33 | 0.65 | 0.87 |
| 4. | Sulphate as $SO^{4-}$ | mg/Kg | 190.09 | 170.70 | 210.19 | 155.27 | 92.28 | 101.26 | 84.17 | 115.9 |
| 5. | Calcium as Ca | mg/Kg | 2165.50 | 2439.90 | 1890.90 | 2947.40 | 1693.10 | 2368.70 | 2427.7 | 2389.6 |
| 6. | Magnesium as Mg | mg/Kg | 1584.50 | 1725.00 | 1826.00 | 1623.00 | 1421.10 | 1089.30 | 1198.2 | 1478 |
| 7. | Silica | g/Kg | 582.9 | 476.3 | 421.3 | 291.71 | 236.4 | 325.63 | 290.1 | 408.3 |
| 8. | Nitrite | mg/Kg | 0.32 | 0.64 | 0.39 | 0.41 | 0.49 | 0.59 | 0.16 | 0.3 |
| 9. | Nitrate | mg/Kg | 21.48 | 18.36 | 29.31 | 23.63 | 14.51 | 16.13 | 13.2 | 7.96 |
| 10 | Sodium | mg/Kg | 3514 | 2453 | 2619 | 3219 | 3442 | 2916 | 6136 | 8643 |
| 11 | Potassium | mg/Kg | 2084 | 1967.9 | 2819 | 3071.2 | 2741 | 2613.7 | 2938 | 2481 |
| 12 | Copper | mg/Kg | 2283.3 | 1826.7 | 1278.5 | 2379.5 | 1628.3 | 1347.8 | 1493.78 | 1681.39 |
| 13 | Aluminium | mg/Kg | 49.51 | 38.7 | 36.83 | 49.1 | 47.2 | 51.3 | 53.6 | 29.7 |
| 14 | Chromium | mg/Kg | 3.11 | 3.57 | 4.07 | 3.91 | 4.97 | 5.27 | 4.58 | 3.78 |
| 15 | Nickel | mg/Kg | 43.35 | 38.9 | 21.47 | 28.11 | 22.64 | 24.39 | 14.79 | 26.87 |
| 16 | Zinc | mg/Kg | 61.16 | 54.6 | 49.3 | 47.7 | 51.26 | 40.65 | 23.68 | 42.96 |
| 17 | Cadmium | mg/Kg | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 18 | Lead | mg/Kg | 4.97 | 5.02 | 3.84 | 5.11 | 4.76 | 4.26 | 4.76 | 5.22 |
| 19 | Arsenic | mg/Kg | 4.47 | 2.55 | 5.2 | 3.63 | 2.98 | 3.21 | 2.83 | 3.42 |
| 20 | Mercury | mg/Kg | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 21 | Texture | - | Sandy loam | Sandy loam | Sandy loam | Sandy loam | Sandy loam | Sandy loam | Sandy loam | Loam |

## 11.3 Data Interpretation and Conclusion

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

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

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

**Heavy Metals**

The sediment quality of Kandla and Vadinar has been compared with respect to the Average Standard guideline applicable for heavy metals in marine sediment specified by EPA have been mentioned in **Table 35.**

**Table 35: Standard Guidelines applicable for heavy metals in sediments**

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

*(Source: G Perin et al. 1997)*

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

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

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

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

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

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

# CHAPTER 12: MARINE ECOLOGY MONITORING

## 12.1 Marine Ecological Monitoring

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

As defined in the scope by DPA, the Marine Ecological Monitoring is required to be carried out once a month specifically at eight locations, six at Kandla and two at Vadinar. The sampling of the Benthic Invertebrates has been carried out with the help of D-frame nets, whereas the sampling of zooplankton and phytoplankton has been carried out with the help of Plankton Nets (60 micron and 20 micron). The details of the locations of Marine Ecological Monitoring have been mentioned in **Table 37** as follows:

**Table 37: Details of the sampling locations for Marine Ecological**

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

The map depicting the locations of Marine Ecological monitoring in Kandla and Vadinar have been mentioned in **Map 20 and 21** as follows:


**Map 20: Locations of Marine Ecological Monitoring at Kandla**


**Map 21: Locations of Marine Ecological Monitoring at Vadinar**

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

**Table 38: List of parameters to be monitored for Marine Ecological Monitoring**

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

## Methodology

- **Processing for chlorophyll estimation:**

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

- **Phytoplankton Estimation**

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

phytoplankton is mostly microscopic and unicellular floating flora, which are the primary producers that support the pelagic food-chain. The two most prominent groups of phytoplankton are Diatoms (*Bacillariophyceae*) and Dinoflagellates (*Dinophyceae*). Phytoplankton also include numerous and diverse collection of extremely small, motile algae which are termed micro flagellates (naked flagellates) as well as Cyanophytes (Bluegreen algae). Algae are an ecologically important group in most aquatic ecosystems and have been an important component of biological monitoring programs. Algae are ideally suited for water quality assessment because they have rapid reproduction rates and very short life cycles, making them valuable indicators of short-term impacts. Aquatic populations are impacted by anthropogenic stress, resulting in a variety of alterations in the biological integrity of aquatic systems. Algae can serve as an indicator of the degree of deterioration of water quality, and many algal indicators have been used to assess environmental status.

- **Zooplankton Estimation**

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

- **Benthic Organisms Estimation**

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

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

- **Diversity Index**

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

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

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

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

Where, ∑ = Summation symbol,

pi = Relative abundance of the species,

ln = Natural logarithm

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

2. **Simpson's index:**

A reasonably high level of dominance by one or a small number of species is indicated by the range of **0.89 to 0.91**. The general health and stability of the ecosystem may be

impacted by this dominance. Community disturbances or modifications that affect the dominant species may be more likely to have an impact. The dominating species determined by the Simpson's index can have big consequences on how the community is organised and how ecological interactions take place.

The formula for calculating D is presented as:

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

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

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

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

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

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

Where, N = total number of individuals collected

S = No. of taxa or species or genera

**4. Berger-Parker index:**

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

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

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

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

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

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

5. **Evenness index–**

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

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

Where, H= Shannon value

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

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

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

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

## 12.2 Result and Discussion

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

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

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

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

- **Productivity (Net and Gross)**
  **Gross primary productivity (GPP)** is the rate at which organic matter is synthesised by producers per unit area and time (GPP). The amount of carbon fixed during photosynthesis by all producers in an ecosystem is referred to as gross primary productivity. The monitoring location of Kandla reported GPP value in range between **0.69 to 1.63 mg/L/48 Hr** where the highest value recorded for ME-4 (Khori Creek) and lowest recorded at ME-6(Nakti creek (near NH-8A)). In Vadinar, the value of **GPP** was observed **0.88** at ME-7 (Near SPM) and **1.23** at ME-8 (Near Vadinar Jetty) monitoring station.

  **Net primary productivity**, is the amount of fixed carbon that is not consumed by plants, and it is this remaining fixed carbon that is made available to various consumers in the ecosystem. The Net primary productivity of the monitoring location at Kandla from (ME-1 to ME-6) has been recorded in as **BQL (Below Quantification Limit).** While in Vadinar, the value of **NPP** was observed **BQL (Below Quantification Limit).** at ME-7 (Near SPM) and ME-8 (Near Vadinar Jetty) monitoring station.

- **Pheophytin**
  The level of Pheophytin was detected in the range from **0.51 to 1.33 mg/m$^3$** where the highest value observed at ME-5 (Nakti Creek (near Tuna Port)) and the lowest value observed at ME-6 (Nakti Creek (near NH - 8A)). While in Vadinar, the value of Pheophytin was observed **1.20 mg/m$^3$** at ME-7 and **1.31 mg/m$^3$** at ME-8 monitoring station.

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

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

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

**Ecological Diversity**

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

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

**Table 40: Phytoplankton variations in abundance and diversity in sub surface sampling stations**

| Genera | ME-1 | ME-2 | ME-3 | ME-4 | ME-5 | ME-6 | ME-7 | ME-8 |
|---|---|---|---|---|---|---|---|---|
| *Bacillaria sp.* | 212 | - | - | 202 | - | 436 | - | 187 |
| *Biddulphia sp.* | - | 315 | 235 | 137 | 118 | - | 268 | 159 |
| *Chaetoceros sp.* | 317 | 166 | - | - | - | 561 | 186 | - |
| *Chlamydomonas sp.* | 185 | - | 188 | - | 298 | - | - | 319 |
| *Cyclotella sp.* | 126 | 468 | - | 266 | 125 | - | 408 | 107 |
| *Coscinodiscus sp.* | - | - | 426 | - | - | 286 | - | 160 |
| *Ditylum sp* | - | 225 | - | 271 | - | - | 270 | - |
| *Fragilaria sp.* | 486 | 174 | 142 | 158 | 210 | 153 | - | 181 |
| *Bacteriastrum sp.* | 252 | - | - | - | 119 | 146 | 161 | - |
| *Pleurosigma sp.* | - | - | 308 | - | - | - | 125 | 212 |
| *Navicula sp.* | 147 | - | - | 147 | 374 | 252 | - | 183 |
| *Merismopedia sp.* | - | 156 | 177 | - | - | - | - | - |
| *Synedra sp.* | - | - | - | - | - | - | 232 | - |
| *Skeletonema sp.* | 239 | - | - | 256 | 415 | 118 | - | 329 |
| *Oscillatoria sp.* | - | 201 | 355 | - | - | - | 178 | - |
| *Thallassiosira* | 187 | - | 158 | - | 175 | 123 | 163 | 280 |
| *Gomphonema sp.* | - | 345 | - | 178 | - | - | 135 | - |
| **Density-Units/L** | **2151** | **2050** | **1989** | **1615** | **1834** | **2075** | **2126** | **2117** |
| **No. of genera** | **9** | **8** | **8** | **8** | **8** | **8** | **10** | **10** |

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

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

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

**Table 41: Species richness Index and Diversity Index in Phytoplankton**

| Indices | ME-1 | ME-2 | ME-3 | ME-4 | ME-5 | ME-6 | ME-7 | ME-8 |
|---|---|---|---|---|---|---|---|---|
| Taxa S | 9 | 8 | 8 | 8 | 8 | 8 | 10 | 10 |
| Individuals | 2151 | 2050 | 1989 | 1615 | 1834 | 2075 | 2126 | 2117 |
| Shannon diversity | 2.11 | 1.96 | 1.93 | 1.75 | 1.81 | 1.89 | 2.22 | 2.23 |
| Simpson 1-D | 0.87 | 0.86 | 0.86 | 0.87 | 0.85 | 0.83 | 0.89 | 0.89 |
| Species Evenness | 0.96 | 0.94 | 0.93 | 0.84 | 0.87 | 0.91 | 0.96 | 0.97 |
| Margalef richness | 1.04 | 0.92 | 0.92 | 0.95 | 0.93 | 0.92 | 1.17 | 1.18 |
| Berger-Parker | 0.23 | 0.23 | 0.21 | 0.17 | 0.23 | 0.27 | 0.19 | 0.16 |
| Relative abundance | 0.42 | 0.39 | 0.40 | 0.50 | 0.44 | 0.39 | 0.47 | 0.47 |

- **Shannon- Wiener's Index (H)** of phytoplankton communities was in the range of **1.75 to 2.11** between selected sampling stations from ME-1 to ME-6 with an average value of **1.91** at Kandla creek and its nearby creeks. While for Vadinar, Shannon Wiener's index of phytoplankton communities recorded to be **2.22** at location ME-7 and **2.23** at ME-8 with an average value of **2.23**. The apportionment of the numbers of individuals among the species observed higher stability at all monitoring location of Kandla.

- **Simpson diversity index (1-D)** of phytoplankton communities was ranged between **0.83 to 0.87** at all sampling stations in the Kandla creek and nearby creeks, with an average of **0.86** Similarly, for Vadinar Simpson diversity index (1-D) of phytoplankton communities was **0.89** at location ME-7 and **0.89** at ME-8 with an average of **0.89**.

- **Margalef's diversity index** (Species Richness) of phytoplankton communities in Kandla and nearby creeks sampling stations was varying from **0.92 to 1.04** with an average of **0.95** during the sampling period. While for Vadinar, Margalef's diversity index (Species Richness) of phytoplankton communities observed **1.17** at ME-7 and **1.18** at ME-8 with an average value of **1.18**.

- **Berger-Parker Index (d)** of phytoplankton communities was in the range of **0.17 to 0.27** between selected sampling stations from ME-1 to ME-6 with an average value of **0.22** at Kandla creek and nearby creeks. Berger-Parker Index (d) of phytoplankton communities in the sampling stations of Vadinar, was in the range of **0.19 to 0.16** with an average value of **0.18**. All the monitoring station signifies a low diversity with an even distribution among the different species.

- The **Species Evenness** is observed in the range of **0.84 to 0.96** for all the six-monitoring station of Kandla and for the Vadinar the species evenness is observed **0.96** at location ME-7 & **0.97** at ME-8 location.

- During the sampling period, **Relative Abundance** of phytoplankton communities was in range of **0.39 to 0.50** between selected sampling stations from ME-1 to ME-6 with an average value of **0.42** at Kandla creek and nearby creeks. Whereas for Vadinar the Index value **0.47** at ME-7 and **0.47** at ME-8 with an average value **0.47**, thus it is concluded that the studied species can be stated as neither highly dominant nor rare.

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

**Table 42: Zooplankton variations in abundance and diversity in sub surface sampling stations**

| Genera | ME-1 | ME-2 | ME-3 | ME-4 | ME-5 | ME-6 | ME-7 | ME-8 |
|---|---|---|---|---|---|---|---|---|
| *Acartia sp.* | - | 1 | 1 | 1 | - | 2 | 2 | - |
| *Acrocalanus* | 1 | - | 1 | - | 1 | - | 2 | - |
| *Amoeba* | - | 1 | 1 | 2 | - | 1 | 1 | 2 |
| *Brachionus sp.* | 2 | 1 | - | - | 1 | 2 | - | 1 |
| *Calanus sp.* | 2 | 1 | 1 | 2 | 2 | - | - | - |
| *Cladocera sp.* | 1 | - | - | - | - | - | 1 | - |
| *Cyclopoid sp.* | - | 1 | 3 | 2 | 1 | 1 | 1 | 3 |
| *Copepod larvae* | 1 | 2 | - | 1 | - | 1 | 1 | 1 |
| *Diaptomus sp.* | - | - | 1 | - | 2 | - | 1 | - |
| *Eucalanus sp.* | 2 | 1 | - | 1 | - | 1 | - | 2 |
| *Mysis sp.* | - | - | 2 | - | 1 | - | - | 1 |
| *Paracalanus sp.* | 1 | 1 | - | - | - | 1 | 1 | 1 |
| **Density Unit/L** | **10** | **9** | **10** | **9** | **8** | **9** | **10** | **11** |
| **No. of genera** | **7** | **8** | **7** | **6** | **6** | **7** | **8** | **7** |

A total of 12 groups/taxa of zooplankton were recorded in Kandla and Vadinar during the study period which mainly constituted by *Mysis*, *brachionus*, *Calanus*, fish and shrimp larval forms. *Cladocera, Mysis* and *Paracalanus* had the largest representation at all stations from (ME-1 to ME-8). The density of Zooplankton of the sampling stations from ME-1 to ME-6 (Kandla) varying from **8 to 10 units/L**, while for Vadinar its density of zooplankton observed **10 units/L at ME-7** and **11 units/L at ME-8**. During the sampling, zooplankton communities were dominated by *Cyclopoid sp, Calanus sp, Amoeba* in Kandla, while *Cyclopoid sp* and *Calanus sp* had the largest representation at monitoring location of Vadinar.

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

**Table 43: Species richness Index and Diversity Index in Zooplankton**

| Indices | ME-1 | ME-2 | ME-3 | ME-4 | ME-5 | ME-6 | ME-7 | ME-8 |
|---|---|---|---|---|---|---|---|---|
| Taxa S | 7 | 8 | 7 | 6 | 6 | 7 | 8 | 7 |
| Individuals | 10 | 9 | 10 | 9 | 8 | 9 | 10 | 11 |
| Shannon diversity | 1.89 | 1.93 | 1.83 | 1.66 | 1.56 | 1.8 | 2.03 | 1.93 |
| Simpson (1-D) | 0.93 | 0.97 | 0.91 | 0.92 | 0.93 | 0.94 | 0.96 | 0.91 |
| Species Evenness | 0.97 | 0.93 | 0.94 | 0.93 | 0.87 | 0.93 | 0.98 | 0.99 |
| Margalef | 2.61 | 3.19 | 2.61 | 2.28 | 2.4 | 2.73 | 3.04 | 2.5 |
| Berger-Parker | 0.2 | 0.22 | 0.3 | 0.22 | 0.25 | 0.22 | 0.2 | 0.27 |
| Relative abundance | 70 | 88.89 | 70 | 66.67 | 75 | 77.78 | 80 | 63.64 |

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

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

- **Simpson diversity index (1-D)** of zooplankton communities was ranged between **0.91 to 0.97** at all sampling stations in the Kandla creek and nearby creeks, with an average of **0.93** Similarly, for Vadinar Simpson diversity index (1-D) of zooplankton communities was **0.96** at ME-7 and **0.91** at ME-8 with an average of **0.93.**

- **Margalef's diversity index** (Species Richness) of zooplankton communities in Kandla and nearby creeks sampling stations was varying from **2.28 to 3.19** with an average of **2.63** during the sampling period. While for Vadinar, Margalef's diversity index (Species Richness) of zooplankton communities observed **3.04** at ME-7 and **2.50** at ME-8 with an average value of **2.77**.

- **Berger-Parker Index (d)** of zooplankton communities was in the range of **0.20 to 0.30** between selected sampling stations from ME-1 to ME-6 with an average value of **0.23** at Kandla creek and nearby creeks. Berger-Parker Index (d) of zooplankton communities in the sampling stations of Vadinar, was observed **0.20** at ME-7 and **0.27** at ME-8 with an average value of **0.23**. All the monitoring station signifies a low diversity with an even distribution among the different species.

- The **Species Evenness** is observed in the range of **0.87 to 0.97** for all the six-monitoring station of Kandla whereas, for the Vadinar the species evenness was observed **0.98** at ME-7 and **0.99** at ME-8 the locations**,** during the monitoring month.

- During the sampling period, **Relative Abundance** of zooplankton communities was in range of 66.67 **to 88.89** between selected sampling stations from ME-1 to ME-6 with an average value of **74.72** at Kandla creek and nearby creeks. Whereas for Vadinar the Index value **80** at ME-7 and **63.64** at ME-8 with an average value **71.82**, thus it can be concluded that the studied species is stated as neither highly dominant nor rare.

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

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

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

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

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

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

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

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

- **Shannon- Wiener's Index (H)** of benthic organism was in the range of **1.39 to 1.91** between selected sampling stations from ME-1 to ME-6 with an average value of **1.56** at Kandla creek and its nearby creeks. While for Vadinar, Shannon Wiener's index of benthic organism recorded to be **1.65** at ME-7 & **1.39** at ME-8 location with an average value of **1.52**. The apportionment of the numbers of individuals among the species observed higher stability at all monitoring location of Kandla and Vadinar.

- **Simpson diversity index (1-D)** of benthic organism was ranged between **0.90 to 0.96** at all sampling stations in the Kandla creek and nearby creeks, with an average of **0.93**. Similarly, for Vadinar Simpson diversity index (1-D) of benthic organism was **0.95** at ME-7 and **0.93** at ME-8 location with an average of **0.94.**

- **Margalef's diversity index** (Species Richness) of benthic organism in Kandla and nearby creeks sampling stations was varying from **2.06 to 2.89** with an average of **2.31** during the sampling period. While for Vadinar, Margalef's diversity index (Species Richness) of

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

- **Berger-Parker Index (d)** of benthic organism was in the range of 0.25 **to 0.33** between selected sampling stations from ME-1 to ME-6 with an average value of **0.29** at Kandla creek and nearby creeks. Berger-Parker Index (d) of benthic organism in the sampling stations of Vadinar, was observed to be **0.29** at ME-7 and **0.33** at ME-8 location with an average value of **0.31**. All the monitoring station signifies a low diversity with an even distribution among the different species.

- The **Species Evenness** is observed in the range of **0.86 to 0.98** for all the six-monitoring station of Kandla and for the Vadinar the species evenness is observed in the range of **0.86 to 0.92** at both of the location.

- During the sampling period, **Relative Abundance** of Benthic organisms was **71.43 to 87.5** between selected sampling stations from ME-1 to ME-6 with an average value of **78.47** at Kandla creek and nearby creeks. Whereas for Vadinar the Index value **85.71** at ME-7 and **83.33** at ME-8 location, with an average value **84.52**, thus it is concluded that the studied species can be stated as neither highly dominant nor rare.

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

STP Monitoring


Noise Monitoring

Soil Monitoring

Marine Monitoring

Air Monitoring

Drinking Water Monitoring

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

Air Monitoring

Noise Monitoring

STP Monitoring

Drinking water Monitoring

Marine Monitoring

Soil Monitoring

Source: GEMI

# Gujarat Environment Management Institute (GEMI)

**(An Autonomous Institute of Government of Gujarat)**

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


**Head Office**

Plot No. B 246 & 247, G.I.D.C. Electronic Estate,

Sector-25, Gandhinagar-382024

**Laboratory**

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*"We Provide Environmental Solutions"*

# Annexure -D

दि न्यू इन्डिया एश्योरन्स कं. लि.
(भारत सरकार का उपक्रम)
बृहत कॉर्पोरेट एवं ब्रोकर्स कार्यालय : 920000
न्यू इन्डिया सेंटर, 11वीं मंजिल, 17/ए, कूपरेज रोड,
डॉ. बी.आर. आंबेडकर चौक, मुंबई - 400 001.
फोन : 022-22044973 / 2204 4976 / 2204 4977 / 2204 4974

THE NEW INDIA ASSURANCE CO. LTD.
( A Govt. of India Undertaking)
Large Corporate & Broker's Office : 920000
New India Centre, 11th Floor, 17/A, Cooperage Road,
Dr. B.R. Ambedkar Chowk, Mumbai - 400 001
Phone : 022 - 2204 4973 / 2204 4976 /2204 4977 / 2204 4974

## RISK DETAILS

| | |
|---|---|
| **TYPE:** | MARINE PORT PACKAGE INSURANCE POLICY |
| **INSURED:** | **DEENDAYAL PORT AUTHORITY,** (hereinafter referred as DPA) and/ or associated and/ or affiliated and/ or interrelated and/ or subsidiary companies and/ or corporations as they now are or may hereafter be created and/ or constituted and/ or for whom the Assured receive instructions to insure and/ or for whom the Assured have or assume a responsibility to arrange insurance, whether contractually or otherwise, as their respective rights and interests may appear hereinafter known as the Assured and/ or as original |
| **PRINCIPAL ADDRESS:** | Address of the Original Insured<br>Administrative Office Building, Near Madhuban Hotel, Gandhidham, Kutch, Gujarat. |
| **INSURANCE INTERMEDIARY:** | Marsh India Insurance Brokers Pvt. Ltd. |
| **PERIOD:** | 12 months with effect from 24th July 2024 till 23rd July 2025, both days included |
| **INTEREST:** | Section 1<br>Port Authority Liabilities including liability of contractor and subcontractors and wreck removal.<br>Section 2<br>Real and Personal Property - In respect of all properties, owned by / under custody of Insured(s) hereunder including adjacent warehouses associate structures.<br>Section 3<br>Port Equipment including all Cargo Handling Equipment /Vehicles, Machineries and spares<br>Section 4<br>Business Interruption consequent upon Property damage (including cargo handling equipment, machineries etc.)<br>-<br>For Business interruption of the Port operation (wholly or partly) due to/consequent upon or arising out of: |



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Regd. & Head Office : New India Assurance Bldg, 87, Mahatama Gandhi Road, Fort, Mumbai - 400 001.
Website : www.newindia.co.in
CIN : L66000MH1919GOI000526

(a) Interruption of electric supply to insured properties Or insured handling equipment, which is beyond the control of the assured.

(b) Blockage of Channel/ Waterways due to any cause

(c)Blockage of any land access within the immediate Vicinity* of the Port/ Terminals.
*(immediate vicinity will mean at least 8 km radii from main entrance of Port's operational area applicable for both Kandla as well as for Vadinar)

**LIMIT OF LIABILITY**

Section 1
Overall Limit of Liability: INR 40,00,00,000 any one accident or occurrence and in the aggregate
Sublimit for liability arising out of wreck removal: INR 5,00,00,000

Sections 2, 3 & 4

**Loss Limit:** INR 760,00,00,000 any one accident or occurrence and in the aggregate

TOTAL SUM INSURED FOR PROPERTIES (excludes owned vessels): **INR 66,018,944,786.**

Sections 4

Indemnity Period: 12 Months
Annual Revenue – INR 27,107,385,666
Annual Gross Profit – INR 25,759,485,666
Loss limit – INR 100,00,00,000

**Combined Single Limit for PD /BI / Liability across all sections is INR 800,00,00,000**

**LOCATION:**

Insured Location addresses as under:

1. Administrative Office Buildng, Near Madhuban Hotel, Gandhidham, Kutch, Gujarat -370201
2. Custom Bounded Area Port of Kandla – 370210.
3. Port Colony, KDLB colony, FCI colony, Residential quarters-400 quarters, Gopalpuri, Gandhidham -370201.
4. Office Buildings and Residential Quarters outside port area, Kandla – 370210
5. Dispensary at Adipur-370205
6. Baba Saheb Ambedkar Convention Centre Gandhidham

7. Jetty Area, Vadinar-361010 – Latitude : 220 44' N ; Longitude : 690 67' E

8. Port Colony, Vadinar-361010 – Latitude : 230 01' N ; Longitude : 700 13' E

**POLICY CONDITIONS:**

**Section 1**

Ports and Terminals Consortium Section 1 – Liability Wording Amended.
Clause 2.3 (Insuring Clause) amended.

Ports and Terminals Consortium Fire Extension (Liability).
Ports and Terminals Consortium Advice and Information Extension
(Liability).

Ports and Terminals Consortium Fines and Duty Extension (Liability).
Ports and Terminals Consortium Infringement of Personal Rights Extension (Liability).
Ports and Terminals Consortium Wrongful Delivery of Cargo Extension (Liability).

Subject to Joint Liability Committee War and Terrorism Exclusion Clause JL2002/02 17/01/02 plus Joint Liability Committee

Deductible:
For Liability (including environmental pollution): Flat: INR 5,00,000

**Section 2**

Ports and Terminals Consortium Section 2 – Property Damage Wording Amended.
Clause 2.1 (Insuring Clause) amended to include electrical and machinery breakdown.
Exclusion 4.8 (Safe working load) amended.
Exclusion 5.2 (Road) deleted.
Exclusion 5.4 (Stock) does not apply to stock of spare parts.
Exclusion 4.9 (Communication Equipment) deleted.
Clause 5.1 amended to include land development cost
Clause 8.1 (Automatic Acquisition) amended to 90 days. Clause 8.2 (Automatic Acquisition) amended to 10%.

Ports and Terminals Consortium Earthquake Extension Clause (Property) Amended, 1/04 LSW1517.
Clause A amended to include Tsunami. Clause B amended to include Tsunami.
48 hours amended to 72 hours.

Deductible:
**(A) Other than AOG peril & Vessel Impact:** 2% of claim amount subject to Minimum **INR 3,00,000 each and every claim**

**(B) AOG Peril**: 2% of claim amount subject to **Minimum INR 20,00,000 each and every claim (including losses affecting breakwater)**

**(C) Vessel impact:** 2% of claim amount subject to **Minimum INR 20,00,000 each and every claim (including losses affecting breakwater)**

Section 3
Ports and Terminals Consortium Section 3 – Handling Equipment Wording Amended.
Clause 2.1 (Insuring Clause) amended to include electrical and machinery breakdown.
Clause 2.4 (Removal of Wreck/Debris) included
Exclusion 4.7 (Communication Equipment) deleted.
Exclusion 4.9 (Safe working load) amended.
Exclusion 4.15 (Mechanical or Electrical Breakdown) deleted.
Clause 8 (Protective Maintenance) amended.
Clause 9.1 (Automatic Acquisition) amended to 90 days
Clause 9.2 (Automatic Acquisition) amended to 10%
Ports and Terminals Consortium Earthquake Extension Clause (Handling Equipment) Amended 1/04 LSW1520. Clause A amended to include Tsunami.
Clause B amended to include Tsunami.
48 hours amended to 72 hours.

Deductible: 2% of claim subject to **Minimum INR 3,00,000**

Section 4
Ports and Terminals Consortium Section 4 Business Interruption Wording Amended 1/04 LSW1522.
Clause 2.3 (Interruption to Utility Supply) amended to include gas, fuel or water supply.
Additional Clause 2.4 interruption due to damage and/or blockage of pipeline.

Deductible: 7days

Applicable to Sections 2, 3 & 4
Subject to Expediting Expenses Clause

Subject to Architects, Surveyors', Legal and Consulting Engineers' Fees Clause

Subject to Minor Works Clause



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Phone : 022 - 2204 4973 / 2204 4976 /2204 4977 / 2204 4974

Subject to Public Authority Clause

Subject to Reinstatement Clause

Subject to Temporary Removal Clause

Subject to Additional Increased Cost of Working Clause.

Subject to Prevention of Ingress/Egress Clause.

Subject to Professional Accountants Fees Clause

Subject to Average Clause (85%)
Pollution Clean-up Costs Clause
Claims Preparation Costs Clause
Minimization of Loss Clause
Designation of Property Clause
Listed Perils resulting from seepage and/or pollution and/or contamination clause
Limited seepage &/or pollution &/or contamination resulting from physical damage caused by listed perils clause

Waiver of under-insurance upto 15% of Sum Insured under property damage and BI Sum Insured
Marine Impact Insurance Clause
Specialized / Heavy Lift/ Oversize Lifting clause
Toxic Mould Exclusion Clause
Claims Control Clause
NMA 2919 War and Civil War and Terrorism Exclusion Clause

Applicable to All Sections

General Policy Provisions LSW1524 01/04 Amended
Clause 5 (Radioactive Contamination, etc) deleted
Clause 6.1 B. amended to delete 'strike, lock-out, labour disturbance, riot, civil commotion'.
Clause 11 (Notice of Potential Claims) amended. Clause 18 (Premium Payment Clause) deleted.
Clause 21 (Governing Law) amended to India.
Clause 10 (Electronic Exclusion Clause) deleted.
Employment Practices Clause
Simultaneous Payment Clause (Losses)
Waiver of Subrogation and Additional Assured Clause
Special Termination Clause.
Continuity Clause

Subject to Institute Radioactive Contamination, Chemical, Biological, Bio-chemical and Electromagnetic Weapons Exclusion



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Clause CL.370 10/11/03, and Marine Cyber Exclusion LMA5402 and Marine Cyber Endorsement LMA5403.

Subject to Sanction Limitation and Exclusion Clause LMA3100 15th September 2010.

Subject to Unintentional Errors and Omission Clause.

Notwithstanding anything contained elsewhere, insurance shall be governed by and construed in accordance with the laws of India and the exclusive jurisdiction of India.

**Payment on account clause** - Payment on account of any loss recoverable under this insurance will be promptly made by the insurers to the insured if so desired, provided that such payment are deducted from the finally agreed claim settlement figures.

**Paneled surveyor clause:** In the event of a claim, the surveyors shall be appointed only from the panel of agreed surveyors as mentioned below:

a) Proclaim Insurance Surveyors and Loss Assessors Private Limited

b) McLarens Insurance Surveyors And Loss Assessors India Pvt. Ltd

c) Alex Stewart International (India) Private Limited

In case above surveyors are not available, the appointment of alternate surveyor by insurance company will be done in agreement and after consent of the assured.

**EXPRESS WARRANTIES:** None

**CONDITIONS PRECEDENT:** None

**SUBJECTIVITIES:** None

**PREMIUM:** Total Premium inclusive of sections 1,2,3 &4:

**INR 14,30,39,825 plus 18% GST of INR 2,57,47,168.50**

**Total premium of INR 16,87,86,993.50**

Paid in full prior to inception

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Phone : 022 - 2204 4973 / 2204 4976 /2204 4977 / 2204 4974

## Terrorism Cover

| | |
|---|---|
| **Insured:** | **DEENDAYAL PORT AUTHORITY,** (hereinafter referred as MPT) and/ or associated and/ or affiliated and/ or interrelated and/ or subsidiary companies and/ orcorporations as they now are or may hereafter be created and/ or constituted and/ or for whom the Assured receive instructions to insure and/ or for whom the Assured have or assume a responsibility to arrange insurance, whether contractually or otherwise, as their respective rights and interests may appear hereinafter known as the Assured and/ or as original. |
| **Insurance Intermediary:** | Marsh India Insurance Brokers Pvt. Ltd. |
| **Risk Location:** | Insured Location addresses as under:<br>1. Administrative Office Buildng, Near Madhuban Hotel, Gandhidham, Kutch, Gujarat -370201<br>2. Custom Bounded Area Port of Kandla – 370210.<br>3. Port Colony, Gopalpuri, Gandhidham -370201.<br>4. Office Buildings and Residential Quarters outside port area, Kandla – 370210<br>5. Dispensary at Adipur-370205<br>6. Baba Saheb Ambedkar Convention Centre Gandhidham<br>7. Jetty Area, Vadinar-361010 – Latitude : 220 44' N ; Longitude : 690 67' E<br>8. Port Colony, Vadinar-361010 – Latitude : 230 01' N ; Longitude : 700 13' E |
| **Occupancy:** | **Marine Port** |
| **Cover:** | Terrorism and Sabotage with third party liability limit |
| **Period:** | 24th July 2024 to 23rd July 2025 |
| **Total Insured Values:** | Property Damage and handling equipment- INR 66,018,944,786.<br>Sections 4<br>Indemnity Period: 2 Months<br>Annual Revenue – INR 27,107,385,666<br>Annual Gross Profit – INR 25,759,485,666<br>Loss limit – INR 100,00,00,000 |



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Website : www.newindia.co.in
CIN : L66000MH1919GOI000526

**Limit:**

Combined Single Limit for Property Damage, handling equipment and Business Interruption – INR 760,00,00,000

Third party liability limit of INR 40,00,00,000

Combined Single Limit for Property Damage, handling equipment and Business Interruption and liability – INR 800,00,00,000

**Deductibles:**

Material damage – 2% claim amount subject to minimum of INR 300,000

Business Interruption – 7 days

Third Party Liability – INR 500,000 any one accident / occurrence

**Total Premium:**

**INR 21,92,181 plus 18% GST of INR 3,94,592.58 totaling to**

**INR 25,86,773.58**

For The New India Assurance Co. Ltd.

Authorized Signatory

# Annexure -2

**Annexure 2**

**Monitoring the implemental Safe guards**
**Ministry of Environment, Forests & Climate Change**
**Regional office, Gandhinagar**
**Monitoring Report (For the period October, 2024 to March, 2025)**

**DATA SHEET**

| | |
|---|---|
| 1. Project type: River valley/ Mining/Industry/ thermal/nuclear/Other (specify) | Infrastructure and Miscellaneous Projects + CRZ |
| 2. Name of the project | Construction of 13th to 16th Cargo Berth at Kandla Port by M/s Deendayal Port Authority (Erstwhile: Deendayal Port Trust) (Under Ministry of Ports, Shipping & Waterways, GoI). |
| 3. Clearance Letter (s). OM no and date | Environment Clearance was issued by the Govt. of India, Ministry of Environment & Forest – New Delhi vide letter No. 11-70/2006-IA-III Dated September 2008.<br><br>Further, the Ministry of Environment & Forest – New Delhi, Govt. of India, extended the Environmental Clearances validity for five years, i.e. up to 30/09/2018, vide letter No. F.NO.11 – 70/ 2006 – IA.III dated 7th February 2014. |
| 4. Location<br>a) District (s)<br><br>b) State (s)<br><br>c) Location/latitude/longitude | <br>District: Kutch<br><br>State : Gujarat<br><br>Location: Deendayal Port Authority, 22°58'33.08"N and 70°13'16.28"E |
| 5. Address for Correspondence<br>a) address of Concerned Project Chief Engineer(with pin code &telephone/telex/fax numbers)<br><br>b) Address of Executive project Engineer/manager/(with pin code fax numbers) | Chief Engineer,<br>Deendayal Port Authority, A.O. Building<br>Post Box No.-50, Gandhidham- Kutch.<br>Gujarat<br>Pin – 370201<br>Tel: 02836-233192,<br>Fax-02836-220050.<br><br>Superintending Engineer (Harbour),<br>Office of the Superintending Engineer (Harbour),<br>Nirman Building,<br>New Kandla (Kutch) Pin 370 210.<br>Gujarat |
| 6. Salient features of the project | All the 4 berths, i.e., 13th to 16th Cargo berths, are under operation.<br>1. The dimension of each berth is 300m x 55m, consisting of a quay and transit area resting on 1200mm and 1000mm R.C.C. |

| | |
|---|---|
| b) Salient features of the Environmental management plan | bored cast-in-situ piles. (Total 1200m x 55m wide for 4 berths).<br>2. The backup area of size 21.7 Hectares/berth for 13th, 14th, 15th&16th CB, including all facilities, roads, railways & other required infrastructure (Total area: 102.17 ha. + 42 Ha. (1200 m X 350 m) = 144.17 ha.)<br>3. The Capacity of each Berth is 4.5 MMTPA (As approved by the Tariff Authority of Major Ports).<br>4. The drawing showing all berths viz. 13th to 16th has already been submitted with an earlier compliance report.<br><br>NIOT, Chennai, had already suggested an Environmental Management Plan for the project's construction & operation phases, as cited in the EIA study report by NIOT, Chennai. A copy of the same has already been communicated with earlier compliance reports submitted. |
| 7. Breakup of the project area<br>a) Submergence area: forest & non-forest<br>b) Others | <br>Nil<br><br>Nil |
| 8. Breakup of the project affected population with enumeration of those losing houses/dwelling units only agricultural land & landless labourers/artisen<br>a) SC. ST/Adivasis<br><br>b) Others<br><br>(Please indicate whether these figures are based on any scientific and systematic survey carried out or only provisional figures, if a survey is carried out give details and years of survey). | <br><br><br><br>Nil<br><br>Nil<br><br>It is based on the EIA report prepared by M/s NIOT, Chennai. |
| 9. Financial details<br><br>a) Project cost as originally planned and subsequent revised estimates and the year of prices reference.<br><br><br><br><br>b) Allocation made for environmental management plans with item wise and year wise breakup | <br><br>Block estimated cost of Rs. 442.90 crores (Dec. 2005); Revised Block estimated cost of Rs. 755.5 crores (Apr 2009).<br><br>Estimated cost revised (The year 2017) for Berth No. 14 C.B.: 253 Crore & Berth No. 16 C.B.: 278 Crore. The Deendayal Port Authority operates all the 4 berths.<br><br>The allocation made under the scheme of "Environmental Services & Clearance thereof other related Expenditure" during RBE 2024-25 is Rs. 585 Lakhs. |

| | |
|---|---|
| c) Benefit cost ratio/Internal rate of Return and the year of assessment Whether (c) includes the cost of environmental management plans so far. | FIRR 13.61% EIRR 14.62%<br><br>Berth No. 14 C.B.: 253 Crore<br>FIRR 15.32% EIRR 17.42%<br><br>Berth No. 16 C.B.: 278 Crore<br>FIRR 14.23% EIRR 16.17% |
| d) Actual expenditure incurred on the project | Yes<br><br>13$^{th}$C.B: 300.23 Crore<br><br>15$^{th}$C.B: 252.45 Crore<br><br>Berth No. 14$^{th}$C. B internal resources DPT: 138.28 Crore (Awarded cost berth & Back up area)<br><br>Berth No. 16$^{th}$C.B internal resources DPT: 149.56 Crore (awarded cost berth & backup area). |
| e) Actual expenditure incurred on the Environmental management plans so far. | "Environmental Services & Clearance of other related Expenditure" is Rs. 522 Lakhs from October 2024 to March 2025. |
| 10. Forest land requirement | Nil |
| a) The status of approval for diversion of forest land for non-forestry use | Not Applicable. |
| b) The status of clear felling | NIL |
| c) The status of compensatory aforestation, if any | **A) Mangrove Plantation Plan carried out:**<br>1) Year 2005-06 – 20 hectares<br>2) Year 2008-09 - 50 hectares<br>3) Year 2010-11 – 100 hectares<br>4) Year 2011-12 – 200 hectares<br>5) Year 2012-13 – 300 hectares<br>6) Year 2013 -14 – 330 hectares<br>7) Year 2015-17 - 300 hectares<br>8) Year 2018-19 - 50 hectares<br>9) Year 2019-20 – 50 Hectares<br>10) Year 2020-21– 100 Hectares<br>11) Year 2022-23- 100 Hectares<br>12) Year 2024-25- 50 Hectares<br>**Total - 1650 hectares** |
| d) Comments on the viability & sustainability of compensatory | As per the directions of the GCZMA and MoEF&CC, |

| | |
|---|---|
| forestation programmed in the light of actual field experience so far | GoI, to date, DPA has undertaken a Mangrove Plantation in an area of 1650 Hectares since the year 2005.<br><br>The final report by GUIDE, Bhuj, was submitted along with the compliance report submitted in November 2019.<br><br>Subsequently, DPA awarded the work for monitoring the mangrove plantation to M/s GUIDE, Bhuj, via a work order dated 3/5/2021 (Period 2021-2022). M/s GUIDE, Bhuj submitted its final report for the said project in May 2022, and the copy has already been communicated with earlier compliance report submitted.<br><br>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.<br><br>Further, DPA has appointed the Gujarat Institute of Desert Ecology (GUIDE) for "Green belt development in Deendayal Port Authority and its Surrounding Areas, Charcoal site' (Phase-l) (5000 plants)" vide Work Order No.EG/WK/4757/Part [Greenbelt GUIDE, dated 31st May 2022. The work is completed.<br><br>Further, DPA assigned work to GUIDE, Bhuj, via a work order dated 23/06/2023 for "Green belt development in Deendayal Port Authority and its Surrounding Areas (Phase II) (10000 plants). The final report is submitting along with this compliance. |
| 11. The status of clear felling in non-forest areas (such as submergence area of reservoir, approach roads), if any with quantitative information. | Nil |
| 12. Status of construction<br>a) Date of commencement (Actual and/or planned)<br><br>b) Date of completion (Actual and/or planned) | All the 4 berths are under operation.<br><br>13th CB: Under operation since 18/02/2013.<br>15th CB: Under Operation since 16/11/2013.<br>14th CB: Under Operation since 08/04/2019.<br>16th CB: Under Operation since 10/03/2019. |
| 13. Reasons for the delay if the Project is yet to start | All the 4 berths are under operation.<br><br>13th CB: Under operation since 18/02/2013.<br>15th CB: Under Operation since 16/11/2013. |

| | |
|---|---|
| | 14th CB: Under Operation since 08/04/2019.<br>16th CB: Under Operation since 10/03/2019. |
| Date of site visited<br><br>a) The dates on which the project was monitored by the regional office on pervious occasion. if any<br><br>b) The date site visit for this monitoring report | <br><br>29/12/2016<br><br><br>------ |

# Annexure–C

दि न्यू इन्डिया एश्योरन्स कं. लि.
(भारत सरकार का उपक्रम)
बृहत कॉर्पोरेट एवं ब्रोकर्स कार्यालय : 920000
न्यू इन्डिया सेंटर, 11वीं मंजिल, 17/ए, कूपरेज रोड,
डॉ. बी.आर. आंबेडकर चौक, मुंबई - 400 001.
फोन : 022-22044973 / 2204 4976 / 2204 4977 / 2204 4974

THE NEW INDIA ASSURANCE CO. LTD.
( A Govt. of India Undertaking)
Large Corporate & Broker's Office : 920000
New India Centre, 11th Floor, 17/A, Cooperage Road,
Dr. B.R. Ambedkar Chowk, Mumbai - 400 001
Phone : 022 - 2204 4973 / 2204 4976 /2204 4977 / 2204 4974

Date: 23rd July, 2025

To,
DEENDAYAL PORT AUTHORITY
PO BOX 50, ADMINISTRATIVE BUILDING GANDHIDHAM, KUTCH GANDHIDHAM ,GUJARAT, 370201
GSTIN: 24AAALK0046N1Z6

Subject- Held Cover Letter for PORT PACKAGE, TERRORISM INSURANCE POLICIES 2025-26

Sir/Madam,

We confirm the receipt of your premium payment of INR 19,07,84,557.23, received via RTGS on July 22, 2025 which includes a premium of INR 18,72,44,557. This payment of INR 18,72,44,557 is for the renewal of your Port Package, Terrorism Insurance policies.

Your risk is now covered for Port Package, Terrorism Insurance, with the sum insured as per Tender No. FA/AC/E-3192 Dated 09.07.2025. This coverage is effective from July 24, 2025, to July 23, 2026.

The official policy documents are currently being prepared and will be issued to you shortly.

Thanking you,

For The New India Assurance Insurance Company Ltd.

Authorized Signatory

दि न्यू इन्डिया एश्योरन्स कं. लि.
(भारत सरकार का उपक्रम)
बृहत कॉर्पोरेट एवं ब्रोकर्स कार्यालय : 920000
न्यू इन्डिया सेंटर, 11वीं मंजिल, 17/ए, कूपरेज रोड,
डॉ. बी.आर. आंबेडकर चौक, मुंबई - 400 001.
फोन : 022-22044973 / 2204 4976 / 2204 4977 / 2204 4974

THE NEW INDIA ASSURANCE CO. LTD.
( A Govt. of India Undertaking)
Large Corporate & Broker's Office : 920000
New India Centre, 11th Floor, 17/A, Cooperage Road,
Dr. B.R. Ambedkar Chowk, Mumbai - 400 001
Phone : 022 - 2204 4973 / 2204 4976 /2204 4977 / 2204 4974

Date: 23rd July, 2025

To,
DEENDAYAL PORT AUTHORITY
PO BOX 50, ADMINISTRATIVE BUILDING GANDHIDHAM, KUTCH GANDHIDHAM, GUJARAT, 370201
GSTIN: 24AAALK0046N1Z6

Subject- Held Cover Letter for MARINE HULL & MACHINERY INSURANCE POLICIES 2025-26

Sir/Madam,

We confirm the receipt of your premium payment of INR 19,07,84,557.23, received via RTGS on July 22, 2025 which includes a premium of INR 35,40,000 for marine H&M Insurance. This premium payment of INR 35,40,000 is for the renewal of your Marine Hull and Machinery Insurance policies.

Your risk is now covered for Marine Hull and Machinery Insurance, with the sum insured as per Tender No. FA/AC/E-3192 Dated 09.07.2025. This coverage is effective from July 24, 2025, to July 23, 2026.

The official policy documents are currently being prepared and will be issued to you shortly.

Thanking you,

For The New India Assurance Insurance Company Ltd.

Authorized Signatory

# Annexure–D

# दीनदयाल पत्तन प्राधिकरण

(आईएसओ 9001:2008 एवं आईएसओ 14001:2004 प्रमाणित पोर्ट)

**DEENDAYAL PORT AUTHORITY**

(AN ISO 9001:2008 & ISO 14001:2004 CERTIFIED PORT)

यातायात प्रबंधक का कार्यालय, दीनदयाल पत्तन प्राधिकरण,श्रमदीप बिल्डिंग, नया कंडला (कच्छ) 370210

*E-mail : traffiemanager@deendayalport.gov.in*

KANDLA SAGARMALA


**No.**TF/SII/GPCB/2019-N/ ५३५

**Date :** 07/05/2025.

## CIRCULAR

Please refer earlier circulars and SOP issued by DPA to control the pollution inside the port area. During the recent inspection, the team of the Gujarat Pollution Control Board (GPCB) has observed the pollution/a huge quantity of dust at Cargo Jetties due to inappropriate handling of bulk cargo. They have taken it seriously and advised to take appropriate measures to control the dust pollution and submit the compliance report.

In view of above, it is once again directed to follow the directions issued under the above referred Circular/SOP strictly, failing which strict actions will be initiated including imposing penalty against the concerned.

**Traffic Manager**
**Deendayal Port Authority**

**All Port Users and Trade Associations**

Copy to :

1. C.E. ...for kind information please
2. Environment Management Cell....for information & necessary action
3. A.T.M. (Operation) & A.T.M. (R/P)...for information & necessary action

# Annexure–E

# *Inception Report*

# *On*

## Greenbelt Development in Deendayal Port Authority (DPA) and its surrounding areas (Phase-III) along with two years maintenance

***Submitted to***

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

***Prepared by***


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

*Inception Report*

on

# Greenbelt Development in Deendayal Port Authority (DPA) and its surrounding areas (Phase-III) along with two years maintenance


**Co-ordinator**
Dr. V. Vijay Kumar, *Director*

**Principal Investigator**
Dr. Jayesh B. Bhatt, *Scientist*

**Co-Principal Investigator**
Mr. Bhagirath Paradva, *Project Fellow*
Mr. Rakesh Popatani, *Project Fellow*

**Team Member**
Mr. Vivek Chauhan, *Junior Research Fellow*


***Submitted by***


**Gujarat Institute of Desert Ecology**
**Opp. Changleshwer Temple, Mundra Road**
**Bhuj-370 001, Kachchh, Gujarat**
**www.gujaratdesertecology.com**

# Content

## Introduction

A greenbelt is a designated area of undeveloped, wild, or agricultural land surrounding urban areas, intended to limit urban sprawl, protect natural environments, improve air quality, and promote biodiversity. Greenbelt development involves creating and maintaining these areas, often through strategic planting of trees, shrubs, or other vegetation to form natural barriers between urban and rural landscapes.

Thus, greenbelt offers a number of benefits for population. Vegetation absorbs various pollutants from the environment and thus help in effective pollution control. However, economic development like industrialization, mining, infrastructural development, etc. have exerted pressure and led to reduction and fragmentation of natural vegetation cover day-by day across the globe. Industrial and infra-structural developmental activities are likely to pollute the environment with varying magnitudes. Nevertheless, the pre-eminence of resistance of each of the organisms helps themselves to overcome the hazards caused by such pollutants.

Therefore, the general concept of greenbelt has evolved to develop vegetation or green spaces alongside of industries, mines, thermal power stations, roadsides, and other developmental unit is an effective measure to rejuvenate the environment through vital vegetation cover that safeguard the health of human and other living organisms. Greenbelts in and around urban and industrial areas are important to the ecological health of any given region.

## Rationale

GUIDE team visited the proposed Greenbelt development site at Kandla port with the officials from Kandla Port as part of site selection. Based on the field observation and its landscape, environment and ecology of the area, suitable plant species were identified to improve the local environment and for the Greenbelt development at the port area.

## Project Site

Based on observation made by the GUIDE team and officials from Deendayal Port Authority, a site at Road Over Bridge (RoB) to oil jetty road and Gopalpuri The area proposed for green development of Deendayal Port is barren land without any vegetation. The soil of the area is black muddy and is high saline soil with saline ground water. The area is very dry and hot during the summer.

## Scope of Work

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

1. Inventories the suitable sites for greenbelt development in and around the Deendayal Port at Kandla.
2. Carryout Soil and Moisture Conservation (SMC) and management of the plantation sites.
3. Identify suitable plant species as per site scenario for the greenbelt plantation and plantation of plant saplings (5000 plants-suitable to the area & 200 plants at Gopalpuri-fruit bearing/medicinal/air purifying) including maintenance of the same for 1st year, along with maintenance, management and monitoring of plantation including drip/tanker water supply for a further period of 2 years.
4. Adopting plantation technique and soil/manure amendments.
5. Regular monitoring (survival and growth) of the plantation.

## Approach and Methodology for Greenbelt Development

Following steps have been adopted for greenbelt development:

1. **Planning Phase**:

- Involves site selection, environmental assessments, and choosing appropriate plant species based on local ecosystems.
- DPA officials and environmental experts collaborate to design sustainable spaces that support biodiversity and recreation.
- Selecting native trees/suitable to the condition and local environment to ensure ecological compatibility and resilience.

2. **Implementation Phase**:

- Includes land preparation (clearing and levelling), planting trees and shrubs, and constructing pathways or recreational facilities.
- Sustainable practices are prioritized to minimize environmental disruption.

**3. Maintenance Phase**:

- Focuses on long-term care such as watering, pruning, pest control, and replanting.
- Regular monitoring ensures the health of vegetation and ecosystems.
- Community involvement and education are key to sustaining the greenbelt

## **Plantation techniques**:

- Site development for a plantation includes clearance for weeds and it involves, bush cutting, soil and moisture conservation works and marking of pits for planting of saplings, etc.
- After clearing the land sites for pits, plantation have been marked on ground using a measuring tape to ensure the desired spacing.
- Pits of the size 45 cm x 45 cm and 45 cm depth have been dug for tree plantation. Pits have been deep enough to ensure that the roots of the plants do not curl up once the planting material is placed in it.
- Since the soil is highly saline, a fertile soil around 06 dumpers have been added for better survival.
- Charcoal have been added for better moisture conservation and survival.
- The pit has been filled a little above the ground level so that after the earth settles the upper surface of the pit is at same level as that of ground thus avoiding any water logging.
- The plantation has been carried out in two phases (1$^{st}$ in Gopalpuri-200 plants & 2$^{nd}$ Road Over Bridge (RoB)-Oil jetty road side-5000 plants)

**Selection of Plant Species for Plantation**: Various indigenous tree species suitable for the area have been identified and selected for plantation areas based on soil quality, available water facility, and other environmental parameters.

**Management and Monitoring of Greenbelt**: The plantation within the identified site will be managed and monitored for a minimum period of two years after the plantation. The management of plantation includes watering at regular intervals, during summer and winter periods and if required even during monsoon with dry spells.


**Fig. Map of Plantation Area at Gopalpuri**

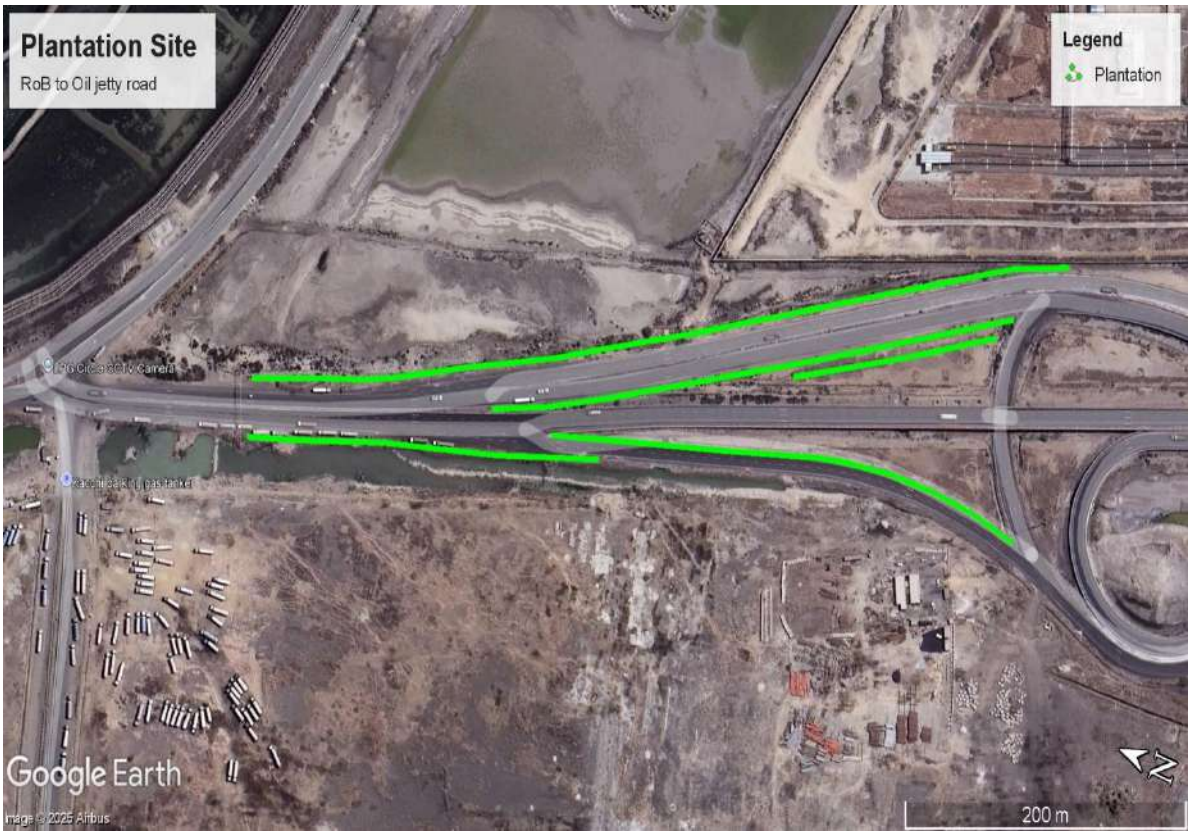



**Fig. Map of Plantation Area RoB to Oil Jetty Road**

**Fig. Digging Out Trench for Plantation**

**Fig. Transportation of Plants to Site**

**Fig. Fertile Soil for Better Survival of Plants**

**Fig. Fertile Soil Filling to the pits**

**Fig. Addition of Charcoal for moisture conservation**


**Fig. Regular Watering of the Plants by Tanker**

## Annexure I
**List of Plants for Plantation at site for Greenbelt Development**
**Site: Gopalpuri**

| Sr. No | Scientific name | Local name | No. of plants |
|---|---|---|---|
| **Fruit Plants** | | | |
| 1 | *Achras sapotta* | Chiku | 3 |
| 2 | *Citrus limonum* | Limbu | 3 |
| 3 | *Citrus medica* | Bijora | 3 |
| 4 | *Cocos nucifera* | Nariyel | 3 |
| 5 | *Eugenia jambolana* | Jambu | 3 |
| 6 | *Ficus carica* | Anjir | 3 |
| 7 | *Morus indica* | Shetur | 5 |
| 8 | *Phyllanthus emblica* | Amla | 3 |
| 9 | *Psidium guajava* | Jamfal | 3 |
| 10 | *Punica granatum* | Dadam | 3 |
| 11 | *Terminalia catappa* | Badam | 5 |
| 12 | *Pithecellobium dulce* | Gorsamli | 3 |
| 13 | *Tamarindus indica* | Khatiamli | 5 |
| 14 | *Carissa carandas* | Karmda | 5 |
| 15 | *Moringa oleifera* | Mitho sargavo | 5 |
| 16 | *Limonia acidissima* | Kothi | 3 |
| **Medicinal Plant** | | | |
| 17 | *Murraya koenigii* | Mitho limdo | 5 |
| 18 | *Plumbago zeylanica* | Chitrak | 5 |
| 19 | *Vitex negundo* | Nagod | 8 |
| 20 | *Nyctanthes arbor-tristis* | Parijat | 8 |
| 21 | *Justicia adhatoda* | Ardusi | 5 |
| 22 | *Butea monosperma* | Khakharo | 5 |
| 23 | *Hibiscus rosa-sinensis* | Jasud | 5 |
| 24 | *Bauhinia variegata* | Kanchnar | 5 |
| 25 | *Terminalia arjuna* | Arjun | 5 |
| 26 | *Azadirachta indica* | Limdo | 5 |
| 27 | *Ficus racemosa* | Umaro | 5 |
| 28 | *Aegle marmelos* | Bili | 5 |
| **Air purifying plant** | | | |
| 29 | *Cestrum diurnum* | Divsno raja | 5 |
| 30 | *Nerium odorum* | Karen | 8 |
| 31 | *Plumeria rubra* | Khadchampo | 8 |
| 32 | *Thespesia lampas* | Parspipalo | 8 |
| 33 | *Alstonia scholaris* | Saptaparni | 8 |
| 34 | *Plumeria rubra* | Kadam | 5 |

| Sr. No | Scientific name | Local name | No. of plants |
|---|---|---|---|
| 35 | *Ficus elastica* | Rabarplant | 3 |
| 36 | *Livistona chinensis* | Fenpalm | 3 |
| 37 | *Polyalthia longifolia* | Asopalav | 8 |
| 38 | *Roystonea regia* | Roayalpalm | 2 |
| 39 | *Pongamia glabra* | Karanj | 8 |
| 40 | *Delonix regia* | Gulmhor | 5 |
| 41 | *Ficus benjamina* | Ficus | 5 |

**Site: RoB to Oil Jetty Road**

| Sr. No. | Scientific Name | Local Name | No. of plants |
|---|---|---|---|
| 1 | *Conocarpus lancifolius* | *Conocarpus* | 1700 |
| 2 | *Peltophorum pterocarpum* | Peltophorum | 660 |
| 3 | *Millettia pinnata* | Karanj | 660 |
| 4 | *Delonix regia* | Gulmahor | 660 |
| 5 | *Tabubia rosea* | Tabubia | 660 |
| 6 | *Senna siamea* | *Kasid* | 660 |

# Annexure–F

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

**(Monitoring Period: August - September 2025)**

**Document Ref No.: GEMI/DPA/782(2)(6)/2025/50**

**Submitted to:**

**Deendayal Port Authority (DPA), Kandla**


## Gujarat Environment Management Institute (GEMI)

**(An Autonomous Institute of Government of Gujarat)**

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

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

# Certificate

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

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

S. S. O. & Lab Head

**Authorized Signatory**

# About this Document

Gujarat Environment Management Institute (GEMI) has been assigned with the work of "Preparing and monitoring of Environmental monitoring and Management plan for Deendayal Port Authority (DPA) at Kandla and Vadinar for a period of 3 years" by DPA, Kandla. Under the said project the report titled *"Environment Monitoring Report (August – September 2025)"* is prepared.

- **Name of the Report:** *Environment Monitoring Report (August-September 2025)*
- **Date of Issue:** 12/11/2025
- **Version:** 1.0
- **Report Ref.:** GEMI/DPA/782(2)(6)/2025/50

## Table of Contents

## List of Tables

# List of Maps



# List of Figures



# List of Graphs

# List of Abbreviations

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

# CHAPTER 1: INTRODUCTION

## 1.1 Introduction

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

## 1.2 Green Ports Initiative

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

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

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

## 1.3 Importance of EMP

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

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

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 16th August -15th September 2025.

## 1.4 Objectives and scope of the Study

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

The scope of work includes not limited to following:

1. To review the locations/stations of Ambient Air, Ambient Noise, drinking water, and Marine Water, Soil and Sediments monitoring within the impacted region in-and-around DPA establishment, in view of the developmental projects.
2. To assess the Ambient Air quality, quality at 6 stations at Kandla and 2 at Vadinar in terms of gases and particulate matter.
3. To assess the DG stack emissions (gases and particulate matter).
4. To assess Drinking water quality at twenty locations (18 at Kandla and 2 at Vadinar) in terms of Physical, Chemical and Biological parameters viz., Color, Odor, turbidity, conductivity, pH, Total Dissolved Solids, chlorides, Hardness, total iron, sulfate, $NH_4$, $PO_4$, and bacterial count on a monthly basis.
5. To assess the Marine water quality in terms of aquatic Flora and Fauna and Sediment quality in terms of benthic flora and fauna.
6. To assess Marine Water Quality and sediment in term of physical and chemical parameter.
7. To assess the trends of water quality in terms of Marine ecology by comparing the data collected over a specified time period.
8. Weekly sample collection and analysis of inlet & Outlet points of the Sewage Treatment Plant (STP) to check the water quality being discharged by DPA as per the CC&A.
9. Carrying out monthly Noise monitoring; twice a day at the representative stations for a period of 24 hours.
10. Meteorological parameters are very important from air pollution point of view; hence precise and continuous data collection is of utmost importance. Meteorological data on wind speed, wind direction, temperature, relative humidity, solar radiation and

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

11. To suggest mitigation measures, based on the findings of this study and also check compliance with Environmental quality standards, Green Port Initiatives, MIV 2030, and any applicable Statutory Compliance.
12. To recommend Environment Management Plans based on Monitoring programme and findings of the study.

# CHAPTER 2: METHODOLOGY

## 2.1 Study Area

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

### a. Kandla

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

- **Climatic conditions of Kandla**

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

### b. Vadinar

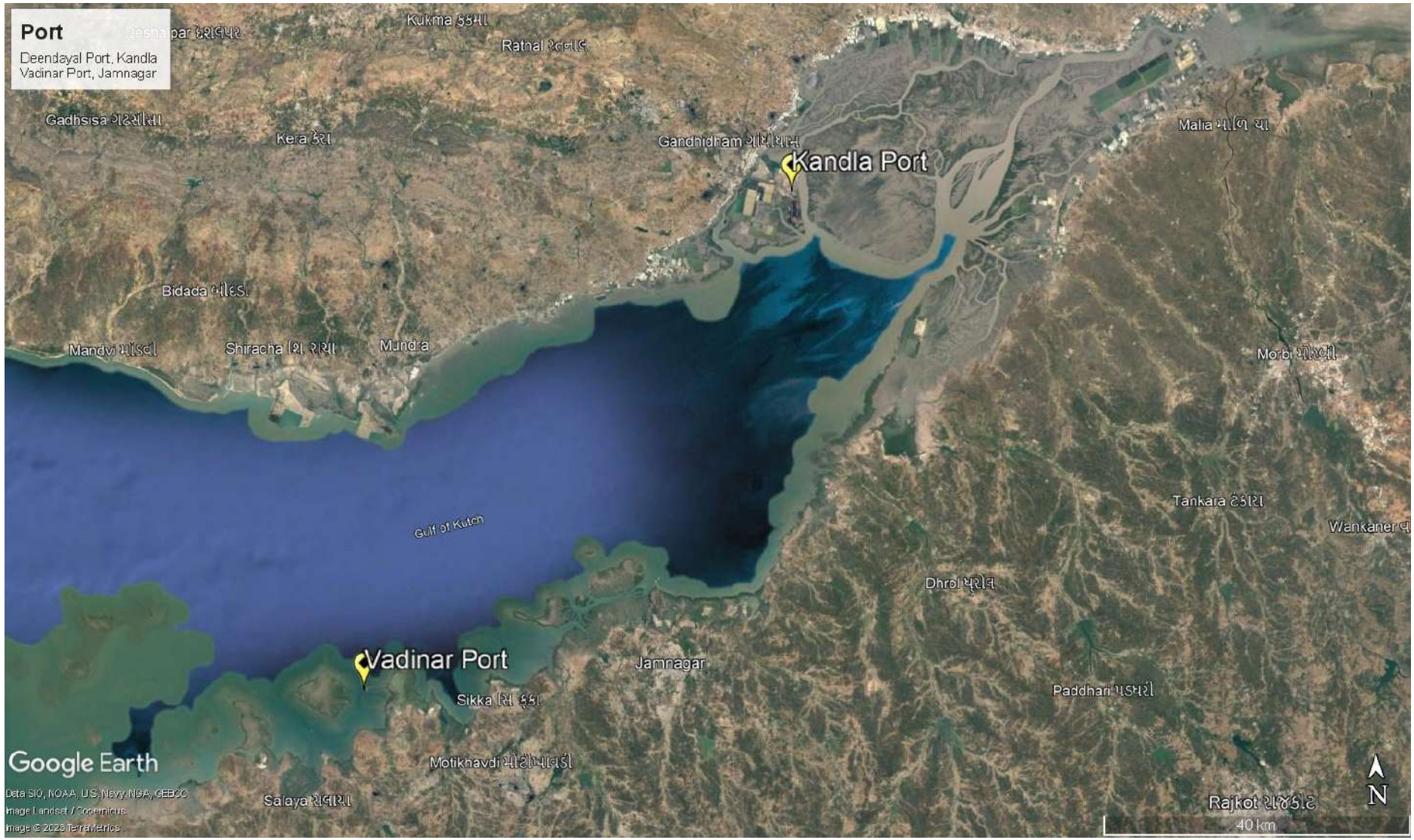
**Vadinar** is a small coastal town located in Devbhumi Dwarka district of the Gujarat state in India located at coordinates 22° 27' 16.20" N - 069° 40' 30.01". DPA had commissioned the Off Shore Oil Terminal (OOT) facilities at Vadinar in the year 1978, for which M/s. Indian Oil Corporation Limited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

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

- **Climatic conditions of Vadinar**

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

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




**Map 1: Locations of Kandla and Vadinar Port**


**Map 2: Locations of Kandla Port**


**Map 3: Locations of Vadinar Port**

## 2.2 Environmental Monitoring at Kandla and Vadinar

Regular monitoring of environmental parameters is of immense importance to assess the status of environment during project operation. With the knowledge of baseline conditions, the monitoring programme will serve as an indicator for identifying any deterioration in environmental conditions, thereby assist in recommending suitable mitigatory steps in time to safeguard the environment. Monitoring is as important as that of control of pollution since the efficiency of control measures can only be determined by a well-defined monitoring program. Environmental Monitoring is vital for monitoring the environmental status of the port for sustainable development. The list of main elements for which Environmental monitoring is to be carried out have been mentioned below:

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

GEMI has been entrusted by DPA to carry out the monitoring of the various aforementioned environmental aspects at the port, so as to verify effectiveness of prevailing Environment Management plan, if it confirms to the statutory and/or legal compliance; and identify any unexpected changes. Standard methods and procedures have been strictly adhered to in the course of this study. QA/QC procedures were strictly followed which covers all aspects of the study, and includes sample collection, handling, laboratory analyses, data coding, statistical analyses, interpretation and communication of results. The analysis was carried out in GEMI's NABL/MoEF accredited/recognized laboratory.

**Methodology adopted for the study**

Methodology is a strictly defined combination of practices, methods and processes to plan, develop and control a project along the continuous process of its implementation and successful completion. The aim of the project management methodology is to allow the control of whole process of management through effective decision-making and problem solving. The methodology adopted for the present study is shown in **Figure 1** as given below:

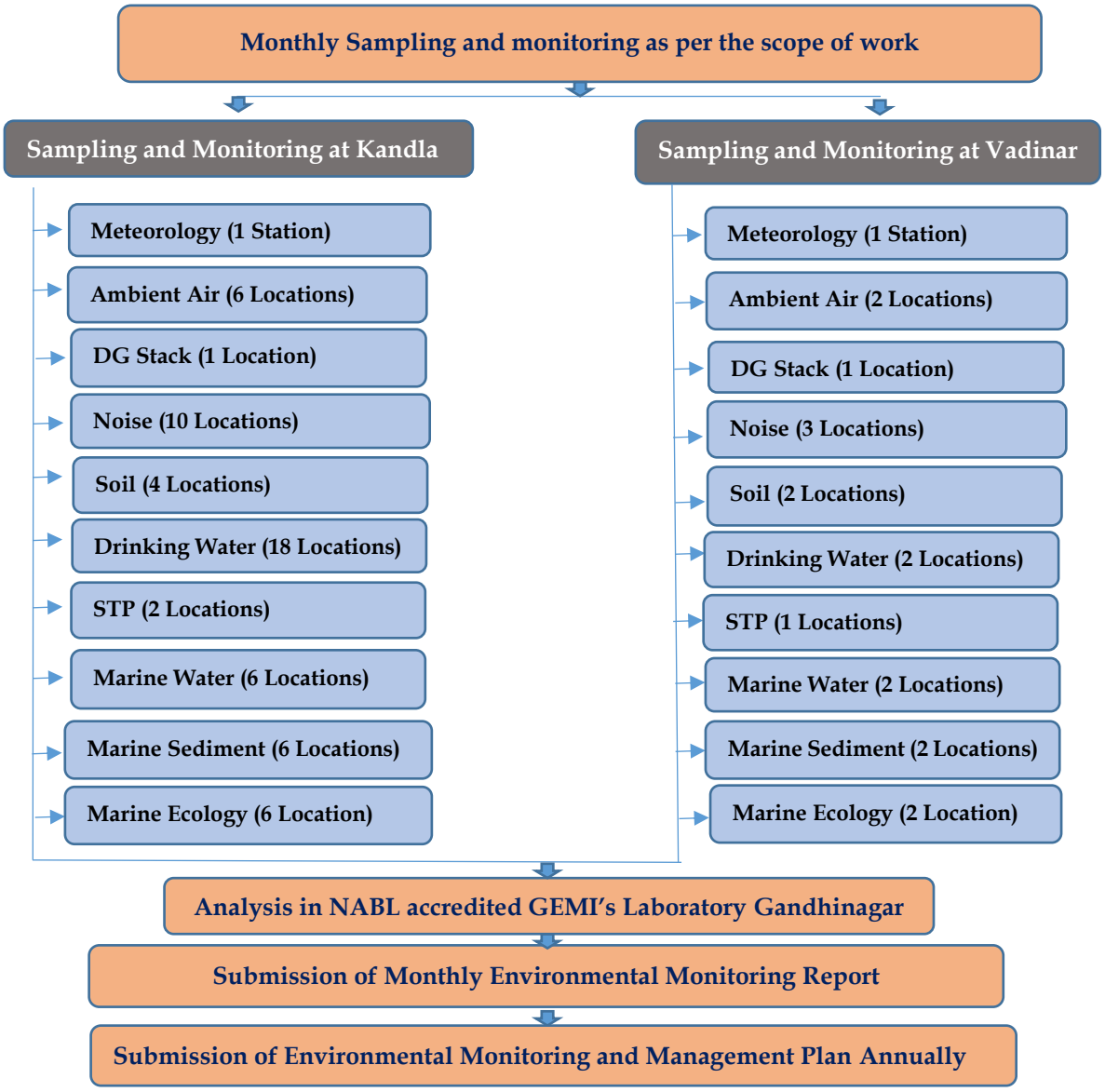



**Figure 1: Methodology flow chart**

The details of various sectors of Environment monitoring are described in subsequent chapters.

# CHAPTER 3: METEOROLOGY MONITORING

## 3.1 Meteorology Monitoring

Meteorological conditions play a crucial role in dispersion of air pollutants as well as in environmental pollution studies particularly in pollutant transport irrespective of their entry into the environment. The wind speed and direction play a major role in dispersion of environment pollutants. In order to determine the prevailing micro-meteorological conditions at the project site an Automatic Weather Monitoring Stations (AWS) of Envirotech make (Model: WM280) were installed at both the sites of Kandla and Vadinar at 10 m above the ground. The details of the AWS installed have been mentioned in **Table 1** as follows:

**Table 1: Details of Automatic Weather Station**

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

**Methodology**

During the study, a continuous automatic weather monitoring station was installed at both the sites to record climatological parameters such as Wind speed, Wind Direction, Relative Humidity, Solar Radiation, Rainfall and Temperature to establish general meteorological regime of the study area. The methodology adopted for monitoring meteorological data shall be as per the standard norms laid down by Bureau of Indian Standards (BIS) and the India Meteorological Department (IMD). The details of Automatic Weather Monitoring Station have been mentioned in **Table 2**.

**Table 2: Automatic Weather Monitoring Station details**

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

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



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

## 3.2 Results and discussion

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

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

| Details of Micro-meteorological data at Kandla Observatory | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Monitoring Period** | **Wind Speed (Km/h)** | | | **Temperature (°C)** | | | **Relative humidity (%)** | | | **Solar Radiation (W/m²)** | **Wind Direction (°)** | **Rainfall (mm)** |
| **Stat.** | **Mean** | **Max.** | **Min** | **Mean** | **Max** | **Min** | **Mean** | **Max** | **Min** | | | |
| **August-September 2025** | 4.35 | 64 | 0.6 | 30.21 | 37.9 | 24.7 | 74.56 | 90.4 | 49.8 | 66.17 | North | 0.33 |
| **Details of Micro-meteorological data at Vadinar Observatory** | | | | | | | | | | | | |
| **Monitoring Period** | **Wind Speed (Km/h)** | | | **Temperature (°C)** | | | **Relative humidity (%)** | | | **Solar Radiation (W/m²)** | **Wind Direction (°)** | **Rainfall (mm)** |
| **Stat.** | **Mean** | **Max.** | **Min** | **Mean** | **Max** | **Min** | **Mean** | **Max.** | **Min** | | | |
| **August-September 2025** | 3.62 | 28 | 0.6 | 27 | 36.3 | 22.2 | 79.72 | 91.5 | 56.8 | 67.58 | SSW | 0.16 |

## 3.3 Data Interpretation and Conclusion

- **Temperature**

a. **Kandla:** The ambient temperature for the monitoring period varies between the range of 24.7– 37.9°C for Kandla, with average temperature of 30.21°C.
b. **Vadinar:** The ambient temperature for the monitoring period varies between the range of 22.2-36.3°C for Vadinar, with average temperature of 27°C.

- **Relative Humidity**

a. **Kandla**: The Relative Humidity recorded between the range of 49.8–90.4, with average Humidity of 74.56%.
b. **Vadinar:** During the study period, the Relative Humidity varies between 56.8-91.5%, with average Humidity of 79.72%.

- **Rainfall**

a. **Kandla:** 0.33 mm/hr rainfall was observed at Kandla.
b. **Vadinar:** 0.16 mm/hr rainfall was observed at Vadinar.

- **Wind Speed**

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

a. **Kandla:** Wind speed recorded ranges between 0.6–64 Km/hr.
b. **Vadinar:** During the monitoring period, the Wind speed recorded ranges between 0.6-28 Km/hr.

- **Solar Radiation:**

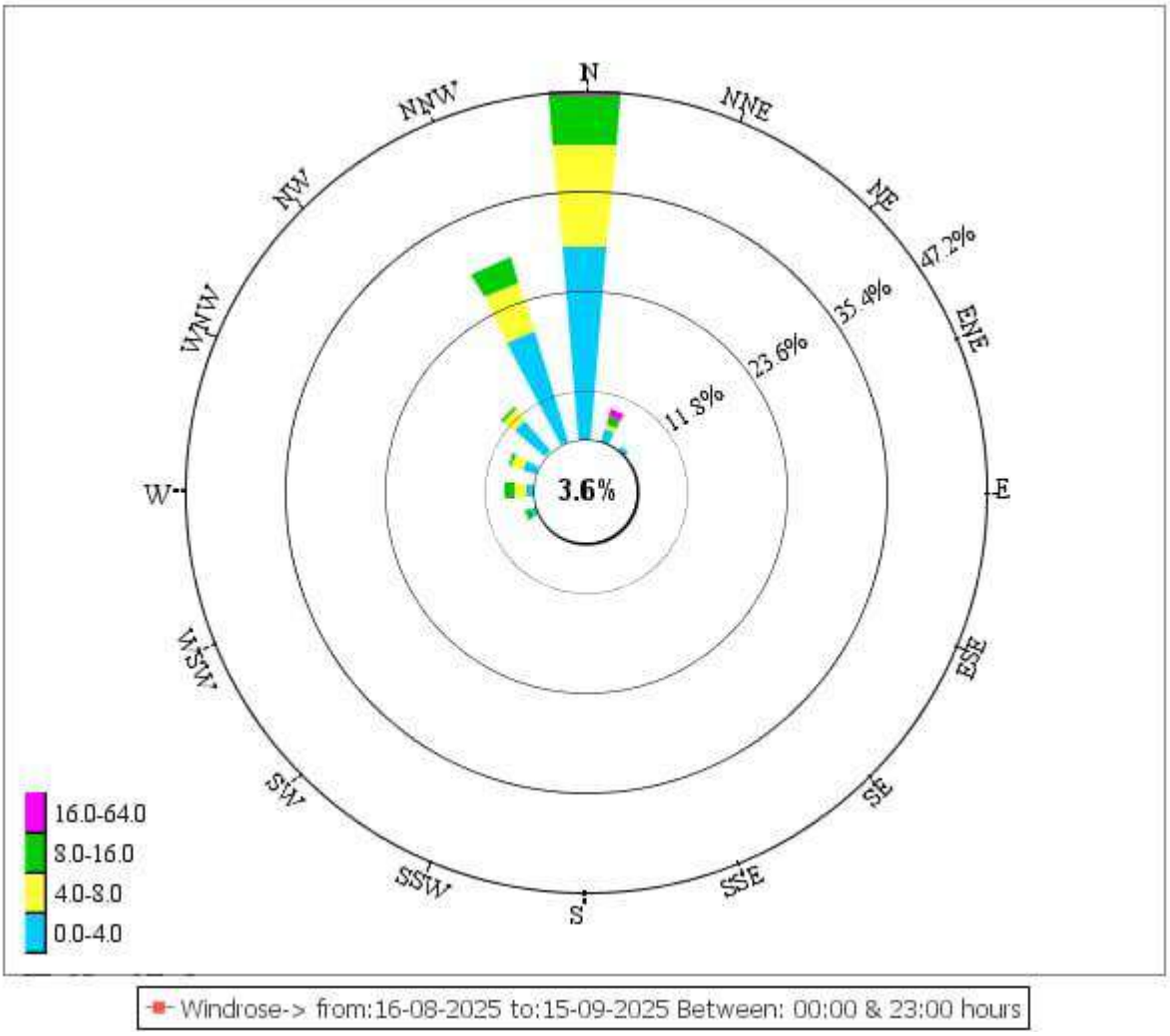
a. **Kandla:** The average Solar Radiation for the monitoring period was recorded as 66.17 W/m$^2$.
b. **Vadinar:** The average Solar Radiation was recorded as 67.58 W/m$^2$.

- **Wind rose diagram -**

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

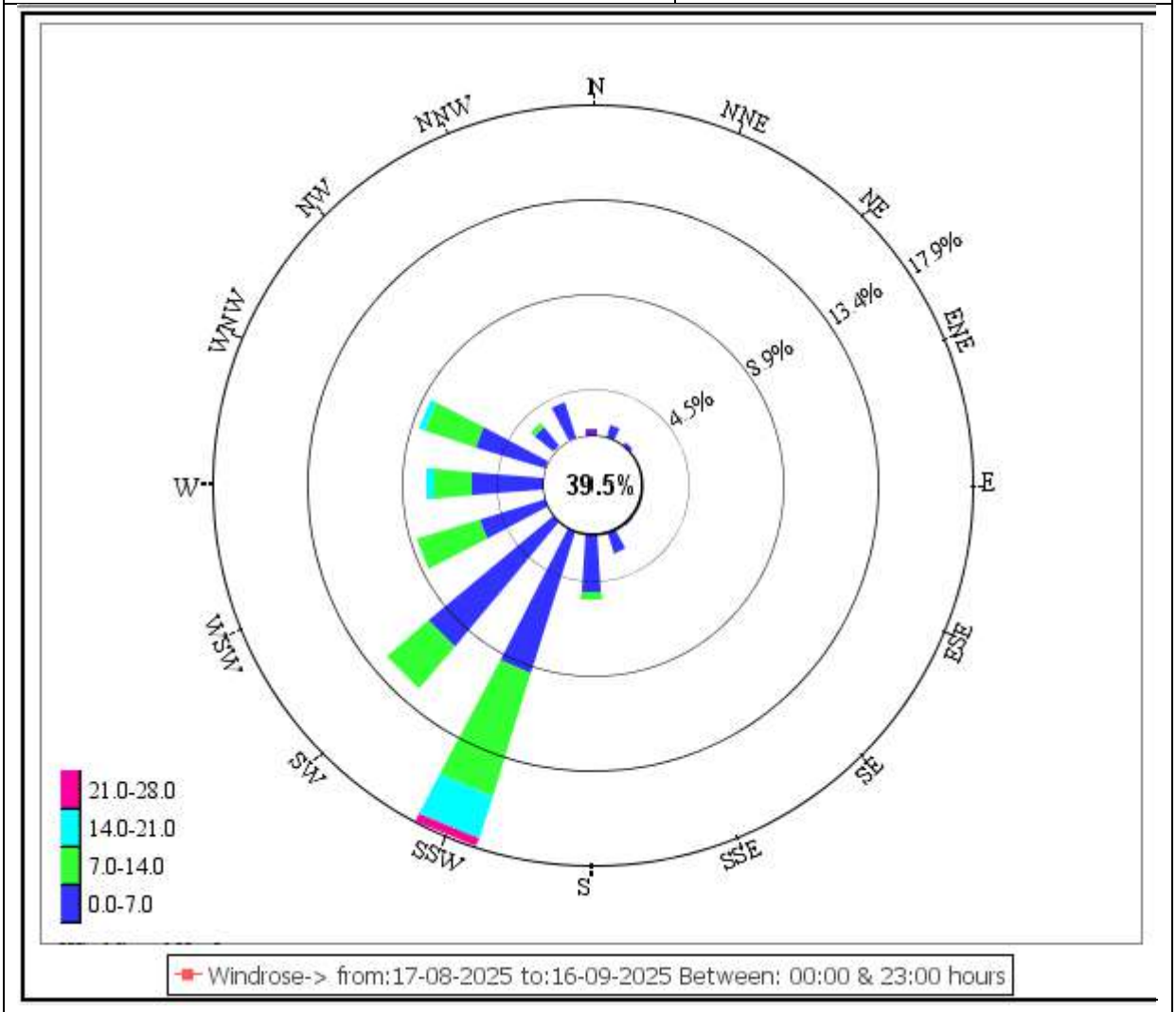
This Wind Rose Diagram reveals that at Kandla and Vadinar, during the monitoring period, the prevailing winds predominantly blow from the North at Kandla. At Vadinar, the winds were observed to blow from South South West Direction.

| Wind Rose Plot<br>M/s Deendayal Port Authority<br>Site: Kandla Port (Environment Laboratory) | Display: Wind Direction<br>Wind Speed (Km/hr) |
|---|---|




Modeler: Envirotech Instruments Pvt. Ltd. Delhi.

| | |
|---|---|
| **Wind Rose Plot**<br>**M/s Deendayal Port Authority**<br>**Site: Vadinar Port (Canteen Area)** | **Display: Wind Direction**<br>**Wind Speed (Km/hr)** |




Modeler: Envirotech Instruments Pvt. Ltd. Delhi.

# CHAPTER 4: AMBIENT AIR QUALITY MONITORING

## 4.1 Ambient Air Quality

It is necessary to monitor the ambient air quality of the study area, in order to determine the impact of the shipping activities and port operations on the ambient air quality. The prime objective of ambient air quality monitoring is to assess the present air quality and its conformity to National Ambient Air Quality Standards i.e. NAAQS, 2009. Ambient air quality has been monitored from 16th August to 15th September 2025.

**Methodology**

The study area represents the area occupied by DPA and its associated Port area. The sources of air pollution in the region are mainly vehicular traffic, fuel burning, loading & unloading of dry cargo, fugitive emissions from storage area and dust arising from unpaved village roads. Considering the below factors, under the study, as per the scope specified by DPA eight locations wherein, 6 stations at Kandla and 2 at Vadinar have been finalized within the study area

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

The description of various air quality stations monitored at Kandla and Vadinar have been specified in **Table 4**.

**Table 4: Details of Ambient Air monitoring locations**

| Sr. No. | Location Code | | Location Name | Latitude Longitude | Significance |
|---|---|---|---|---|---|
| 1. | Kandla | A-1 | Oil Jetty No. 1 | 23.029361N 70.22003E | Liquid containers and emission from ship |
| 2. | | A-2 | Oil Jetty No. 7 | 23.043538N 70.218617E | |
| 3. | | A-3 | Bansal Canteen | 23.027197N 70.195451E | Vehicular activity and dust emission |
| 4. | | A-4 | Sewa Sadan-3 | 23.009945N 70.221745 E | 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 two ambient air monitoring locations have been changed: Location A-3, previously at Kandla Port Colony, has now been shifted to Bansal Canteen, and Location A-4, earlier at Marine Bhavan, is now relocated to Sew Sadan-3. 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

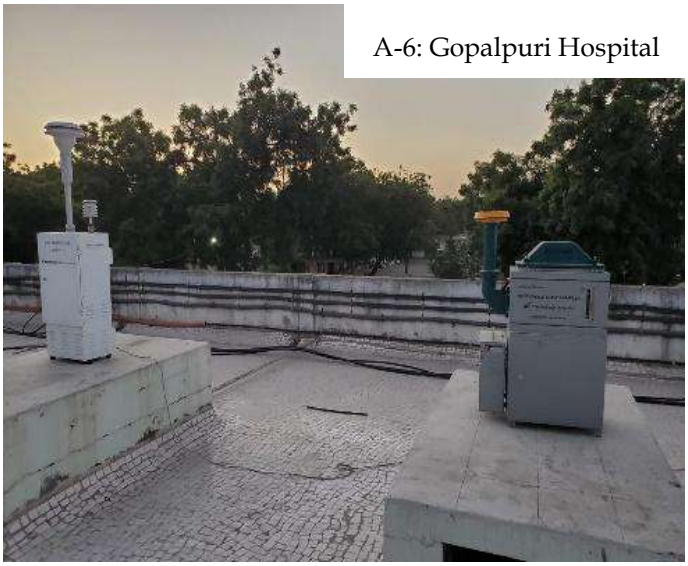
A-2: Oil Jetty No. 7

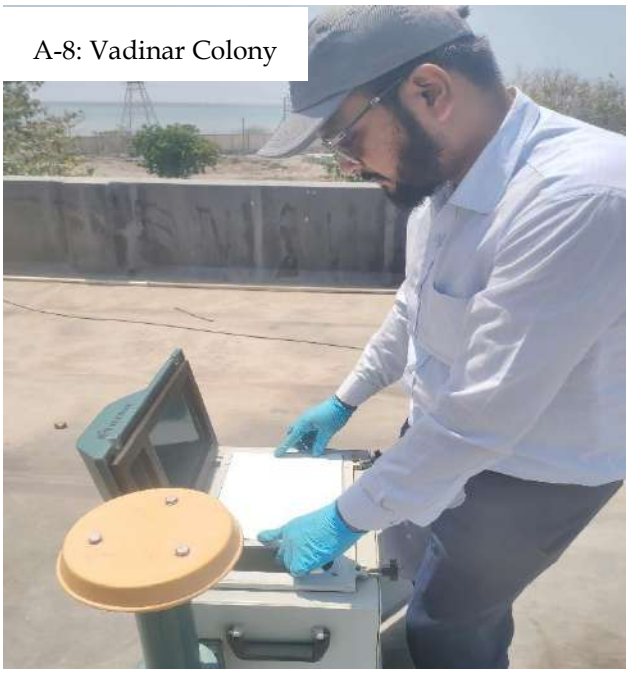
A-3: Bansal Canteen

A-4: Sewa Sadan-3

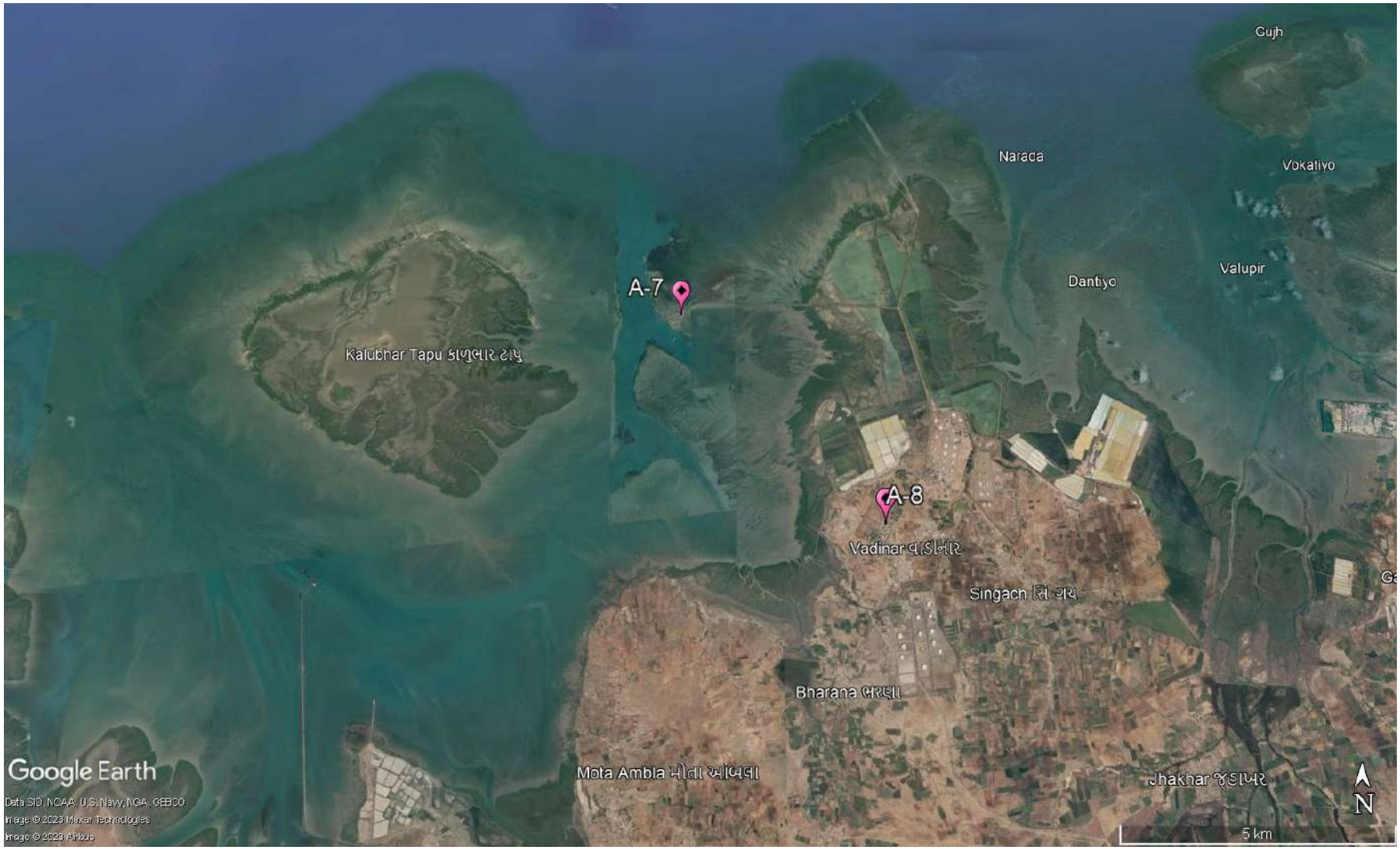
A-5: Coal Storage Area

A-6: Gopalpuri Hospital



| Vadinar | |
|---|---|
| A-7: Admin Building  | A-8: Vadinar Colony  |


**Map 4: Locations for Ambient Air Monitoring at Kandla**




**Map 5: Locations for Ambient Air Monitoring at Vadinar**

**Frequency**

The sampling for Particulate matter i.e. $PM_{10}$ and $PM_{2.5}$ and the gaseous components like $SO_x$, $NO_x$, CO as well as the Total VOCs were monitored twice in a week for a period of 24 hours a day. Whereas, the sampling for the components of PAH, Benzene and non-Methane VOCs was conducted on monthly basis.

**Sampling and Analysis**

The Sampling of the Ambient Air Quality parameters and analysis is conducted as per the CPCB guidelines of National Ambient Air Quality Monitoring. The sampling was performed at a height of 3.5 m (approximately) from the ground level. For the sampling of $PM_{10}$, calibrated 'Respirable Dust Samplers' were used, where Whatman GF/A microfiber filter paper of size 8"x 10" were utilized, where the Gaseous attachment of the make Envirotech instrument was attached with Respirable Dust Sampler for the measurement of $SO_x$ and $NO_x$. The Fine Particulate Sampler for collection of $PM_{2.5}$ was utilized for the particulate matter of size <2.5 microns. A known volume of ambient air is passed through the cyclone to the initially pre-processed filter paper. The centrifugal force in cyclone acts on particulate matter to separate them into two parts and collected as following:

- Particles <10 µ size (Respirable): GF/A Filter Paper
- Particles <2.5 µ size (Respirable): Polytetrafluoroethylene (PTFE)

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

Data has been compiled for $PM_{10}$, $PM_{2.5}$, $SO_x$ and $NO_x$ samples of 24-hour carried out twice a week. In case of CO, one hourly sample were taken on selected monitoring days using the sensor-based CO Meter. For the parameters Benzene, Methane & Non-methane and Volatile Organic Carbons (VOCs), the Low Volume Sampler is used, where the charcoal tubes are used as sampling media. The sampling in the Low Volume Sampler (LVS) is carried out as per IS 5182 (Part 11): 2006 RA: 2017, where the ambient air flow rate is maintained at 200 cc/min, the volume of air that passes through the LVS during two hours monitoring is approx. 24 L.

The sampling of PAHs is carried out as per IS: 5182 (Part 12): 2004. Where, the EPM 2000 Filter papers are utilized in the Respirable Dust Sampler (RDS). For the parameters, Benzene, PAH & Non-methane VOC's, monthly monitoring is carried out. The details of the parameters with their frequency monitored are mentioned in **Table 5:**

**Table 5: Parameters for Ambient Air Quality Monitoring**

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

## 4.2 Result and Discussion

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

**Table 6: Summarized results of $PM_{10}$, $PM_{2.5}$, $SO_2$, $NO_x$, VOC and CO for Ambient Air quality monitoring**

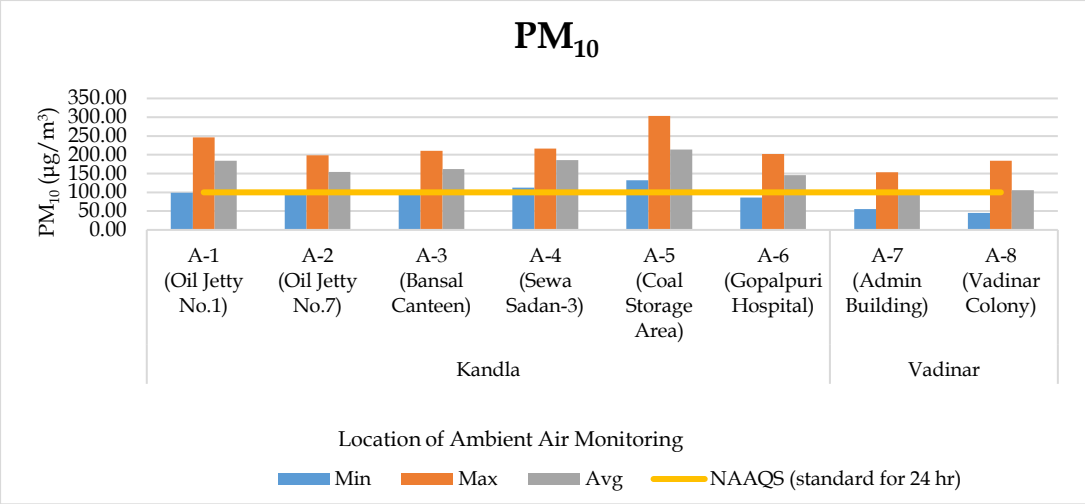
| Station Code & Name | Unit of Average Concentration | Average Pollutant Concentration | | | | | |
|---|---|---|---|---|---|---|---|
| | **Pollutants** | **$PM_{10}$ (µg/m³)** | **$PM_{2.5}$ (µg/m³)** | **$SO_2$ (µg/m³)** | **$NO_X$ (µg/m³)** | **VOC (µg/m³)** | **CO (mg/m³)** |
| | **Duration** | **(24 hr)** | | | | **(2 hr)** | **(1 hr)** |
| | **NAAQS by CPCB** / **Monitoring days** | **100** | **60** | **80** | **80** | **-** | **2** |
| **A-1:** Oil Jetty No.1, | 18-08-2025 | 156.24 | 31.25 | 8.36 | 12.21 | 0.12 | 0.81 |
| | 20-08-2025 | 166.33 | 33.27 | 9.65 | <6 | 0.08 | 0.79 |
| | 25-08-2025 | 200.15 | 40.03 | 15.62 | 11.23 | 0.19 | 0.85 |
| | 28-08-2025 | 194.26 | 38.85 | 22.11 | <6 | 0.21 | 0.81 |

| Station Code & Name | Unit of Average Concentration | Average Pollutant Concentration | | | | | |
|---|---|---|---|---|---|---|---|
| | Pollutants | $PM_{10}$ (µg/m³) | $PM_{2.5}$ (µg/m³) | $SO_2$ (µg/m³) | $NO_X$ (µg/m³) | VOC (µg/m³) | CO (mg/m³) |
| | Duration | (24 hr) | | | | (2 hr) | (1 hr) |
| | NAAQS by CPCB / Monitoring days | 100 | 60 | 80 | 80 | - | 2 |
| Kandla | 01-09-2025 | 99.12 | 19.82 | 26.54 | 13.24 | 0.13 | 0.82 |
| | 02-09-2025 | 246.58 | 49.32 | 6.21 | 22.05 | 0.16 | 0.86 |
| | 08-09-2025 | 210.21 | 42.04 | 21.36 | <6 | 0.17 | 0.88 |
| | 10-09-2025 | 199.52 | 39.90 | 8.62 | 19.21 | 0.24 | 0.80 |
| | **Minimum** | **99.12** | **19.82** | **6.21** | **11.23** | **0.08** | **0.79** |
| | **Maximum** | **246.58** | **49.32** | **26.54** | **22.05** | **0.24** | **0.88** |
| | **Average** | **184.05** | **36.81** | **14.81** | **15.59** | **0.16** | **0.83** |
| | **Std. Deviation** | **43.91** | **8.78** | **7.70** | **4.76** | **0.05** | **0.03** |
| **A-2:** Oil Jetty No.7, Kandla | 18-08-2025 | 96.24 | 19.25 | 9.46 | 15.43 | 0.13 | 0.84 |
| | 20-08-2025 | 123.52 | 24.70 | 6.12 | 14.11 | 0.16 | 0.82 |
| | 25-08-2025 | 154.21 | 30.84 | 10.46 | 18.32 | 0.17 | 0.80 |
| | 28-08-2025 | 198.25 | 39.65 | <5 | 14.33 | 0.12 | 0.83 |
| | 01-09-2025 | 162.35 | 32.47 | 18.42 | <6 | 0.11 | 0.85 |
| | 02-09-2025 | 184.23 | 36.85 | 13.63 | 9.27 | 0.08 | 0.81 |
| | 08-09-2025 | 164.21 | 32.84 | 19.41 | 12.20 | 0.15 | 0.82 |
| | 10-09-2025 | 152.45 | 30.49 | 7.68 | 18.24 | 0.2 | 0.84 |
| | **Minimum** | **96.24** | **19.25** | **6.12** | **9.27** | **0.08** | **0.80** |
| | **Maximum** | **198.25** | **39.65** | **19.41** | **18.32** | **0.20** | **0.85** |
| | **Average** | **154.43** | **30.89** | **12.17** | **14.56** | **0.14** | **0.83** |
| | **Std. Deviation** | **32.32** | **6.46** | **5.17** | **3.22** | **0.04** | **0.02** |
| **A-3:** Bansal Canteen , Kandla | 18-08-2025 | 165.24 | 33.05 | 15.22 | <6 | 0.22 | 0.79 |
| | 20-08-2025 | 101.25 | 20.25 | 9.45 | 15.23 | 0.23 | 0.82 |
| | 25-08-2025 | 154.65 | 30.93 | 18.43 | 14.28 | 0.08 | 0.83 |
| | 28-08-2025 | 177.20 | 35.44 | 15.46 | <6 | 0.15 | 0.82 |
| | 01-09-2025 | 210.33 | 42.07 | <5 | 16.36 | 0.12 | 0.79 |
| | 02-09-2025 | 138.24 | 27.65 | 14.53 | 17.57 | 0.14 | 0.84 |
| | 08-09-2025 | 145.22 | 29.04 | 7.45 | 13.43 | 0.16 | 0.86 |
| | 10-09-2025 | 205.24 | 41.05 | 16.32 | 12.23 | 0.07 | 0.80 |
| | **Minimum** | **101.25** | **20.25** | **7.45** | **12.23** | **0.07** | **0.79** |
| | **Maximum** | **210.33** | **42.07** | **18.43** | **17.57** | **0.23** | **0.86** |
| | **Average** | **162.17** | **32.43** | **13.84** | **14.85** | **0.15** | **0.82** |
| | **Std. Deviation** | **35.93** | **7.19** | **3.92** | **1.95** | **0.06** | **0.02** |
| **A-4:** Sewa Sadan - 3, Kandla | 18-08-2025 | 188.24 | 37.65 | 6.31 | 6.68 | 0.18 | 0.81 |
| | 20-08-2025 | 200.33 | 40.07 | <5 | <6 | 0.19 | 0.80 |
| | 25-08-2025 | 195.44 | 39.09 | 6.43 | 11.23 | 0.18 | 0.85 |
| | 28-08-2025 | 216.24 | 43.25 | 8.13 | <6 | 0.18 | 0.80 |
| | 01-09-2025 | 164.27 | 32.85 | 10.34 | 14.55 | 0.13 | 0.81 |
| | 02-09-2025 | 206.61 | 41.32 | <5 | <6 | 0.05 | 0.87 |
| | 08-09-2025 | 112.36 | 22.47 | 13.52 | 15.63 | 0.08 | 0.88 |
| | 10-09-2025 | 202.32 | 40.46 | <5 | 17.69 | 0.12 | 0.82 |
| | **Minimum** | **112.36** | **22.47** | **6.31** | **6.68** | **0.05** | **0.78** |
| | **Maximum** | **216.24** | **43.25** | **13.52** | **17.69** | **0.19** | **0.89** |

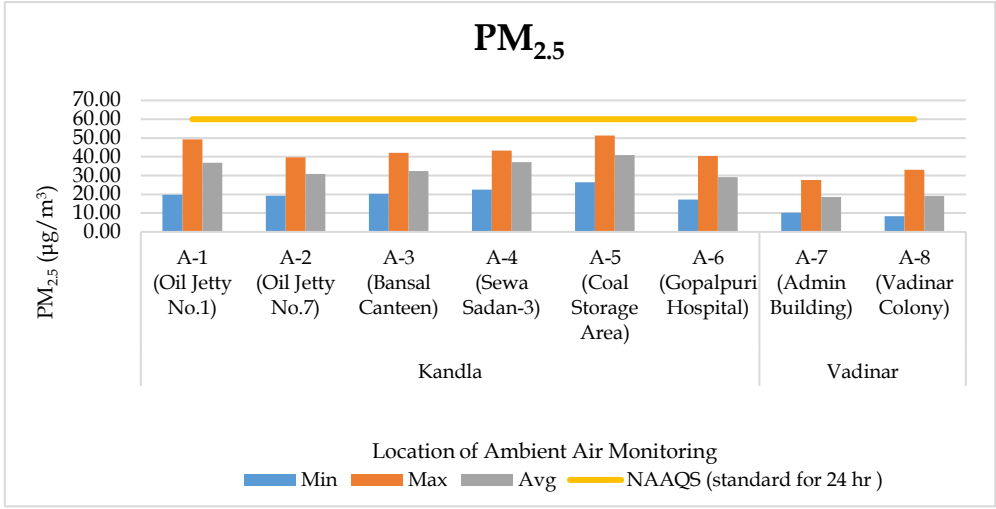
| Station Code & Name | Unit of Average Concentration | Average Pollutant Concentration | | | | | |
|---|---|---|---|---|---|---|---|
| | Pollutants | $PM_{10}$ (µg/m³) | $PM_{2.5}$ (µg/m³) | $SO_2$ (µg/m³) | $NO_X$ (µg/m³) | VOC (µg/m³) | CO (mg/m³) |
| | Duration | (24 hr) | | | | (2 hr) | (1 hr) |
| | NAAQS by CPCB / Monitoring days | 100 | 60 | 80 | 80 | - | 2 |
| | **Average** | **185.73** | **37.15** | **8.95** | **13.16** | **0.14** | **0.83** |
| | **Std. Deviation** | **33.38** | **6.68** | **3.03** | **4.31** | **0.05** | **0.03** |
| **A-5:** Coal Storage Area, Kandla | 18-08-2025 | 210.66 | 42.13 | 29.54 | 11.34 | 0.2 | 0.81 |
| | 20-08-2025 | 186.32 | 37.26 | 14.52 | 9.22 | 0.06 | 0.82 |
| | 25-08-2025 | 132.26 | 26.45 | 15.12 | 18.42 | 0.26 | 0.88 |
| | 28-08-2025 | 200.52 | 40.10 | 21.21 | 26.32 | 0.07 | 0.90 |
| | 01-09-2025 | 303.45 | 46.25 | 21.42 | 17.17 | 0.15 | 0.75 |
| | 02-09-2025 | 212.36 | 42.47 | 20.36 | 26.26 | 0.15 | 0.85 |
| | 08-09-2025 | 209.51 | 41.90 | 17.54 | 25.43 | 0.17 | 0.86 |
| | 10-09-2025 | 256.44 | 51.29 | 12.26 | 19.43 | 0.13 | 0.83 |
| | **Minimum** | **132.26** | **26.45** | **12.26** | **9.22** | **0.06** | **0.75** |
| | **Maximum** | **303.45** | **51.29** | **29.54** | **26.32** | **0.26** | **0.90** |
| | **Average** | **213.94** | **40.98** | **19.00** | **19.20** | **0.15** | **0.84** |
| | **Std. Deviation** | **49.95** | **7.21** | **5.43** | **6.61** | **0.07** | **0.05** |
| **A-6:** Gopalpuri Hospital, Kandla | 18-08-2025 | 86.52 | 17.30 | 7.21 | <6 | 0.09 | 0.71 |
| | 20-08-2025 | 112.22 | 22.44 | 9.26 | 10.32 | 0.1 | 0.79 |
| | 25-08-2025 | 132.68 | 26.54 | 8.54 | 16.43 | 0.14 | 0.81 |
| | 28-08-2025 | 154.22 | 30.84 | 8.23 | 11.21 | 0.16 | 0.85 |
| | 01-09-2025 | 121.32 | 24.26 | 6.45 | <6 | 0.09 | 0.79 |
| | 02-09-2025 | 172.54 | 34.51 | 8.02 | <6 | 0.1 | 0.66 |
| | 08-09-2025 | 202.33 | 40.47 | 10.22 | <6 | 0.11 | 0.84 |
| | 10-09-2025 | 187.41 | 37.48 | <5 | 12.43 | 0.15 | 0.81 |
| | **Minimum** | **86.52** | **16.14** | **6.12** | **6.45** | **0.09** | **0.79** |
| | **Maximum** | **202.33** | **34.47** | **9.76** | **13.46** | **0.16** | **0.84** |
| | **Average** | **146.16** | **25.54** | **7.56** | **9.68** | **0.12** | **0.81** |
| | **Std. Deviation** | **39.87** | **6.42** | **1.20** | **3.01** | **0.03** | **0.02** |
| **A-7:** Admin Building, Vadinar | 18-08-2025 | 91.25 | 16.42 | 7.42 | 13.46 | 0.04 | 0.65 |
| | 20-08-2025 | 55.22 | 10.32 | 10.25 | 19.23 | 0.19 | 0.63 |
| | 25-08-2025 | 126.21 | 22.71 | 32.65 | <6 | 0.13 | 0.69 |
| | 28-08-2025 | 153.26 | 27.58 | 23.21 | <6 | 0.15 | 0.7 |
| | 01-09-2025 | 84.25 | 15.16 | <5 | <6 | 0.19 | 0.72 |
| | 02-09-2025 | 101.41 | 18.25 | <5 | <6 | 0.16 | 0.73 |
| | 08-09-2025 | 122.08 | 21.55 | <5 | 12.55 | 0.09 | 0.72 |
| | 10-09-2025 | 92.35 | 16.52 | 6.21 | 7.22 | 0.18 | 0.75 |
| | **Minimum** | **55.22** | **10.32** | **6.21** | **7.22** | **0.04** | **0.63** |
| | **Maximum** | **153.26** | **27.58** | **32.65** | **19.23** | **0.19** | **0.75** |
| | **Average** | **103.25** | **18.56** | **15.95** | **13.12** | **0.14** | **0.70** |
| | **Std. Deviation** | **30.04** | **5.29** | **11.53** | **4.92** | **0.05** | **0.04** |
| **A-8**: Vadinar Colony, | 18-08-2025 | 84.52 | 15.21 | 8.26 | 9.45 | 0.25 | 0.70 |
| | 20-08-2025 | 101.22 | 18.21 | 12.34 | <6 | 0.2 | 0.62 |
| | 25-08-2025 | 111.56 | 20.08 | 30.21 | 10.36 | 0.11 | 0.59 |
| | 28-08-2025 | 184.13 | 33.14 | 15.34 | 8.45 | 0.22 | 0.65 |

| Station Code & Name | Unit of Average Concentration | Average Pollutant Concentration | | | | | |
|---|---|---|---|---|---|---|---|
| | Pollutants | $PM_{10}$ (µg/m³) | $PM_{2.5}$ (µg/m³) | $SO_2$ (µg/m³) | $NO_X$ (µg/m³) | VOC (µg/m³) | CO (mg/m³) |
| | Duration | (24 hr) | | | | (2 hr) | (1 hr) |
| | NAAQS by CPCB / Monitoring days | 100 | 60 | 80 | 80 | - | 2 |
| Vadinar | 01-09-2025 | 45.21 | 8.43 | 5.21 | <6 | 0.15 | 0.71 |
| | 02-09-2025 | 123.36 | 22.20 | <5 | <6 | 0.14 | 0.54 |
| | 08-09-2025 | 102.27 | 18.40 | <5 | 29.51 | 0.13 | 0.58 |
| | 10-09-2025 | 95.24 | 17.14 | 7.54 | 9.11 | 0.14 | 0.56 |
| | **Minimum** | **45.21** | **8.43** | **5.21** | **8.45** | **0.11** | **0.54** |
| | **Maximum** | **184.13** | **33.14** | **30.21** | **29.51** | **0.25** | **0.71** |
| | **Average** | **105.94** | **19.10** | **13.15** | **13.38** | **0.17** | **0.62** |
| | **Std. Deviation** | **39.18** | **6.99** | **9.11** | **9.05** | **0.05** | **0.06** |

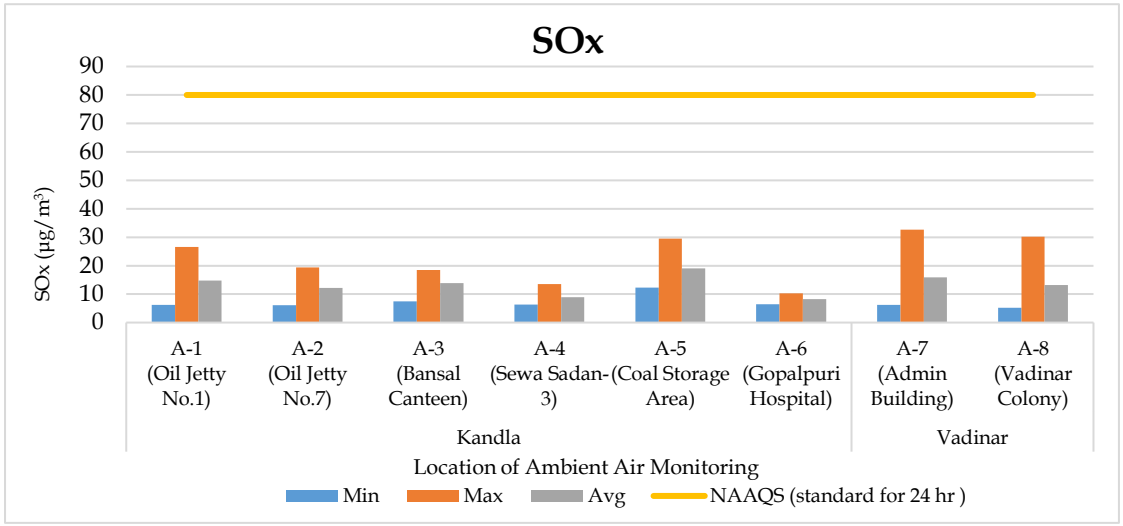
**Graphs 1-6** shows spatial trend of ambient air parameter at all the eight-monitoring location (six at Kandla and 2 at Vadinar)



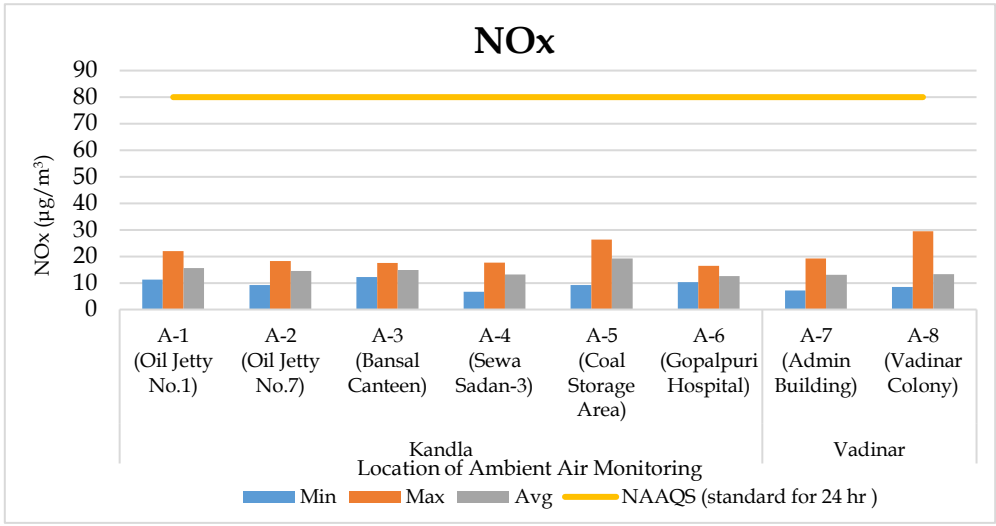

Graph 1: Spatial trend in Ambient $PM_{10}$ Concentration



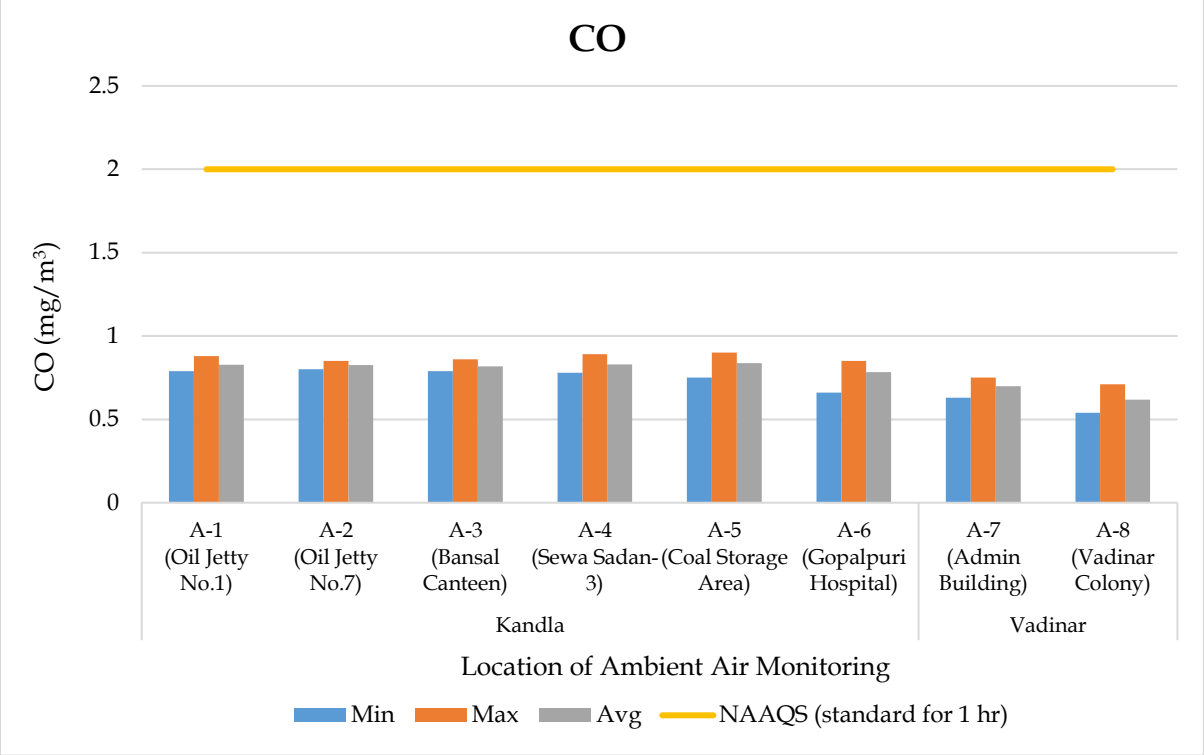

Graph 2: Spatial trend in Ambient $PM_{2.5}$ Concentration



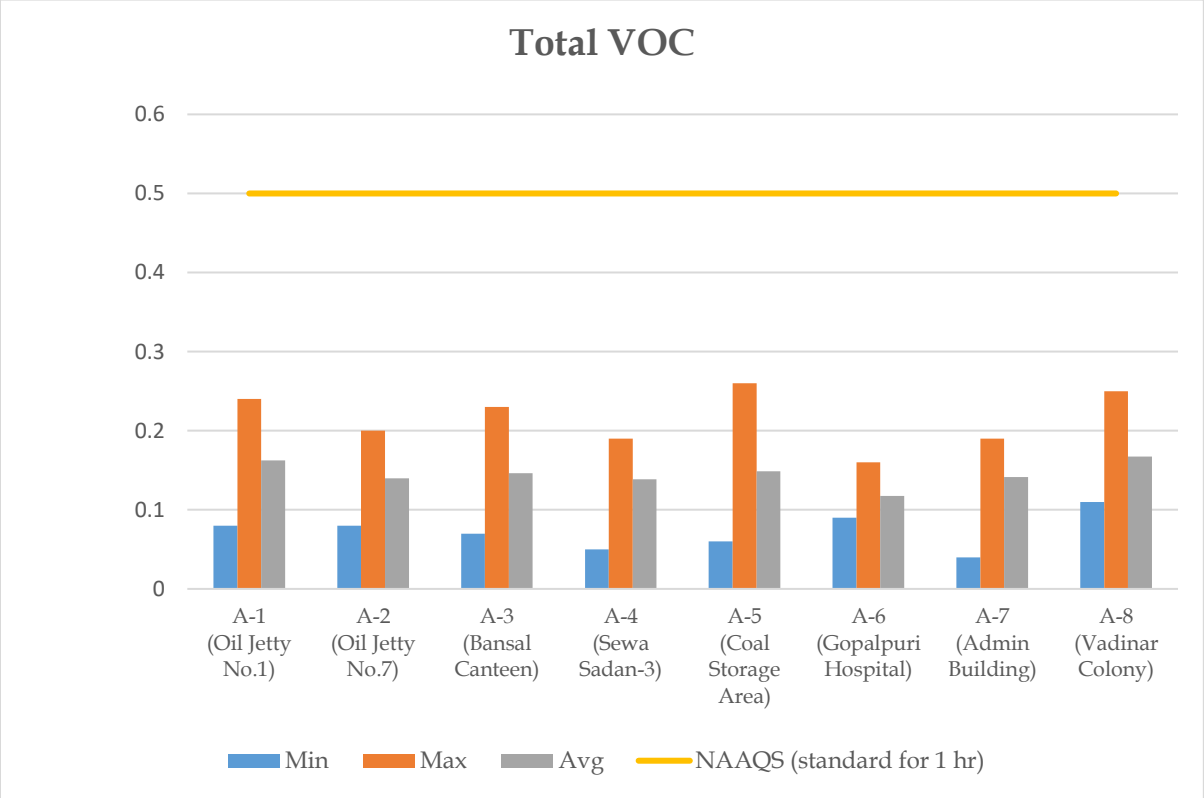

Graph 3: Spatial Trend in Ambient SOx Concentration




Graph 4: Spatial trend in Ambient Nox Concentration




**Graph 5: Spatial trend in Ambient CO Concentration**




**Graph 6: Spatial trend in Ambient Total VOCs**

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

| Benzene (µg/m³) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sr. No | Kandla | | | | | | Vadinar | | NAAQS standards (24 hr) |
| | A-1 | A-2 | A-3 | A-4 | A-5 | A-6 | A-7 | A-8 | |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 µg/m3 |

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

| Sr. No. | Components | Kandla | | | | | | Vadinar | |
|---|---|---|---|---|---|---|---|---|---|
| | | A-1 | A-2 | A-3 | A-4 | A-5 | A-6 | A-7 | A-8 |
| 1 | Napthalene | 0.450 | 0.680 | 0.180 | 0.180 | 1.520 | 1.170 | 0.000 | 0.000 |
| 2 | Acenaphthylene | 0.050 | 0.090 | 0.110 | 0.960 | 0.460 | 0.500 | 0.050 | 0.000 |
| 3 | Acenaphthene | 0.010 | 0.040 | 0.420 | 0.060 | 0.650 | 0.000 | 0.000 | 0.000 |
| 4 | Fluorene | 0.500 | 0.250 | 0.220 | 0.240 | 0.210 | 0 | 0.000 | 0.000 |
| 5 | Anthracene | 0.300 | 0.360 | 0.290 | 0.620 | 0.330 | 0.100 | 0.090 | 0.000 |
| 6 | Phenanthrene | 0.075 | 0.075 | 0.080 | 0.080 | 0.000 | 0.240 | 0.030 | 0.000 |
| 7 | Fluoranthene | 0.060 | 0.840 | 0.610 | 0.180 | 0.600 | 0.390 | 0.000 | 0.000 |
| 8 | Pyrene | 0.085 | 0.640 | 0.420 | 0.720 | 0.710 | 0.300 | 0.060 | 0.000 |
| 9 | Chrycene | 0.920 | 1.220 | 0.620 | 0.510 | 0.760 | 1.120 | 0.150 | 0.070 |
| 10 | Banz(a)anthracene | 0.750 | 1.010 | 0.490 | 0.410 | 0.440 | 0.880 | 0.080 | 0.000 |
| 11 | Benzo[k]fluoranthene | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 3.200 | 0.480 | 0.510 |
| 12 | Benzo[b]fluoranthene | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 1.250 | 0.070 | 0.120 |
| 13 | Benzopyrene | 2.110 | 3.265 | 2.020 | 1.990 | 3.101 | 2.210 | 0.310 | 0.480 |
| 14 | Indeno [1,2,3-cd] fluoranthene | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 15 | Dibenz(ah)anthracene | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 16 | Benzo[ghi]perylene | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

**Table 9: Summarized results of Non-methane VOC**

| Sr No | Kandla | | | | | | Vadinar | |
|---|---|---|---|---|---|---|---|---|
| | A-1 | A-2 | A-3 | A-4 | A-5 | A-6 | A-7 | A-8 |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## 4.3 Data Interpretation and Conclusion

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

- The concentration of $PM_{10}$ at Kandla varies in the range of **86.52 to 256.44 µg/m³** with an average value of **172.91 µg/m³**. $PM_{10}$ exceeded NAAQS of all the monitoring locations in Kandla. Whereas, at Vadinar, the concentration varies from **45.21 to 184.13 µg/m³**, with an average value of **104.60 µg/m³**.
- The elevated $PM_{10}$ concentration at location A-5, the Coal Storage Area, can be attributed to several factors. Heavy vehicular traffic in upwind areas significantly contributes to the dispersion of particulate matter into the ambient air. The process of unloading coal directly onto trucks using grabs leads to the emission of coal dust into the air and its subsequent settling on the ground. This settled dust is re-entrained into the atmosphere as trucks travel through the area. Additionally, coal-loaded trucks are often not adequately covered with tarpaulin sheets, which exacerbates the suspension of coal particles during transit from vessels to the storage yard or site. These factors collectively contribute to increased $PM_{10}$ levels in and around the Coal Storage Area and Marine.
- The **$PM_{2.5}$** concentrations at Kandla varies from **17.30 to 51.29 µg/m³** with average **34.58 µg/m³**. The **$PM_{2.5}$** concentration falls within the NAAQS limit for all locations of Kandla. Whereas, at Vadinar its concentration varies from **8.43 to 33.14 µg/m³** with average **18.83 µg/m³**. Also, due to construction and demolition all around the port contributing in increased particulate matter levels.
- The concentrations of **$PM_{10}$** at the Vadinar sampling locations are exceeding the limits prescribed by the National Ambient Air Quality Standards (NAAQS), primarily due to ongoing construction activities in the Vicinity.
- The concentration of **$SO_x$** varies from **6.12 to 29.54 µg/m³** with average concentration as **12.84 µg/m³** at Kandla and **5.21 to 32.65 µg/m³** with average as **14.55 µg/m³** at Vadinar. The average concentration of $SO_x$ complies with the prescribed limit of NAAQS (80 µg/m³) for both the monitoring site.
- The concentration of **$NO_x$** varies from **6.68 to 26.32 µg/m³** with average **14.99 µg/m³** at Kandla and **7.22 to 29.51 µg/m³** with average **13.25 µg/m³** at Vadinar. The concentration of **$NO_x$** falls within the prescribed limit of NAAQS i.e. 80 µg/m³ at both the monitoring site of Kandla and Vadinar.
- The concentration of **CO** varies from **0.66 to 0.90 µg/m³** with average **0.82 µg/**m³ at Kandla and **0.54 to 0.75 µg/m³** with average **0.66 µg/m³** at Vadinar. The concentration falls within the norm of 2 mg/m³ specified by NAAQS at both the monitoring sites
- The concentration of **Total VOCs** levels was recorded in range of **0.05 to 0.26 µg/m³** at Kandla and **in range of 0.04 to 0.25 µg/m³** at the location of Vadinar respectively. The main source of VOCs in the ambient air may be attributed to the burning of Gasoline and Natural gas in Vehicle exhaust and burning fossil fuels, and garbage that release VOCs into the atmosphere. During the monitoring period, the wind flows towards South direction at Kandla, and hence the wind direction and speed also contribute to increased dispersion of pollutants from the upward areas towards the downward areas.
- **Benzene** was not detected on the location of Kandla & Vadinar.

- **Polycyclic Aromatic Hydrocarbons (PAHs)** are ubiquitous pollutants in urban atmospheres. Anthropogenic sources of total PAHs in ambient air emissions are greater than those that come from natural events. These locations are commercial areas where Vehicular activity and dust emission is common. PAHs are a class of chemicals that occur naturally in coal, crude oil, and gasoline. The higher concentration which results from burning coal, oil, gas, road dust, etc. Other outdoor sources of PAHs may be the industrial plants in-and-around the DPA premises.
- The Ambient air Monitoring location of Kandla recorded the **Non-methane VOC** (NM-VOC) concentration Value to be **0 µg/m³**. While at Vadinar, the concentration of NM-VOC falls is found to be **0 µg /m³** at both the location.

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

1. **Port Machinery:** Port activities involve the use of various machinery and equipment, including cranes, for lifts, tugboats, and cargo handling equipment. These machines often rely on diesel engines, which can emit pollutants such as $NO_x$, Particulate matter, and CO. Older or poorly maintained equipment tends to generate higher emissions.
2. **Port Vehicles:** Trucks and other vehicles operating within port and port area contributes to air pollution. Similar to port machinery, diesel-powered vehicles can emit $NO_x$, PM, CO, and other pollutants such as PAH, VOCs etc. Vehicle traffic and congestion in and around port areas can exacerbate the air quality issues.
3. Apart from that, construction and demolition activities majorly contribute to particulate matter pollution.

## 4.4 Remedial Measures:

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

- Practice should be initiated for using mask as preventative measure, to avoid Inhalation of dust particle-Mask advised in sensitive areas. Covering vehicles with tarpaulin during transportation will help to reduce the suspension of pollutants in air.

- Store fine particulate cargo (e.g., coal, fertilizers) in covered sheds or domes.
- 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.
- Develop green belts using dust-tolerant species along port boundaries and roads.
- Frequent water sprinkling on roads to reduce dust suspension due to vehicular movement, this can be use during transporting coal to avoid suspension of coal dust.
- Use of proper transport methods, such as a conveyor belt, for excavated material and screens around the construction site.
- Temporary pavement of roads in construction site could considerably reduce dust emission. Prohibition of use of heavy diesel oil as fuel could be possibly reduce pollutants. Encouraging use of low-sulfur fuels (viz. Marine Gas Oil (MGO)/Liquefied Natural Gas (LNG), can significantly reduce sulfur and PM emissions from ships.
- Investing in infrastructure for cold ironing allows ships to connect to the electrical grid while docked, reducing the need for auxiliary engines and associated emissions.
- Implementing efficient cargo-handling processes, optimizing logistics to reduce congestion and idling times, and encouraging use of cleaner port machinery and vehicles can all contribute to reducing air pollution in port areas.

# CHAPTER 5: DG STACK MONITORING

## 5.1 DG Stack Monitoring

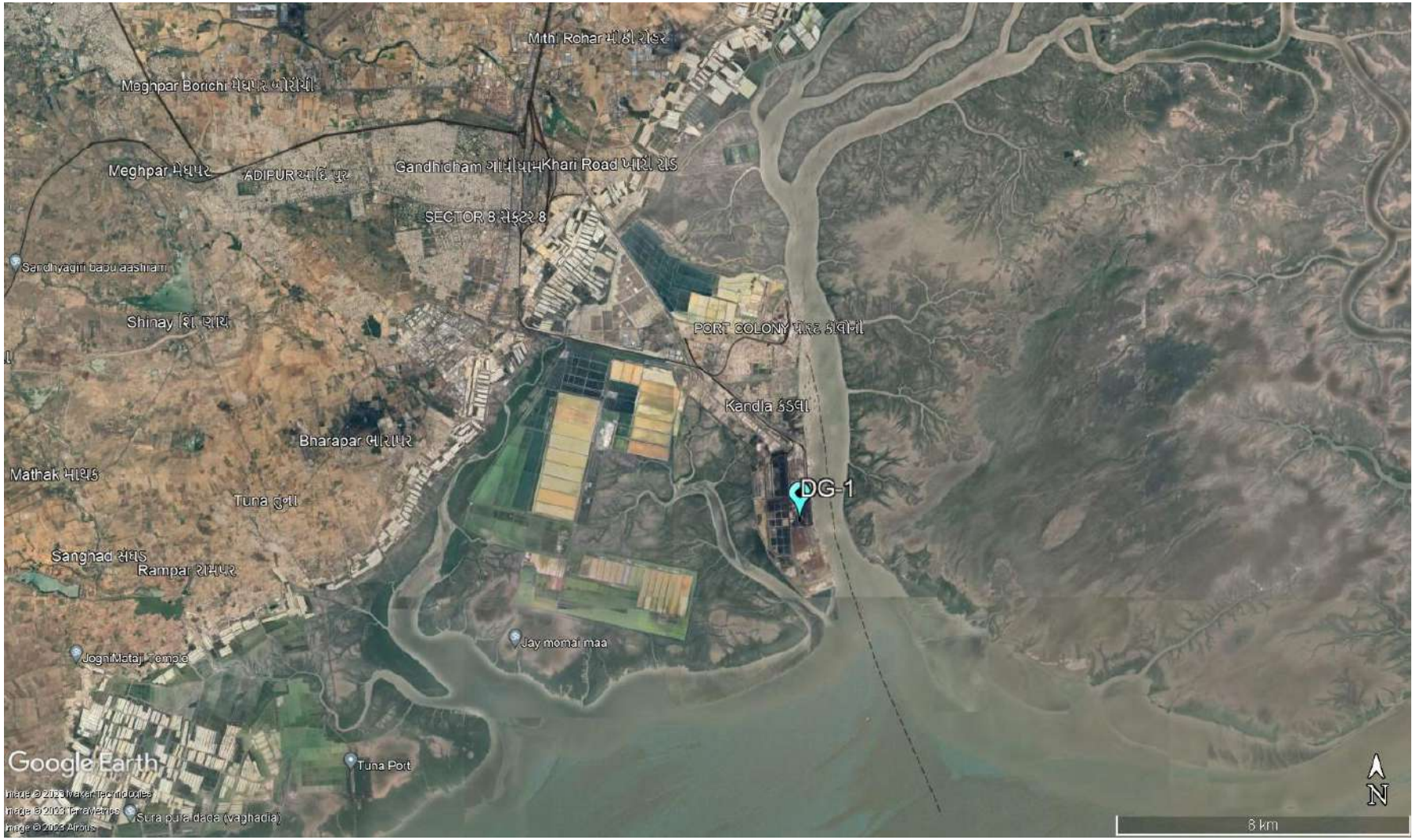
A diesel generator is a mechanical-electrical machine that produces electrical energy (electricity) from diesel fuel. They are used by the residential, commercial, charitable and governmental sectors to provide power in the event of interruption to the main power, or as the main power source. Diesel generating (DG) sets are generally used in places without connection to a power grid, or as an emergency power supply if the grid fails. These DG sets utilize diesel as fuel and generate and emit the air pollutants such as Suspended Particulate Matter, $SO_2$, $NO_x$, CO, etc. from the stack during its functioning. The purpose of stack sampling is to determine emission levels from plant processes to ensure they are in compliance with any emission limits set by regulatory authorities to prevent macro environmental pollution. The stack is nothing but chimney which is used to disperse the hot air at a great height, emissions & particulate matters that are emitted. Hence, monitoring of these stacks attached to DG Sets is necessary in order to quantify the emissions generated from it.

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

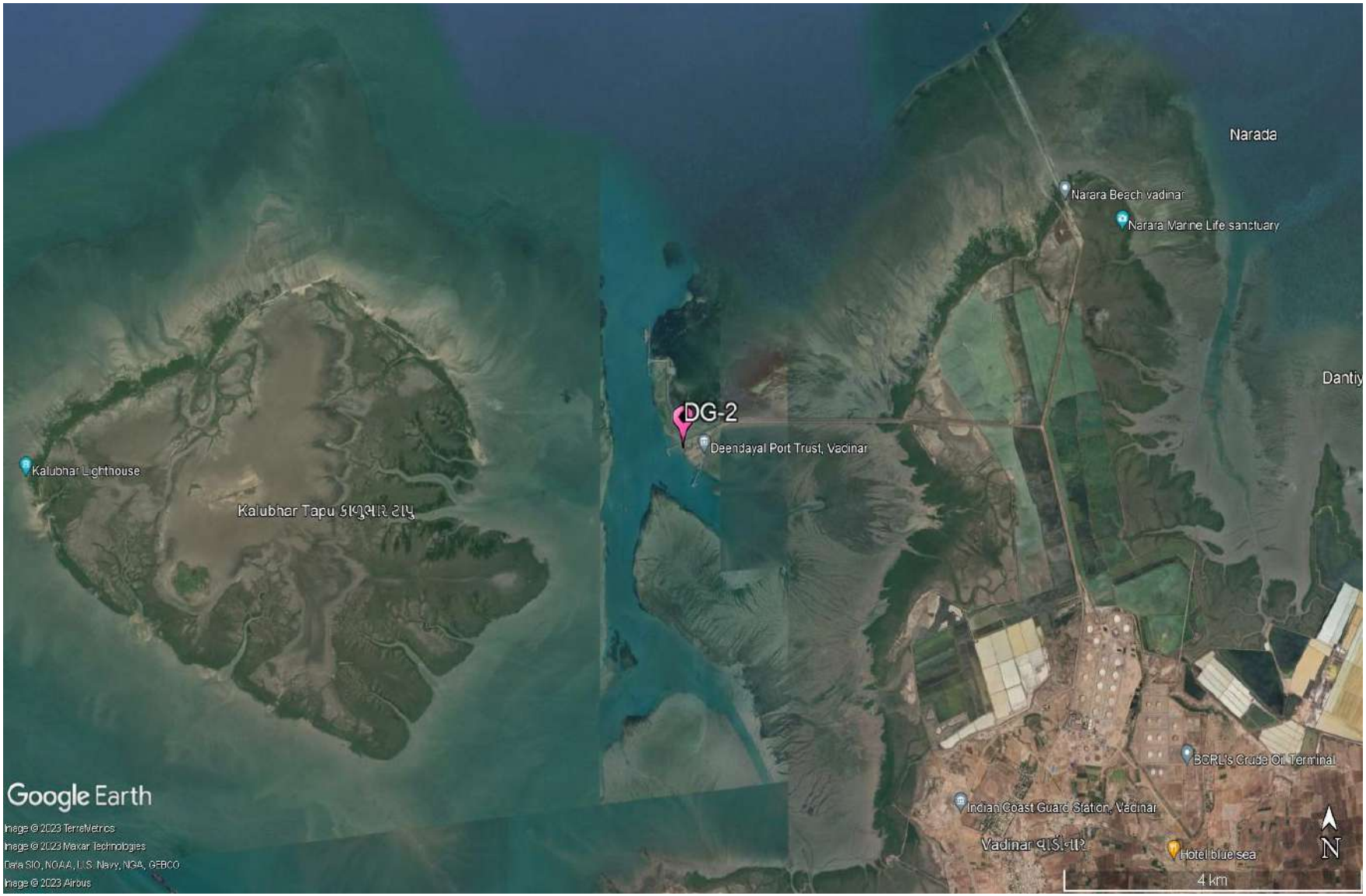
**Table 10: Details of DG Stack monitoring locations**

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

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




**Map 6: Locations for DG Stack monitoring at Kandla**




**Map 7: Locations for DG Stack monitoring at Vadinar**

### Methodology:

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

**Table 11: DG stack parameters**

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

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

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

**Frequency**

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

## 5.2 Result and Discussion

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

**Table 12: DG monitoring data**

| Sr. No. | Stack Monitoring Parameters for DG Sets | Stack Monitoring Limits / Standards As per CPCB | DG- 1 (Kandla) | DG-2 (Vadinar) |
|---|---|---|---|---|
| 1. | Suspended Particulate Matter (SPM) (mg/Nm$^3$) | 150 | 70.23 | 34.65 |
| 2. | Sulphur Dioxide ($SO_2$) (PPM) | 100 | 1.03 | N.D. |
| 3. | Oxides of Nitrogen ($NO_x$) (PPM) | 50 | 23.46 | 13.25 |
| 4. | Carbon Monoxide (CO) (%) | 1 | 0.23 | 0.03 |
| 5. | Carbon Dioxide ($CO_2$) (%) | - | 1.12 | 1.33 |

## 5.3 Data Interpretation and Conclusion

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

# CHAPTER 6: NOISE MONITORING

## 6.1 Noise Monitoring

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

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

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

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


**Map 8: Locations for Noise Monitoring at Kandla**


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

**Methodology:**

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

**Frequency**

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

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

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

**Standard for Noise**

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

**Table 15: Ambient Air Quality norms in respect of Noise**

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

## 6.2 Result and Discussion

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

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

| Sr. No. | Station Code | Station Name | Category of Area | Standard | Day Time | | | Standard | Night Time | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Max. | Min. | Leq dB(A) Total | | Max. | Min. | Leq dB(A) Total |
| 1 | N-1 | Oil Jetty 7 | A | 75 | 55.8 | 42.5 | 49.4 | 70 | 41.7 | 34.2 | 45 |
| 2 | N-2 | West Gate No.1 | A | 75 | 61.4 | 46.2 | 53.9 | 70 | 47.5 | 41.2 | 46.2 |
| 3 | N-3 | Canteen Area | B | 65 | 59.2 | 47.4 | 52.6 | 55 | 49.2 | 34.6 | 45.8 |
| 4 | N-4 | Main Gate | A | 75 | 57.9 | 46.8 | 52 | 70 | 45.2 | 38.2 | 45.5 |
| 5 | N-5 | Main Road | A | 75 | 56.2 | 45.6 | 50.9 | 70 | 43.2 | 36.2 | 45.1 |
| 6 | N-6 | Marin Bhavan | B | 65 | 59.1 | 41.6 | 51.4 | 55 | 47.1 | 34.6 | 45.4 |
| 7 | N-7 | Port & Custom Building | B | 65 | 56.2 | 40.3 | 49.5 | 55 | 45.1 | 37.4 | 45.2 |
| 8 | N-8 | Nirman Building | B | 65 | 56.4 | 41.6 | 49.3 | 55 | 42.6 | 35.4 | 45.1 |
| 9 | N-9 | ATM Building | B | 65 | 55.7 | 42.2 | 50.5 | 55 | 49.7 | 38.9 | 45.9 |
| 10 | N-10 | Wharf Area/ Jetty | A | 75 | 58.6 | 41.2 | 51.6 | 70 | 48.7 | 36.2 | 45.5 |
| 11 | N-11 | Near Main Gate | A | 75 | 63.5 | 54.2 | 58.8 | 70 | 54.3 | 43.8 | 49.0 |
| 12 | N-12 | Near Vadinar Jetty | A | 75 | 62.4 | 56.9 | 59.8 | 70 | 54.7 | 49.4 | 52.0 |
| 13 | N-13 | Port Colony Vadinar | C | 55 | 42.9 | 36.7 | 39.8 | 45 | 38.6 | 31.7 | 35.1 |

## 6.3 Data Interpretation and Conclusion

The noise level at both the locations (Kandla and Vadinar) was compared with the standard limits specified in NAAQS by CPCB. During the Day Time, the average noise level at all 10 locations at Kandla ranged from **40.3 dB(A) to 61.4 dB(A)**, while at Vadinar, he noises levels for the three-location ranged from **36.7 dB(A) to 63.5 dB(A).** Whereas, during Night Time the average Noise Level ranged from **34.2 dB(A) to 49.7 dB(A)** at Kandla and **31.7 dB(A) to 54.7 dB(A)** at Vadinar. In some locations at the Kandla site, spikes in noise levels were observed due to construction and demolition activities.

## 6.4 Remedial Measures

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

# CHAPTER 7: SOIL MONITORING

## 7.1 Soil Quality Monitoring:

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

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

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

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

### Methodology

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

The samples of soil collected from the locations of Kandla and Vadinar and analyzed for the various physico-chemical parameter. Collection and analysis of these samples was carried out as per established standard methods and procedures. The samples were analyzed for selected parameters to get the present soil quality status and environmental risks associated with various practices prevalent at the location. GEMI has framed its own guidelines for collection of soil samples titled as ***'Soil Sampling Manual'***. Soil samples were collected from 30 cm depth below the surface using scrapper, filled in polythene bags, labelled on-site with specific location code and name and sent to GEMI's laboratory, Gandhinagar for further detailed analysis. The samples collected from all locations are homogeneous representative of each location. The list of parameters to be monitored under the projects for the Soil Quality Monitoring been mentioned in **Table 18** as follows:

### Frequency

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

**Table 18: Soil parameters**

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

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


**Map 10: Locations for Soil Quality Monitoring at Kandla**


**Map 11: Locations for Soil Quality Monitoring at Vadinar**

## 7.2 Result and Discussion

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

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

| Sr. No | Location / Parameters | Unit | Kandla | | | | Vadinar | |
|---|---|---|---|---|---|---|---|---|
| | | | S-1 (Oil Jetty 7) | S-2 IFFCO Plant) | S-3 (Khori Creek) | S-4 (Nakti Creek) | S-5 (Near SPM) | S-6 (Near Vadinar Jetty) |
| 1 | pH | - | 9.21 | 8.85 | 9.23 | 8.33 | 8.16 | 8.45 |
| 2 | Conductivity | µS/cm | 6548 | 4265 | 654 | 9578 | 155 | 298 |
| 3 | Inorganic Phosphate | Kg/ha | 1.26 | 0.88 | 1.68 | 1.1 | 0.24 | 0.18 |
| 4 | Organic Carbon | % | 0.26 | 0.44 | 0.44 | 0.28 | 0.65 | 0.56 |
| 5 | Organic Matter | % | 0.33 | 0.56 | 1.1 | 0.47 | 0.72 | 0.26 |
| 6 | SAR | meq/L | 8.56 | 9.12 | 1.35 | 13.25 | 0.16 | 0.2 |
| 7 | Aluminium | mg/Kg | 13562.26 | 10255.68 | 6587.16 | 12365.33 | 28563.35 | 21472.38 |
| 8 | Chromium | mg/Kg | 65.32 | 55.21 | 45.16 | 60.25 | 82.14 | 55.21 |
| 9 | Nickel | mg/Kg | 31.26 | 27.54 | 18.62 | 22.15 | 28.54 | 25.11 |
| 10 | Copper | mg/Kg | 45.21 | 55.47 | 32.51 | 42.13 | 66.21 | 72.14 |
| 11 | Zinc | mg/Kg | 53.33 | 60.21 | 22.14 | 42.18 | 42.15 | 59.21 |
| 12 | Cadmium | mg/Kg | BQL | BQL | BQL | BQL | BQL | BQL |
| 13 | Lead | mg/Kg | 3.65 | 2.11 | 4.21 | 6.25 | 0.55 | 0.29 |
| 14 | Arsenic | mg/Kg | 0.2 | 0.07 | 1.01 | 2.12 | BQL | BQL |
| 15 | Mercury | mg/Kg | BQL | BQL | BQL | BQL | BQL | BQL |
| 16 | Water Holding Capacity | % | 60.13 | 50.24 | 38.52 | 51.23 | 55.12 | 62.54 |
| 17 | Sand | % | 32.08 | 57.51 | 62.12 | 48.21 | 66.21 | 69.57 |
| 18 | Silt | % | 42.31 | 38.23 | 33.36 | 23.14 | 26.14 | 28.21 |
| 19 | Clay | % | 25.61 | 4.26 | 4.52 | 28.65 | 7.65 | 2.22 |
| 20 | Texture | - | slit sandy | Sandy loam | sandy loam | Loam | sandy 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:

- The value of **pH** ranges from **8.21 to 9.23,** highest at location S-3 (Khori Creek) and lowest at S-4 (Nakti Creek); while the average pH for Kandla was observed to be **8.905**.

Whereas, at Vadinar the pH value observed at S-5 i.e., **Near SPM (8.16)** and at S-6 i.e., **Near Jetty Area (8.45).** As per the observation the pH was found to be **moderately to strongly alkaline** both the monitoring station of Kandla and Vadinar**.**

- At entire monitoring locations of Kandla the value of **Electrical Conductivity** ranges from **654-9578 µs/cm**, highest at location S-4 (Nakti Creek) with the average as 5261.25 **µs/cm**. Whereas, at Vadinar the range of conductivity was between the range of **155 to 298 µs/cm** with an average value of 226.5 **µs/cm**.

- At Kandla, the concentration of **Inorganic Phosphate** varied from **0.88-1.68 Kg/ha**, with average **1.23 Kg/ha**. Whereas, at the locations of Vadinar, the Inorganic Phosphate was observed at S-5 i.e., Near SPM (**0.24 Kg/ha**) and detected at S-6 i.e., near Jetty Area (**0.18 Kg/ha**). The phosphorus availability in soil solution is influenced by a number of factors such as Organic matter, clay content, pH, temperature, etc.

- The concentration of **Total Organic Carbon** ranges from **0.26 to 0.44** % while the average TOC at Kandla was detected as **0.35 %.** Whereas, at Vadinar the average TOC was found to be **0.60**% where the observed TOC value found at S-5 i.e. Near SPM (**0.65**%) and S-6 i.e. near Jetty Area to be **0.56** % respectively.

- The concentration of **Water Holding Capacity** in the soil samples of Kandla and Vadinar varies from **38.52-60.13** % and **55.12-62.54** % respectively.

- The concentration of **Sodium Adsorption Ratio** ranges from **1.35–13.25 meq/L** with an average value **8.07 meq/L** at Kandla. Whereas, at Vadinar, the concentration of Sodium Adsorption Ratio ranges from 0.16 to 0.20 **meq/L** with an average SAR was found to be **0.18 meq/L**. A component of conductivity is the SAR. A high SAR indicates a large concentration of sodium ions in the soil, which raises conductivity.

Sandy loam, loamy sand, and silty sand were the soil textures observed at all the monitoring locations of Kandla and Vadinar.

**Heavy Metals**

For the sampling period, the concentration of **Aluminium** varied from **6587.16 to 13562.26 mg/kg** at Kandla and **21472.38 to 28563.35 mg/kg** at Vadinar and the average value was observed to be **10692.61 and 25017.87 mg/kg** at Kandla and Vadinar monitoring station, respectively.

- The concentration of **Chromium** varied from **45.16 to 65.32 mg/kg** at Kandla and **55.21 to 82.14 mg/kg** at Vadinar and the average value was observed to be **56.48 and 68.67 mg/kg** at Kandla and Vadinar monitoring station, respectively.

- The concentration of **Nickel** varied from **18.62 to 31.26 mg/kg** at Kandla and **25.11 to 28.54 mg/kg** at Vadinar and the average value was observed to be **24.89 and 26.82 mg/kg** at Kandla and Vadinar monitoring station, respectively.

- The concentration of **Zinc** varied from **22.14 to 60.21 mg/kg** at Kandla and **42.15 to 59.21 mg/kg** at Vadinar and the average value was observed to be **44.46 and 50.68 mg/kg** at Kandla and Vadinar monitoring station, respectively

- The concentration of **copper** varied from **32.51 to 55.47 mg/kg** at Kandla and **66.21 to 72.14 mg/kg** at Vadinar and the average value was observed to be **43.83 and 69.17 mg/kg** at Kandla and Vadinar monitoring station, respectively.

- The concentration of **Arsenic** varied from 0.07 **to 2.12 mg/kg** at Kandla and the average value was observed to be **0.85** at Kandla while at Vadinar the average value was observed to be **BQL**.

- The concentration of **Lead** varied from **2.11 to 6.25 mg/kg** at Kandla and the average value was observed to be **4.05** at Kandla while at Vadinar the average value was observed to be **0.42 mg/kg**.

- While other heavy metals in the Soil i.e., **Mercury, Cadmium** were observed "Below Quantification Limit" for majority of the soil samples collected at Kandla and Vadinar.

# CHAPTER 8: DRINKING WATER MONITORING

## 8.1 Drinking Water Monitoring

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

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

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

| Sr. No. | Location Code | | Location Name | Latitude/ Longitude |
|---|---|---|---|---|
| 1. | Kandla | DW-1 | Oil Jetty 7 | 23.043527N 70.218456E |
| 2. | | DW-2 | Shramdeep | 23.009631N, 70.220877E |
| 3. | | DW-3 | North Gate | 23.007938N 70.222411E |
| 4. | | DW-4 | Workshop | 23.009372N 70.222236E |
| 5. | | DW-5 | Canteen Area | 23.003707N 70.221331E |
| 6. | | DW-6 | West Gate 1 | 23.006771N 70.217340E |
| 7. | | DW-7 | Sewa Sadan -3 | 23.009779N 70.221838E |
| 8. | | DW-8 | Nirman Building | 23.009642N 70.220623E |
| 9. | | DW-9 | Custom Building | 23.018930N 70.214478E |
| 10. | | DW-10 | Port Colony Kandla | 23.019392N 70.212619E |
| 11. | | DW-11 | Wharf Area/ Jetty | 22.997833N 70.223042E |
| 12. | | DW-12 | Hospital Kandla | 23.018061N 70.212328E |
| 13. | | DW-13 | A.O. Building | 23.061914N 70.144861E |
| 14. | | DW-14 | School Gopalpuri | 23.083619N 70.132061E |
| 15. | | DW-15 | Guest House | 23.078830N 70.131008E |
| 16. | | DW-16 | E- Type Quarter | 23.083306N 70.132422E |
| 17. | | DW-17 | F- Type Quarter | 23.077347N 70.135731E |
| 18. | | DW-18 | Hospital Gopalpuri | 23.081850N 70.135347E |
| 19. | Vadinar | DW-19 | Near Vadinar Jetty | 22.440759N 69.675210E |
| 20. | | DW-20 | Near Port Colony | 22.401619N 69.716822E |


**Map 12: Locations for Drinking Water Monitoring at Kandla**


**Map 13: Locations for Drinking Water Monitoring at Vadinar**

## Methodology

The water samples were collected from the finalized sampling locations and analysed for physico-chemical and microbiological parameter, for which the analysis was carried out as per APHA, 23rd Edition and Indian Standard method in GEMI's NABL Accredited Laboratory, Gandhinagar. GEMI has followed the CPCB guideline as well as framed its own guidelines for the collection of water/wastewater samples, under the provision of Water (Preservation and Control of Pollution) Act 1974, titled as '**Sampling Protocol for Water & Wastewater'**; approved by the Government of Gujarat vide letter no. ENV-102013-299-E dated 24-04-2014. The samples under the study were collected and preserved as per the said Protocol. The parameters finalized to assess the drinking water quality have been mentioned in **Table 21** as follows:

**Table 21: List of parameters for Drinking Water Quality monitoring**

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

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

## 8.2 Result and Discussion

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

**Table 22: Summarized results of Drinking Water quality**

| Sr. No. | Parameters | Units | Standard values as per IS | | Kandla | | | | | | | | | | | | | | | | | Vadinar | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | P | DW-1 | DW-2 | DW-3 | DW-4 | DW-5 | DW-6 | DW-7 | DW-8 | DW-9 | DW-10 | DW-11 | DW-12 | DW-13 | DW-14 | DW-15 | DW-16 | DW-17 | DW-18 | DW-19 | DW-20 |
| 1. | pH | - | **6.5-8.5** | **-** | 7.55 | 7.92 | 7.50 | 7.62 | 7.42 | 7.36 | 7.22 | 7.56 | 7.12 | 6.56 | 7.01 | 6.95 | 7.21 | 7.54 | 6.92 | 7.26 | 7.30 | 7.15 | 6.94 | 7.36 |
| 2. | Colour | Hazen | **5** | **15** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 3. | EC | µS/ cm | **-** | **-** | 238 | 20.3 | 32.6 | 26.5 | 40.2 | 65.8 | 29.4 | 36.6 | 75.4 | 132.3 | 155.4 | 125.8 | 55.4 | 49.7 | 142 | 16.3 | 29.7 | 96.5 | 232 | 75.2 |
| 4. | Salinity | PSU | **-** | **-** | 0.16 | 0.05 | 0.03 | 0.03 | 0.02 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.08 | 0.06 | 0.03 | 0.02 | 0.08 | 0.03 | 0.03 | 0.05 | 0.15 | 0.02 |
| 5. | Turbidity | NTU | **1** | **5** | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 6. | Chloride | mg/L | **250** | **1000** | 45.63 | 3.56 | 10.25 | 16.24 | 8.45 | 15.27 | 8.13 | 9.34 | 22.36 | 29.57 | 40.23 | 29.37 | 20.13 | 16.44 | 36.36 | 11.05 | 13.25 | 25.27 | 42.45 | 13.25 |
| 7. | Total Hardness | mg/L | **200** | **600** | 6 | BQL | 5 | 5.5 | 6 | 8 | 3 | 2.5 | 5 | 18 | 18 | 23 | 2.5 | 3.5 | 18 | BQL | 2 | 6 | 132 | 20 |
| 8. | Ca Hardness | mg/L | **-** | **-** | 2 | BQL | 3 | 3.5 | 3.5 | 6 | 2.5 | 1.5 | 2 | 10 | 9 | 12 | 1.5 | 3 | 8 | BQL | 1 | 4 | 67 | 9 |
| 9. | Mg Hardness | mg/L | **-** | **-** | 4 | BQL | 2 | 2 | 2.5 | 2 | BQL | 1 | 3 | 8 | 9 | 11 | 1 | BQL | 10 | BQL | BQL | 2 | 65 | 11 |
| 10. | Free Residual Chlorine | mg/L | **0.2** | **1** | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 11. | TDS | mg/L | **500** | **2000** | 132 | 12 | 16 | 18 | 20 | 31 | 15 | 17 | 32 | 52 | 82 | 62 | 26 | 30 | 74 | 18 | 21 | 60 | 180 | 38 |
| 12. | TSS | mg/L | **-** | **-** | BQL | BQL | 4 | BQL | BQL | BQL | BQL | 3 | BQL | BQL | 4 | BQL | BQL | 3 | BQL | BQL | 1 | BQL | BQL | BQL |
| 13. | Fluoride | mg/L | **1.0** | **1.5** | 0.42 | BQL | 0.39 | BQL | 0.41 | 0.25 | 0.31 | BQL | 0.42 | 0.38 | 0.39 | 0.35 | 0.26 | 0.31 | 0.394 | 0.39 | 0.30 | 0.31 | 0.65 | 0.29 |
| 14. | Sulphate | mg/L | **200** | **400** | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | 21.25 | BQL |
| 15. | Nitrate | mg/L | **45** | **-** | 7.65 | BQL | BQL | BQL | BQL | BQL | BQL | BQL | 1.54 | BQL | BQL | BQL | 1.10 | BQL | BQL | BQL | BQL | BQL | 1.65 | BQL |
| 16. | Nitrite | mg/L | **-** | **-** | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 17. | Sodium | mg/L | **-** | **-** | 36.21 | BQL | 2.12 | 3.95 | 1.92 | 1.85 | 1.24 | 2.21 | 3.62 | 4.11 | 4.23 | 6.54 | 4.69 | 3.12 | 9.52 | 1.02 | 1.52 | 3.67 | 19.54 | BQL |
| 18. | Potassium | mg/L | **-** | **-** | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |

| Sr. No. | Parameters | Units | Standard values as per IS | | Kandla | | | | | | | | | | | | | | | | | Vadinar | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | P | DW-1 | DW-2 | DW-3 | DW-4 | DW-5 | DW-6 | DW-7 | DW-8 | DW-9 | DW-10 | DW-11 | DW-12 | DW-13 | DW-14 | DW-15 | DW-16 | DW-17 | DW-18 | DW-19 | DW-20 |
| 19. | Hexavalent Chromium | mg/L | - | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 20. | Odour | TON | Agreeable | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 21. | Arsenic | mg/L | 0.01 | 0.05 | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 22. | Cadmium | mg/L | 0.003 | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 23. | Copper | mg/L | 0.05 | 1.5 | BQL | BQL | 0.010 | BQL | 0.005 | BQL | BQL | BQL | 0.004 | 0.020 | 0.004 | 0.018 | BQL | BQL | BQL | BQL | BQL | BQL | BQL | 0.011 |
| 24. | Iron | mg/L | 0.3 | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 25. | Lead | mg/L | 0.01 | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 26. | Manganese | mg/L | 0.1 | 0.3 | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 27. | Mercury | mg/L | 0.001 | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 28. | Total Chromium | mg/L | 0.05 | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 29. | Zinc | mg/L | 5 | 15 | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 30. | Total Coliform* | MPN/ 100ml | Shall not be detected | | 60 | 20 | 50 | BQL | BQL | 100 | BQL | 80 | BQL | BQL | 30 | BQL | 15 | BQL | BQL | 40 | BQL | BQL | BQL | 40 |

A: Acceptable, P:Permissible, BQL: Below Quantification limit; Turbidity (QL=0.5 NTU), Free Residual Chlorine (QL=2 mg/L), Total Suspended Solids (QL=2 mg/L), Fluoride (QL=0.3 mg/L), Sulphate (QL=10 mg/L), Nitrate as $NO_3$ (QL=1 mg/L), Nitrite as $NO_2$ (QL=0.1mg/L), Sodium as Na (QL=5mg/L), Potassium as K (QL=5mg/L), Hexavalent Chromium (QL=0.01 mg/L), Arsenic (QL=0.005 mg/L), Cadmium (QL=0.002 mg/L), Copper (QL=0.005 mg/L), Iron (QL=0.1mg/L), Lead (QL=0.002 mg/L), Manganese (QL=0.04 mg/L), Mercury (QL=0.0005 mg/L), Total Chromium (QL=0.005 mg/L), Zinc (QL=0.5 mg/L), Total Coliforms (QL=1 MPN/ 100ml)

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

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

## 8.3 Data Interpretation and Conclusion

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

- **pH:** The pH values of drinking water samples in Kandla were reported to be in the range of **6.56 to 7.92** with an average pH of **7.28.** In Vadinar, its values ranged from **6.94 to 7.36,** with an average pH of **7.15.** remarkably, the pH values at project locations are within the permissible range of 6.5 to 8.5 specified under IS: 10500:2012.
- **Colour:** The value of Color in Drinking water sample at Kandla is found to be **1 Hazen** in each sample. In Vadinar the Color value is found to be **1 Hazen** in both the locations.
- **Turbidity:** At the drinking water locations of Kandla & Vadinar, the turbidity was reported **BQL** for All the monitoring location.
- **Total Dissolved Solids (TDS):** Monitoring TDS is crucial because it provides an indication of overall quality of the water. During the monitoring period, the TDS concentrations in Kandla were observed to vary in a wide range i.e., between **12 to 132 mg/L,** with an average concentration of **39.88 mg/L**. while in Vadinar, it ranged from **38 to 180 mg/L,** with average at **109 mg/L.**

  It is important to note that the TDS concentrations in both Kandla and Vadinar fall well within the acceptable limit of 500 mg/L.
- **Electrical Conductivity (EC):** It is a measure of the ability of a solution to conduct electric current, and it is often used as an indicator of the concentration of dissolved solids in water. During the monitoring period, the EC values for samples collected in Kandla were observed to range from **16.3 to 238 µS/cm**, with an average value of **75.99 µS/cm**. In Vadinar, the EC values showed variation from **75.2 to 232 µS/cm,** with an average value of **153.60 µS/cm**. It's important to regularly monitor EC levels in drinking water as it can provide valuable information about water quality and presence of dissolved substances.
- **Chlorides:** The concentrations in the drinking water samples collected from Kandla and Vadinar were within acceptable limits, as specified by the BIS. The chloride in Kandla varied from **3.56 to 45.63 mg/L**, with an average value of **20.05 mg/L**. In Vadinar, it ranged from **13.25 to 42.45 mg/L**, with an average value of **27.85 mg/L.** It's important to note that all the recorded chloride concentrations in both Kandla and Vadinar were well below the acceptable limit of 250 mg/L.
- **Total Hardness (TH):** Total Hardness varied from **2 to 23 mg/L**, with the average value as **8.25 mg/L**. While at Vadinar, the variation was observed from **20 to 132 mg/L**; with the average conc. at **76 mg/L**. It's important to note that all the recorded chloride concentrations in both Kandla and Vadinar were well below the acceptable limit of 200 mg/L.
- **Sulphate:** During monitoring period in Kandla and Vadinar, the sulphate concentrations were found to be within the acceptable limits i.e., 200 mg/L as per the specified norms. In Kandla, the sulphate concentrations Was found to be **Below Quantification Limit** at all Monitoring locations. In Vadinar, the sulphate

concentration was observed at DW-19 is **21.25 mg/L &** DW-20 is **Below Quantification Limit.**

- **Sodium:** During the monitoring period, at Kandla variation in the concentration of sulphate was observed to be in the range of **1.02 to 36.21 mg/L**, with the average concentration of **5.38 mg/L**. While at Vadinar, the Sodium concentration was Observed to be in range of **BQL to 19.54 mg/L**, with the average Concentration of **19.54 mg/L.**
- **Nitrate:** During the monitoring period, at Kandla & Vadinar variation in the concentration of Nitrate was observed to be in the range of **1.10 to 7.65 mg/L**, with the average concentration of **3.43 mg/L** also majority of the location recorded as "**BQL".** While at Vadinar, the concentration was observed at DW-19 is **1.658 mg/L &** DW-20 is **Below Quantification Limit.**
- **Fluoride:** The concentration was found to be in the range of **0.253 to 0.421** mg**/L** with an average concentration of **0.354 mg/L** at all the monitoring location at Kandla. While at Vadinar the concentration was found to be in the range of **0.298 to 0.658 mg/L** with an average concentration of **0.48 mg/L** for both the monitoring location.
- **Nitrite:** The Concentration was found to be **BQL** in all the monitoring location at Kandla. While at Vadinar its value also reported to be BQL for both the Monitoring location.
- **Iron:** The Concentration was found to be **BQL** in all of the monitoring location for location at Kandla While at Vadinar, the Concentration recorded as Below Quantification Limit.
- **Copper:** During the monitoring period, at Kandla variation in the concentration of copper was observed to be in the range of **0.004 to 0.020 mg/L**, with the average concentration of **0.010 mg/L**. While at Vadinar, the concentration was observed at DW-19 is **Below Quantification limit &** DW-20 is **0.011**
- **TSS:** The Concentration was found to be **BQL** in most of the monitoring location except for location DW-3 (North Gate) i.e. 4 mg/L, DW-8 (Nirman Building) i.e. 3 mg/L and DW-11 (Wharf Jetty Area) i.e. 4 mg/L and more locations at Kandla. While at Vadinar, the Concentration was observed at DW-19 & DW-20 is **Below Quantification limit.**
- **Free Residual Chlorine:** The Concentration was found to be **BQL** in all of the monitoring location at Kandla While at Vadinar, the Concentration recorded at both location is found Below Quantification Limit.
- **Lead:** The Concentration was found to be **BQL** in all of the monitoring location at Kandla. While at Vadinar, the Concentration recorded as Below Quantification Limit at all the Monitoring locations.
- **Potassium:** The Concentration was found to be **BQL** in all of the monitoring location at Kandla While at Vadinar, the Concentration was found to be BQL in both Location.
- **Manganese:** The Concentration was found to be **BQL** in all of the monitoring location at Kandla While at Vadinar, the Concentration was found to be BQL in both Location.
- **Zinc:** The Concentration was found to be **BQL** in all of the monitoring location at Kandla While at Vadinar, the Concentration was found to be BQL in both Location.

- **Arsenic:** The concentration was found to be **Below Quantification Limit** in all of the Monitoring Location at Kandla. While at Vadinar was Observed **Below Quantification Limit** at both the locations.
- The parameters such **as Hexavalent Chromium**, and **the metals Arsenic, Cadmium, Total Chromium** were all observed to have concentrations "Below the Quantification Limit (BQL)" at majority of the locations during the monitoring period.
- **Total Coliforms:** During the monitoring period, at Kandla variation in the concentration of Total coliform was observed to be in the range of **BQL to 100 MPN/100ml**. While at Vadinar, the concentration recorded at DW-19 is **Below Quantification Limit** and at DW-20 is **40 MPN/100ml.**

## 8.4 Remedial Measures

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

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

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

# CHAPTER 9: SEWAGE TREATMENT PLANT MONITORING

## 9.1 Sewage Treatment Plant (STP) Monitoring:

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

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

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

The Consolidated Consent and Authorization (CC&A) issued by the GPCB were referred for the details of the STP for Kandla and Gopalpuri. The CC&A of Kandla and Gopalpuri entails that the treated domestic sewage should conform to the norms specified in **Table 24**. The treated effluent conforming to the norms shall be discharged on the land within the premises strictly for the gardening and plantation purpose. Whereas, no sewage shall be disposed outside the premises in any manner.

**Table 24: Treated effluent Standards (as per CC&A of Kandla STP)**

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

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

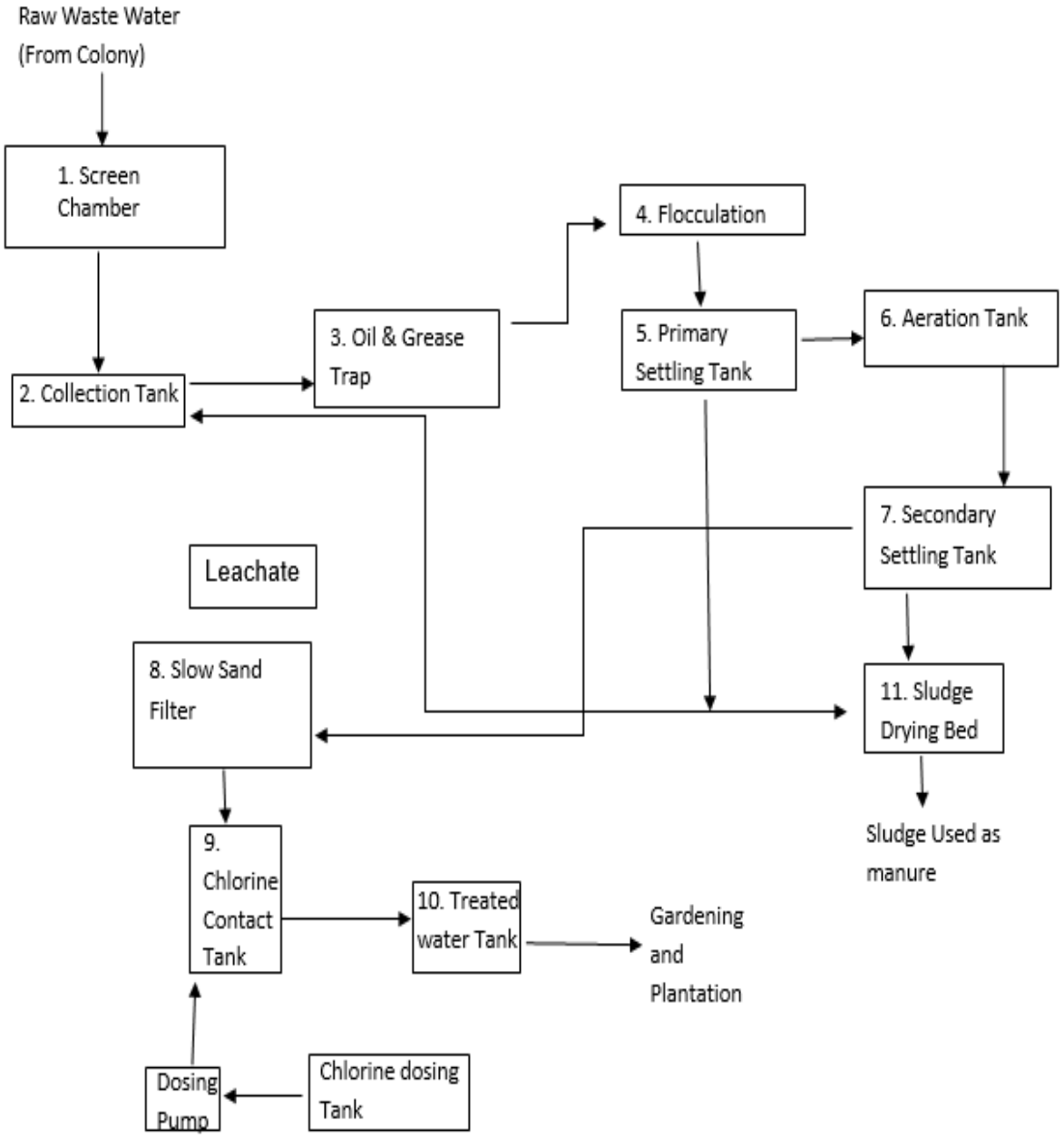



**Figure 3: Process flow diagram of STP at Kandla**

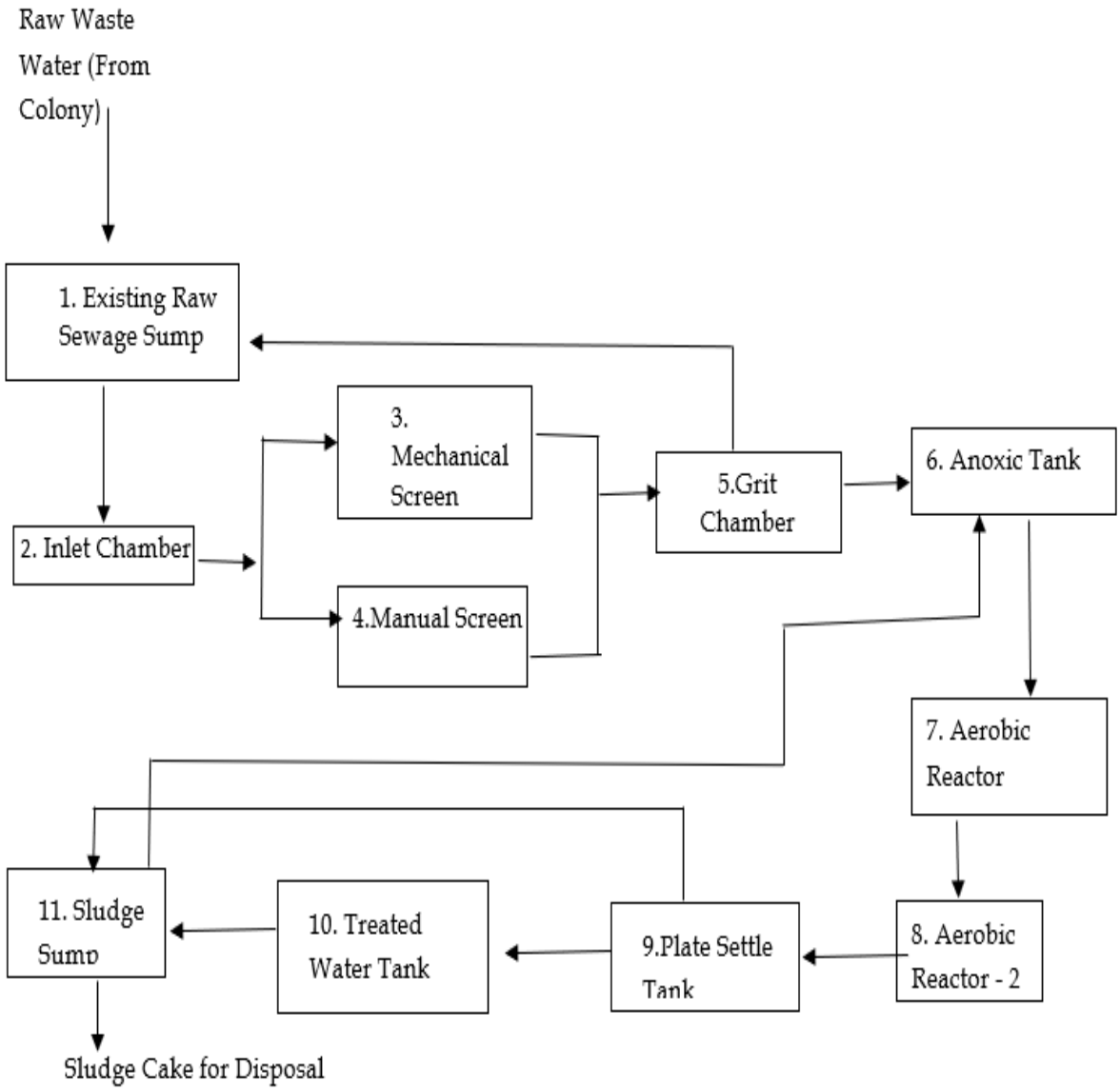



**Figure 4: Process flow diagram of STP at Gopalpuri**

**STP at Vadinar**

The STP at Vadinar has been built with a treatment capacity of 450 KLD/day. The Consolidated Consent and Authorization (CC&A) issued by the GPCB has been referred for the details of the said STP. The CC&A of the Vadinar STP suggests that the domestic effluent generated shall be treated as per the norms specified in **Table 25**. The treated effluent conforming to the norms shall be discharged on the land within the premises strictly for the gardening and plantation purpose. Whereas, no sewage shall be disposed outside the premises in any manner.

**Table 25: Norms of treated effluent as per CC&A of Vadinar STP**

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

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

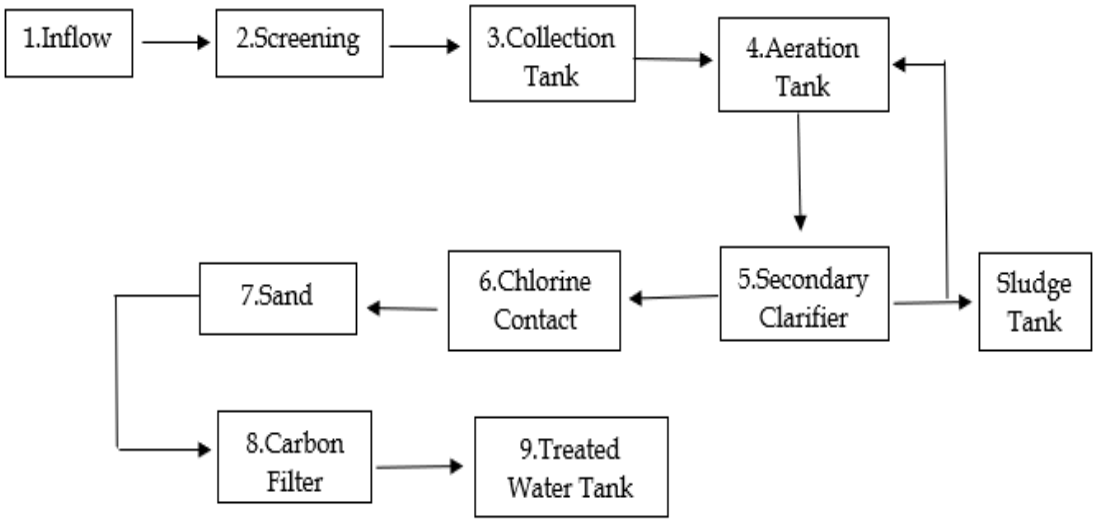
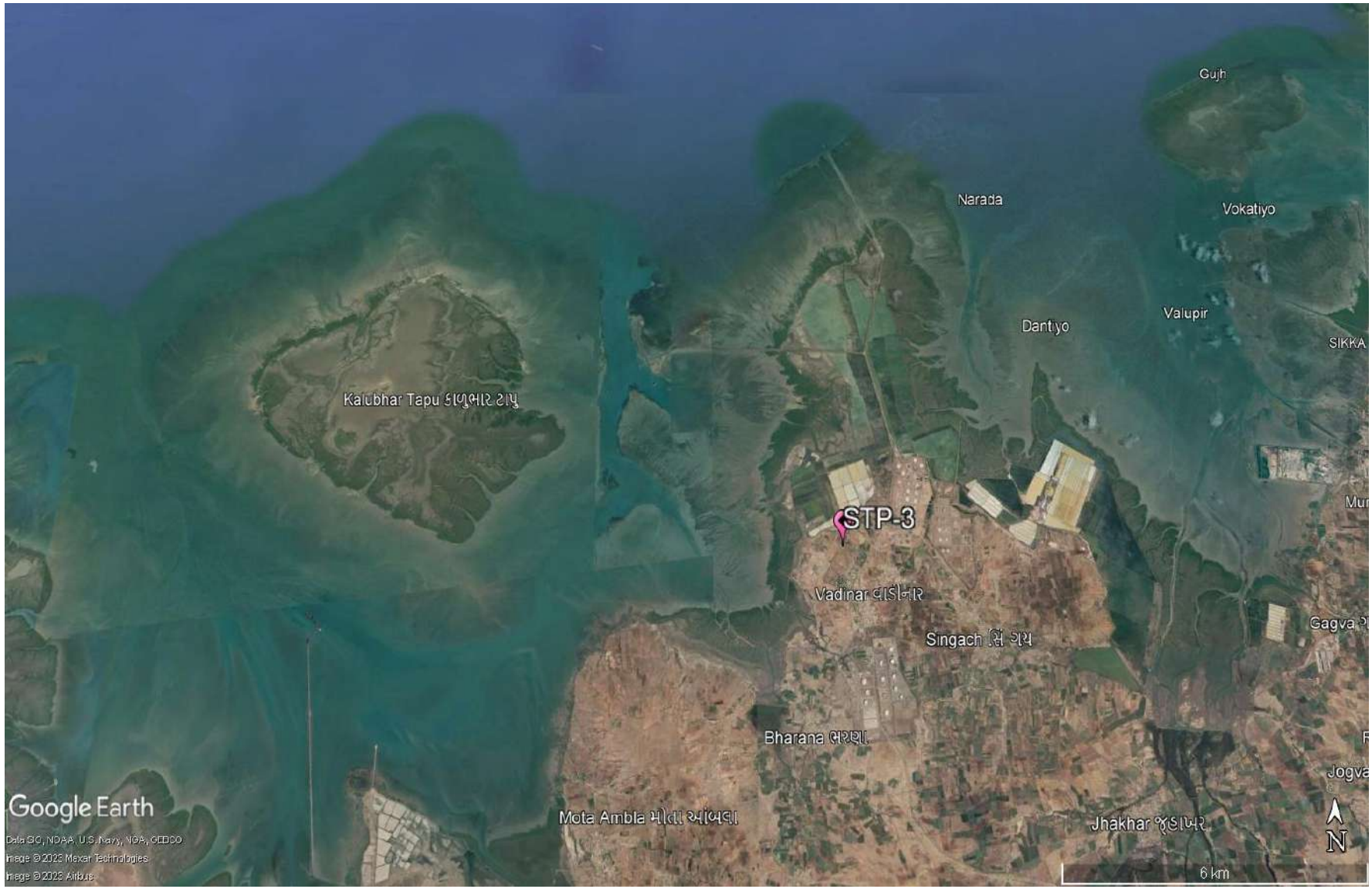



**Figure 5: Process flowchart for the STP at Vadinar**

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


**Map 14: Locations for STP Monitoring at Kandla**




**Map 15: Locations for STP Monitoring at Vadinar**

### Methodology

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

The water samples were collected from inlet and the outlet of the STP's and analyzed for physico-chemical and microbiological parameter. Collection and analysis of these samples was carried out as per established standard methods and procedures for the examination of water. The samples were analyzed for selected parameters to establish the existing water quality of the inlet and outlet points of the STP. GEMI has framed its own guidelines for collection of water/wastewater samples titled as 'Sampling Protocol for Water & Wastewater'; which has been approved by the Government of Gujarat vide letter no. ENV-102013-299-E dated 24-04-2014 under the provision of Water (Preservation and Control of Pollution) Act 1974. The sample collection and preservation are done as per the said Protocol. Under the project, the list of parameters to be monitored for the STP have been mentioned in **Table 26** as follows:

### Frequency

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

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

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

## 9.2 Result and Discussion

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

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

| Sr No. | Parameter | Units | GPCB Norms (Kandla) | Kandla | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Week 3 of August | | | | Week 4 of August | | | | Week 1 of September | | | | Week 2 of September | | | |
| | | | | STP-1 (Inlet) | STP-1 (Outlet) | STP-2 (Inlet) | STP-2 (Outlet) | STP-1 (Inlet) | STP-1 (Outlet) | STP-2 (Inlet) | STP-2 (Outlet) | STP-1 (Inlet) | STP-1 (Outlet) | STP-2 (Inlet) | STP-2 (Outlet) | STP-1 (Inlet) | STP-1 (Outlet) | STP-2 (Inlet) | STP-2 (Outlet) |
| **1.** | pH | - | **6.5-8.5** | 7.50 | 7.21 | 7.04 | 7.25 | 7.12 | 7.02 | 6.96 | 7.24 | 7.62 | 7.41 | 7.51 | 7.10 | 7.22 | 7.18 | 7.35 | 7.22 |
| **2.** | TDS | mg/L | - | 1354 | 1289 | 1268 | 1516 | 1423 | 1254 | 1438 | 1516 | 1321 | 1220 | 1126 | 1023 | 1365 | 1254 | 865 | 821 |
| **3.** | TSS | mg/L | **100** | 30 | 15 | 92 | 16 | 39 | 28 | 56 | 14 | 65 | 28 | 96 | 45 | 45 | 25 | 101 | 22 |
| **4.** | COD | mg/L | - | 132 | 55.2 | 206.5 | 68.8 | 198 | 112 | 227.6 | 36.6 | 112.3 | 58.4 | 71.1 | 28.3 | 122.0 | 60.0 | 111.0 | 41.0 |
| **5.** | DO | mg/L | - | BQL | 2.1 | BQL | 2.1 | BQL | 3.5 | BQL | 2.8 | BQL | 3.9 | BQL | 4.2 | BQL | 3.6 | BQL | 4.1 |
| **6.** | BOD | mg/L | **30** | 30.26 | 18.5 | 61.95 | 8.60 | 20.36 | 12.25 | 68.28 | 4.58 | 36.58 | 12.25 | 40.26 | 19.25 | 29.54 | 12.36 | 40.23 | 15.69 |
| **7.** | SAR | meq/L | - | 14.56 | 5.55 | 5.83 | 4.71 | 5.23 | 2.2 | 12.11 | 13.03 | 10.65 | 4.22 | 6.35 | 4.25 | 6.24 | 2.36 | 3.25 | 1.52 |
| **8.** | Total Coliforms | MPN/ 100ml | **<1000** | 1600 | 210 | 500 | 23 | 1600 | 120 | 1600 | 20 | 1600 | 50 | 1600 | 120 | 1600 | 220 | 1600 | 23 |

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

| Sr No. | Parameter | Units | GPCB Norms (Vadinar) | Vadinar | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Week 3 of August | | Week 4 of August | | Week 1 of September | | Week 2 of September | |
| | | | | STP-3 (Inlet) | STP-3 (Outlet) | STP-3 (Inlet) | STP-3 (Outlet) | STP-3 (Inlet) | STP-3 (Outlet) | STP-3 (Inlet) | STP-3 (Outlet) |
| **1.** | pH | - | **5.5-9** | 6.98 | 7.01 | 7.64 | 7.60 | 7.06 | 7.08 | 7.34 | 7.99 |
| **2.** | TDS | mg/L | - | 406 | 378 | 368 | 332 | 448 | 390 | 418 | 330 |
| **3.** | TSS | mg/L | **20** | 10 | 10 | 10 | 4 | 14 | 4 | 12 | 10 |
| **4.** | COD | mg/L | **50** | 100.8 | 36.3 | 96.8 | 36.3 | 94.9 | 39.5 | 105.7 | 28.5 |
| **5.** | DO | mg/L | - | 4.6 | 6.1 | 3.8 | 4.0 | 2.8 | 5.3 | 4.1 | 7.5 |
| **6.** | BOD | mg/L | **10** | 15.12 | 4.54 | 12.10 | 4.54 | 17.79 | 4.94 | 19.82 | 3.56 |
| **7.** | SAR | meq/L | - | 2.19 | 2.38 | 1.76 | 1.84 | 3.01 | 2.19 | 3.02 | 2.38 |
| **8.** | Total Coliforms | MPN/100ml | **100-230** | 1600 | 100 | 1600 | 50 | 1600 | 20 | 1600 | 23 |

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

## 9.3 Data Interpretation and Conclusion

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

- The **pH** of treated effluent from STPs at Kandla (STP-1 and STP-2) and Vadinar (STP-3) conform to their respective stipulated norms of **7.02 to 7.41** at Kandla and **7.01 to 7.99** at Vadinar respectively.
- The **TDS** of treated sewage at Kandla was ranges from **821 to 1516 mg/L**, whereas for Vadinar it ranges from **330 to 390 mg/L**.
- The **TSS** of the Treated effluent for the STP-1 and STP-2 at Kandla and STP-3 at Vadinar falls within the stipulated norms of 14 **to 45 mg/L and 4 to 10 mg/L** respectively as mentioned in their respective CCA.
- **COD** value for Kandla was observed in the range of **28.30 to 112 mg/L**. Whereas for Vadinar the value of COD falls within the range of **28.50 to 39.50 mg/L**.
- The value of **DO** was observed in the range of **2.10 to 4.20 mg/L** at Kandla, whereas for Vadinar it was observed in the range of **4.00 to 7.50 mg/L.**
- The **BOD** of the outlet for the STPs of Kandla and Vadinar falls within the stipulated norms.
- The value of **SAR** for Kandla was observed in the range of **1.52 to 13.03 meq/L**, whereas for Vadinar, it was observed in the range of **1.84 to 2.38 meq/L**.
- The value of **Total Coliforms** for Kandla was observed in the range of **20 to 220 MPN/100 ml**, whereas for Vadinar, it was observed in the range of **20 to 100 MPN/100 ml**.

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

## 9.4 Remedial Measures:

- The quantum of raw sewage (influent) entering the STP should be monitored by installation of the flow meter. If the quantity of the sewage exceeds the treatment capacity of the treatment plant, then provision of additional capacity of collection sump should be provided.
- The adequacy and efficacy of the stages of Sewage treatment units shall be conducted.
- The results show the presence of total coliforms; hence the method of disinfection (Chlorination) sodium or calcium Hypochlorite can be used.
- Effectiveness of any technology depends on factors such as the specific pollutants in the wastewater, plant size, local regulations, and available resources. There are several processes that may be implemented such as - Advanced oxidation process involve using strong oxidants to break down complex organic compounds. Methods like Fenton's

reagent (hydrogen peroxide and iron catalyst) and UV/$H_2O_2$ treatment can help in reducing COD through oxidation.

- Electrochemical processes like Electrocoagulation (EC) and Electrooxidation (EO) that involve the application of an electric current to facilitate the removal of pollutants through coagulation, flocculation, and oxidation. These methods can be useful for treating sewage containing various pollutants.

# CHAPTER 10: MARINE WATER QUALITY MONITORING

## 10.1 Marine Water

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

Major water quality concerns at ports include wastewater and leakage of toxic substances from ships, stormwater runoff, etc. This discharge of wastewater, combined with other ship wastes which includes sewage and wastewater from other on-board uses, is a serious threat to the water quality as well as to the marine life. As defined in the scope by DPA, the Marine Water sampling and analysis has to be carried out at a total of eight locations, six at Kandla and two at Vadinar. The marine water sampling has been carried out with the help of Niskin Sampler with a capacity of 5L. The Niskin Sampler is a device used to take water samples at a desired depth without the danger of mixing with water from other depths. Details of the locations to be monitored have been mentioned in **Table 29:**

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

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

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


**Map 16: Locations for Marine Water Monitoring at Kandla**


**Map 17: Locations for Marine Water Monitoring at Vadinar**

## Methodology

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

**Frequency:**

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

**Table 30: List of parameters monitored for Marine Water**

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

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

## 10.2 Result and Discussion

The quality of the Marine water samples collected from the locations of Kandla and Vadinar during the monitoring period has been summarized in the **Table 31**. The said water quality has been represented in comparison with the standard values as stipulated by CPCB for Class SW-IV Waters.

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

| Sr. No. | Parameters | Unit | Primary Water Quality Criteria for Class SW-IV Waters | Kandla | | | | | | Vadinar | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MW-1 | MW-2 | MW-3 | MW-4 | MW-5 | MW-6 | MW-7 | MW-8 |
| 1. | Density | kg/m³ | - | 1.02 | 1.021 | 1.022 | 1.023 | 1.021 | 1.02 | 1.023 | 1.022 |
| 2. | pH | - | 6.5-9.0 | 7.23 | 7.54 | 7.84 | 7.72 | 7.48 | 7.92 | 7.77 | 7.51 |
| 3. | Color | Hazen | No Noticeable | 1 | 1 | 1 | 1 | 1 | 1 | 5 | 5 |
| 4. | EC | µS/cm | - | 51,300 | 51,700 | 51,400 | 51,300 | 51,500 | 51,100 | 52,100 | 52,900 |
| 5. | Turbidity | NTU | - | 142 | 156 | 174 | 155 | 98 | 75 | 12.36 | 8.21 |
| 6. | TDS | mg/L | - | 37,168 | 37,256 | 37,214 | 37,159 | 37,145 | 36,847 | 35,264 | 34,156 |
| 7. | TSS | mg/L | - | 251 | 232 | 255 | 210 | 210 | 199 | 242 | 286 |
| 8. | COD | mg/L | - | 36.2 | 61.1 | 40.7 | 30.5 | 72.3 | 50.8 | 60.54 | 41.23 |
| 9. | DO | mg/L | 3.0 mg/L | 6.9 | 6.2 | 7.1 | 6.9 | 6.1 | 6.6 | 7.3 | 6.9 |
| 10. | BOD | mg/L | 5.0 mg/L | 3.2 | 3.5 | 3.3 | BQL | BQL | 4.1 | BQL | BQL |
| 11. | Oil & Grease | mg/L | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 12. | Sulphate | mg/L | - | 2568.3 | 2654.8 | 2695.1 | 2415.3 | 2587.6 | 2459.3 | 2514.62 | 2856.37 |
| 13. | Nitrate | mg/L | - | 3.255 | 3.369 | 3.568 | 3.321 | 3.125 | 3.198 | 1.569 | 1.328 |
| 14. | Nitrite | mg/L | - | BQL | BQL | 0.156 | BQL | BQL | BQL | BQL | BQL |
| 15. | Phosphate | mg/L | | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 16. | Silica | mg/L | - | 4.56 | 4.21 | 4.22 | 4.01 | 3.58 | 4.10 | 1.52 | 1.02 |
| 17. | Sodium | mg/L | - | 3,562 | 3,965 | 4,235 | 6,154 | 4,802 | 3,826 | >10000 | >10000 |
| 18. | Potassium | mg/L | - | 121.0 | 136.0 | 145.0 | 212.0 | 169.0 | 154.0 | 524.0 | 658.00 |
| 19. | Hexavalent Chromium | mg/L | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 20. | Odour | - | - | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 21. | Arsenic | mg/L | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 22. | Cadmium | mg/L | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 23. | Copper | mg/L | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 24. | Iron | mg/L | - | 1.489 | 1.548 | 1.266 | 1.85 | 1.269 | 0.514 | 0.189 | BQL |
| 25. | Lead | mg/L | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 26. | Manganese | mg/L | - | 0.060 | 0.073 | 0.050 | 0.065 | 0.039 | 0.022 | BQL | BQL |
| 27. | Total Chromium | mg/L | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 28. | Zinc | mg/L | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 29. | Mercury | mg/L | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 30. | Particulate Organic Carbon | mg/L | - | 1.25 | 1.45 | 1.69 | 1.39 | 1.2 | 0.41 | 0.09 | BQL |
| 31. | Total Coliforms | MPN/ 100ml | 500/100 ml | 4 | 8 | 4 | 2 | 8 | 16 | 18 | 22 |

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

## 10.3 Data Interpretation and Conclusion

The Marine water quality of Deendayal Port Harbor waters at Kandla and Vadinar has been monitored for various physico-chemical and biological parameters during the monitoring period. The detailed interpretation of the parameters in comparison to the Class SW-IV for Harbour Waters is as follows:

- **Density** at Kandla was observed in the range of **1.02 to 1.023 kg/m³**, with the average of **1.02 kg/m³.** Whereas for the location of Vadinar, it was observed **1.023 kg/m³** at MW-7 and **1.022 kg/m³** at MW-8, with the average of **1.023 kg/m³**.
- **pH** at Kandla was observed in the range of **7.23 to 7.92,** with the average pH as **7.62**. Whereas for the locations of Vadinar, it was observed in the range of be **7.51 to 7.77**, with the average pH as **7.64**. For the monitoring location of both the study areas, pH was found to comply with the norms of 6.5-8.5.
- **Color** range varied from **1 Hazen** at all the monitoring locations in Kandla, and for Vadinar, it found **5 Hazen** for the both of the location.
- **Electrical conductivity (EC)** was observed in the range of **51,100 to 51,700 µS/cm**, with the average EC as **51,383.3 µS/cm** for the locations of Kandla, whereas for the locations of Vadinar, it was observed in the range of **52,100 to 52,900 µS/cm**, with the average EC as **52,500 µS/cm**.
- For all monitoring locations of Kandla the value of **Turbidity** was observed in the range of **75 to 174 NTU**, with average value of **133.33 NTU**. For Vadinar it ranges from **8.21 to 12.36 NTU**, with average of **10.28 NTU**. Materials that cause water to be turbid include clay, silt, finely divided organic and inorganic matter, soluble coloured organic compounds, plankton and microscopic organisms. Turbidity affects the amount of light penetrating to the plants for photosynthesis.
- For the monitoring locations at Kandla the value of **Total Dissolved Solids (TDS)** ranged from **36,847 to 37,256 mg/L**, with an average value of **37,131.50 mg/L**. Similarly, at Vadinar, the TDS values ranged from **34,156 to 35,264 mg/L**, with an average value of 34,710 **mg/L**.
- **TSS** values in the studied area varied between **199 to 255 mg/L** at Kandla and **242 to 286 mg/L** at Vadinar, with the average value of **226.17 mg/L and 264 mg/L** respectively for Kandla and Vadinar.

- **COD** varied between **30.5 to 72.3 mg/L** at Kandla and **41.23 to 60.54 mg/L** at Vadinar, with the average value as **48.60 and 50.88 mg/L** respectively for Kandla and Vadinar.
- **DO** level in the studied area varied between **6.1 to 7.1 mg/L** at Kandla and **6.9 to 7.3 mg/L** at Vadinar, with the average value of **6.63 mg/L and 7.10 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 **3.2 to 4.1 mg/L**, with average of **3.53 mg/L** for the location of Kandla and for the locations of Vadinar, it was detected **Below Quantification Limit** for all sampling locations.
- **Sulphate** concentration in the studied area varied between **2415.36 to 2695.12 mg/L** at Kandla and **2514.62 to 2856.37 mg/L** at Vadinar. The average value observed at Kandla was **2563.44 mg/L**, whereas **2685.49 mg/L** was the average value of Vadinar. Sulphate is naturally formed in inland waters by mineral weathering or the decomposition and combustion of organic matter.
- **Nitrate** in the study area was observed in the range of **3.125 to 3.568 mg/L**, with the average of **3.31 mg/L**. Whereas for the Vadinar, recorded value was observed in the range of **1.328 to 1.569 mg/L**, with the average of **1.449 mg/L.**
- In the study area of Kandla the concentration of **Potassium** varied between **121 to 212 mg/L** and **524 to 658 mg/L** at Vadinar, with the average value as **156.17 mg/L and 591 mg/L** respectively for Kandla and Vadinar.
- **Silica** in the studied area varied between **3.58 to 4.56 mg/L**, with the average of **4.11 mg/L**, at Kandla. Vadinar, observed value was found to be **1.52 mg/L** at location MW-7 and **1.02 mg/L** at MS-8 location.
- **Sodium** in the study area varied between **3562 to 6154 mg/L**, with average of **4424 mg/L**, at Kandla whereas at Vadinar the sodium concentration value was detected to be **more than 10,000 mg/L** at both locations.
- **Odour** was observed **1** for all locations of Kandla and Vadinar.
- **Copper** in the study area, was detected **below the quantification limit (BQL)" at** Kandla and whereas Vadinar was detected **below the quantification limit (BQL)"** for the all-sampling location.
- **Iron** in the studied area varied between **0.514 to 1.85 mg/L**, with the average of **1.32 mg/L,** at Kandla, and for Vadinar value were recorded **0.189 mg/L** for location MW-7 and **Below Quantification Limit** for location MW-8.
- **Lead** concentration at Kandla was detected **below the quantification limit (BQL)"** for the all-sampling location. and whereas Vadinar was detected **below the quantification limit (BQL)"** for the all-sampling location.
- **Manganese** in the studied area varied between **0.022 to 0.073 mg/L**, with the average of 0.052 mg/L, at Kandla and whereas Vadinar was detected **below the quantification limit (BQL)"** for the all-sampling location.
- **Particulate Organic Carbon** in the study area was observed in the range of **0.41 to 1.69**, with the average value of **1.23**. Whereas for the Vadinar, the value observed was **0.09** at MW-7 and **Below Quantification Limit** at MW-8.

- **Oil & Grease, Nitrite, Phosphate, Hexavalent Chromium, Arsenic, Cadmium, Total Chromium, Zinc, Mercury and Floating Material (Oil grease scum, petroleum products)** were observed to have concentrations **"Below the Quantification Limits (BQL)"** for most of the locations of Kandla and Vadinar.
- **Total Coliforms** were detected complying with the specified norm of 500 MPN/100ml for all the locations of Kandla and Vadinar.

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

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

# CHAPTER 11: MARINE SEDIMENT QUALITY MONITORING

## 11.1 Marine Sediment Monitoring

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

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

### Methodology

As defined in the scope by DPA, the Marine Sediment sampling is required to be carried out once in a month at total eight locations, i.e., six at Kandla and two at Vadinar. The sampling of the Marine Sediment is carried out using the Van Veen Grab Sampler (make Holy Scientific Instruments Pvt. Ltd). The Van Veen Grab sampler is an instrument to sample (disturbed) sediment up to a depth of 20-30 cm into the sea bed. While letting the instrument down on the seafloor, sediment can be extracted. The details of locations of Marine Sediment to be monitored under the study are mentioned in **Table 32** as follows:

**Table 32: Details of the sampling locations for Marine Sediment**

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

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


**Map 18: Location of Marine Sediment Monitoring at Kandla**


**Map 19: Locations of Marine Sediment Monitoring at Vadinar**

The list of parameters to be monitored under the projects for the Marine Sediment sampling been mentioned in **Table 33** as follows:

**Table 33: List of parameters to be monitored for Sediments at Kandla and Vadinar**

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

## 11.2 Result and Discussion

The quality of Marine Sediment samples collected from the locations of Kandla and Vadinar during the monitoring period has been summarized in the **Table 34.**

**Table 34: Summarized result of Marine Sediment Quality**

| Sr No. | Parameters | Unit | Kandla | | | | | | Vadinar | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | MS-1 | MS-2 | MS-3 | MS-4 | MS-5 | MS-6 | MS-7 | MS-8 |
| 1. | Inorganic Phosphate | kg/ ha | 1.02 | 4.23 | 2.65 | 1.56 | 0.91 | 0.94 | 0.91 | 0.62 |
| 2. | Phosphate | mg/Kg | 321.25 | 512.36 | 436.51 | 320.16 | 265.21 | 220.14 | 423.65 | 303.54 |
| 3. | Organic Matter | % | 1.2 | 1.96 | 1.56 | 1.12 | 1.45 | 1.20 | 1.45 | 1.72 |
| 4. | Sulphate as $SO^{4-}$ | mg/Kg | 303.21 | 108.51 | 110.36 | 85.46 | 100.25 | 92.17 | 125.36 | 136.28 |
| 5. | Calcium as Ca | mg/Kg | 4200.00 | 1800.00 | 2200.00 | 1600.00 | 1900.00 | 1700.00 | 2300.00 | 1900.00 |
| 6. | Magnesium as Mg | mg/Kg | 795.00 | 958.00 | 1475.00 | 745.00 | 1023.00 | 841.00 | 982.00 | 1265.40 |
| 7. | Silica | g/Kg | 421.31 | 326.24 | 169.46 | 326.42 | 315.41 | 421.28 | 200.25 | 259.64 |
| 8. | Nitrite | mg/Kg | 1.15 | 1.09 | 1.2 | 1.01 | 1.03 | 1.12 | 0.45 | 0.26 |
| 9. | Nitrate | mg/Kg | 6.12 | 5.21 | 4.13 | 5.23 | 6.42 | 6.31 | 15.24 | 8.29 |
| 10. | Sodium | mg/Kg | 2861 | 2215 | 2856 | 2036 | 3014 | 3954 | 7546 | 8952 |
| 11. | Potassium | mg/Kg | 1956 | 1854 | 1926 | 2136 | 2525 | 3067 | 1347 | 3256 |
| 12. | Copper | mg/Kg | 38.22 | 42.57 | 45.56 | 32.17 | 42.1 | 29.53 | 16.25 | 22.31 |
| 13. | Aluminium | mg/Kg | 35268.4 | 36529.5 | 37514.6 | 25187.6 | 35268.6 | 29543 | 15423.61 | 25146.25 |
| 14. | Chromium | mg/Kg | 72.36 | 74.65 | 71.39 | 72.55 | 62.58 | 51.36 | 40.26 | 35.28 |
| 15. | Nickel | mg/Kg | 29.35 | 25.21 | 22.59 | 21.85 | 36.27 | 21.26 | 20.24 | 30.58 |
| 16. | Zinc | mg/Kg | 101.26 | 268.54 | 362.14 | 101.22 | 85.36 | 79.58 | 18.25 | 39.41 |
| 17. | Cadmium | mg/Kg | BQL | BQL | BQL | 0.54 | BQL | BQL | 0.006 | BQL |
| 18. | Lead | mg/Kg | 7.31 | 10.25 | 19.24 | 12.33 | 9.51 | 6.22 | 3.26 | 8.47 |
| 19. | Arsenic | mg/Kg | 4.12 | 3.62 | 6.28 | 7.26 | 4.26 | 3.2 | 2.59 | 5.21 |
| 20. | Mercury | mg/Kg | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 21. | Texture | - | Silt Loam | Sandy Loam | Silt Loam | Loam | Silt Loam | Silt Loam | Sandy Loam | Loam |

## 11.3 Data Interpretation and Conclusion

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

- **Inorganic Phosphate** for the sampling period was observed in range of **0.91 to 4.23** Kg/ha for Kandla. Whereas for Vadinar the value observed at location MS-7 (Nakti creek) is 0.91 Kg/ha and MS-8 (Near Vadinar Jetty) is 0.62 Kg/ha. For Kandla and Vadinar the average value of Inorganic Phosphate was observed 1.89 and 0.77 Kg/ha respectively.
- The concentration of **Phosphate** was observed in range of **220.14 to 512.36 mg/Kg** for Kandla and for Vadinar the value observed at location MS-7 (Nakti creek) as 423.65 mg/Kg and MS-8 (Near Vadinar Jetty) as 303.54 mg/Kg. For Kandla and Vadinar the average concentration of Phosphate was observed 345.94 and 363.60 mg/Kg respectively.

- The **Organic Matter** for the sampling period was observed in the range of **1.12 to 1.96**% for Kandla with the average value of 1.42% and for Vadinar the value recorded at location MS-7 and MS-8 was observed 1.45% & 1.72% respectively, with average concentration as 1.59 %.
- The concentration of **Sulphate** was observed in the range of **85.46 to 303.21 mg/Kg** for Kandla and for Vadinar the value observed at MS-7 is 125.36 mg/Kg and at MS-8 is 136.28 mg/Kg. For Kandla and Vadinar the average value of Sulphate was observed 133.33 and 130.82 mg/Kg respectively.
- The value of **Calcium** was observed in the range of **1600 to 4200 mg/Kg** for Kandla and for Vadinar the value observed at MS-7 is 2300 mg/Kg and at MS-8, is 1900 mg/Kg. The average value of Calcium for the monitoring period was observed 2233.33 mg/Kg and 2100 mg/Kg at Kandla and Vadinar, respectively.
- The value of **Magnesium** for the sampling period was observed in the range of **745 to 1475 mg/Kg** for Kandla and for Vadinar the value observed at MS-7 is 982 mg/Kg and at MS-8, is 1265.40 mg/Kg. For Kandla and Vadinar the average value of Magnesium was observed 972.83 mg/Kg and 1123.70 mg/Kg respectively.
- For the sampling period **Silica** was observed in the range of **169.46 to 421.31 mg/Kg** for Kandla with average value 330.02 mg/Kg and for Vadinar the value observed to be 200.25 and 259.64 mg/Kg at MS-7 and MS-8, respectively with average 229.95 mg/Kg.
- The value of **Nitrate** was observed in the range of **4.13 to 6.42 mg/Kg** for Kandla with average value 5.57 mg/Kg and for Vadinar the value observed to be 15.24 and 8.29 mg/Kg at MS-7 and MS-8, respectively with average 11.77 mg/Kg.
- The value of **Nitrite** was observed in the range of **1.01 to 1.20 mg/Kg** for Kandla with average value 1.10 mg/Kg and for Vadinar the value observed to be 0.45 and 0.26 mg/Kg at MS-7 and MS-8, respectively with average 0.36 mg/Kg.
- The value of **Sodium** was observed in the range of 2036 **to 3954 mg/Kg** for Kandla with average value 2822.67 mg/Kg and for Vadinar the value observed to be 7546 and 8952 mg/Kg at MS-7 and MS-8, respectively with average 8249 mg/Kg.
- The value of **Potassium** was observed in the range of **1854 to 3067 mg/Kg** for Kandla with average value 2244 mg/Kg and for Vadinar the value observed to be 1347 and 3256 mg/Kg at MS-7 and MS-8, respectively with average 2301.50 mg/Kg.
- The value of **Aluminium**, was observed in the range of **25187.6 to 37514.6 mg/Kg** for Kandla with average value 33218.62 mg/Kg and for Vadinar the value observed to be 15423.61 and 25146.25 mg/Kg at MS-7 and MS-8, respectively with average 20284.93 mg/Kg.
- The value of **Mercury** was observed "Below the Quantification Limit" at all the eight-monitoring location of Kandla and Vadinar.
- Texture was observed to be "**Sandy Loam**" and "Slit Loam" at location MS-1, MS-2, MS-3, MS-4, MS-5, MS-6 in Kandla. "**Sandy Loam**" at location MS-7 & "**loam"** at location MS-8 in Vadinar during sampling period.

**Heavy Metals**

The sediment quality of Kandla and Vadinar has been compared with respect to the Average Standard guideline applicable for heavy metals in marine sediment specified by EPA have been mentioned in **Table 35.**

**Table 35: Standard Guidelines applicable for heavy metals in sediments**

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

*(Source: G Perin et al. 1997)*

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

| Sr. No. | Parameters | Unit | Kandla | | | | | | Vadinar | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | MS-1 | MS-2 | MS-3 | MS-4 | MS-5 | MS-6 | MS-7 | MS-8 |
| 1. | Arsenic | mg/Kg | 4.12 | 3.62 | 6.28 | 7.26 | 4.26 | 3.2 | 2.59 | 5.21 |
| 2. | Copper | mg/Kg | 38.22 | 42.57 | 45.56 | 32.17 | 42.1 | 29.53 | 16.25 | 22.31 |
| 3. | Chromium | mg/Kg | 72.36 | 74.65 | 71.39 | 72.55 | 62.58 | 51.36 | 40.26 | 35.28 |
| 4. | Nickel | mg/Kg | 29.35 | 25.21 | 22.59 | 21.85 | 36.27 | 21.26 | 20.24 | 30.58 |
| 5. | Lead | mg/Kg | 7.31 | 10.25 | 19.24 | 12.33 | 9.51 | 6.22 | 3.26 | 8.47 |
| 6. | Zinc | mg/Kg | 101.26 | 268.54 | 362.14 | 101.22 | 85.36 | 79.58 | 18.25 | 39.41 |
| 7. | Cadmium | mg/Kg | BQL | BQL | BQL | 0.54 | BQL | BQL | 0.006 | BQL |

- **Arsenic** was observed in the range of **3.2 to 7.26 mg/Kg** for Kandla with average value 4.79 mg/Kg and for Vadinar the value observed to be 2.59 and 5.21 mg/Kg at MS-7 and MS-8, respectively with average 3.90 mg/Kg. With reference to the guidelines mentioned in table 35, the sediment quality with respect to arsenic falls in moderately polluted class.
- **Copper** was observed in the range of **29.53 to 45.56 mg/Kg** for Kandla with average value 38.36 mg/Kg and for Vadinar the value observed to be 16.25 and 22.31 mg/Kg at MS-7 and MS-8, respectively with average 19.28 mg/Kg. With reference to the guidelines mentioned in table 35, the sediment quality with respect to copper falls in Moderately polluted class.
- **Chromium** was observed in the range of 71.39 **to 99.39 mg/Kg** for Kandla with average Value 79.03 mg/Kg and for Vadinar the value observed to be 40.26 and 35.28 mg/Kg at MS-7 and MS-8, respectively with average 37.77 mg/Kg. With reference to the guidelines mentioned in table 35, the sediment quality with respect to chromium falls under moderately polluted class.

- **Nickel** was observed in the range of **21.26 to 36.27 mg/Kg** for Kandla with average value 26.09 mg/Kg and for Vadinar the value observed to be 20.24 and 30.58 mg/Kg at MS-7 and MS-8, respectively with average 25.41 mg/Kg. With reference to the guidelines mentioned in table 35, the sediment quality with respect to nickel falls in moderately polluted class.
- **Lead** was observed in the range of **6.22 to 19.24 mg/Kg** for Kandla with average value 10.81 mg/Kg and for Vadinar the value observed to be 3.26 and 8.47 mg/Kg at MS-7 and MS-8, respectively with average 5.87 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 **79.58 to 195.43 mg/Kg** for Kandla with average value 119.21 mg/Kg and for Vadinar the value observed to be 18.25 and 39.41 mg/Kg at MS-7 and MS-8, respectively with average 28.83 mg/Kg. With reference to the guidelines mentioned in table 35, the sediment quality with respect to zinc falls in moderately polluted class
- **Cadmium** was observed BQL for all locations at Kandla and Vadinar except MS-7 during sampling period. With reference to the guidelines mentioned in table 35, the sediment quality with respect to cadmium falls in non-polluted class.

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

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

# CHAPTER 12: MARINE ECOLOGY MONITORING

## 12.1 Marine Ecological Monitoring

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

As defined in the scope by DPA, the Marine Ecological Monitoring is required to be carried out once a month specifically at eight locations, six at Kandla and two at Vadinar. The sampling of the Benthic Invertebrates has been carried out with the help of D-frame nets, whereas the sampling of zooplankton and phytoplankton has been carried out with the help of Plankton Nets (60 micron and 20 micron). The details of the locations of Marine Ecological Monitoring have been mentioned in **Table 37** as follows:

**Table 37: Details of the sampling locations for Marine Ecological**

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

The map depicting the locations of Marine Ecological monitoring in Kandla and Vadinar have been mentioned in **Map 20 and 21** as follows:


**Map 20: Locations of Marine Ecological Monitoring at Kandla**


**Map 21: Locations of Marine Ecological Monitoring at Vadinar**

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

**Table 38: List of parameters to be monitored for Marine Ecological Monitoring**

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

## Methodology

- **Processing for chlorophyll estimation:**

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

- **Phytoplankton Estimation**

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

phytoplankton is mostly microscopic and unicellular floating flora, which are the primary producers that support the pelagic food-chain. The two most prominent groups of phytoplankton are Diatoms (*Bacillariophyceae*) and Dinoflagellates (*Dinophyceae*). Phytoplankton also include numerous and diverse collection of extremely small, motile algae which are termed micro flagellates (naked flagellates) as well as Cyanophytes (Bluegreen algae). Algae are an ecologically important group in most aquatic ecosystems and have been an important component of biological monitoring programs. Algae are ideally suited for water quality assessment because they have rapid reproduction rates and very short life cycles, making them valuable indicators of short-term impacts. Aquatic populations are impacted by anthropogenic stress, resulting in a variety of alterations in the biological integrity of aquatic systems. Algae can serve as an indicator of the degree of deterioration of water quality, and many algal indicators have been used to assess environmental status.

- **Zooplankton Estimation**

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

- **Benthic Organisms Estimation**

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

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

- **Diversity Index**

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

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

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

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

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

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

2. **Simpson's index:**

A reasonably high level of dominance by one or a small number of species is indicated by the range of **0.89 to 0.91**. The general health and stability of the ecosystem may be

impacted by this dominance. Community disturbances or modifications that affect the dominant species may be more likely to have an impact. The dominating species determined by the Simpson's index can have big consequences on how the community is organised and how ecological interactions take place.

The formula for calculating D is presented as:

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

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

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

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

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

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

Where, N = total number of individuals collected

S = No. of taxa or species or genera

**4. Berger-Parker index:**

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

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

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

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

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

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

5. **Evenness index–**

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

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

Where, H= Shannon value

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

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

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

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

## 12.2 Result and Discussion

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

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

| Sr. No. | Parameters | Unit | Kandla | | | | | | Vadinar | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | ME-1 | ME-2 | ME-3 | ME-4 | ME-5 | ME-6 | ME-7 | ME-8 |
| 1. | Biomass | mg/L | 202 | 89 | 55 | 120 | 65 | 101 | 91 | 112 |
| 2. | Net Primary Productivity | mg/L/hr | BQL | 0.42 | BQL | BQL | 0.26 | BQL | BQL | BQL |
| 3. | Gross Primary Productivity | mg/L/hr | 0.21 | 0.32 | 1.02 | 1.31 | 1.21 | 0.36 | 0.71 | 1.02 |
| 4. | Pheophytin | mg/m$^3$ | BQL | 1.12 | 0.72 | 1.29 | 1.08 | 0.62 | 1.05 | 1.32 |
| 5. | Chlorophyll-a | mg/m$^3$ | 3.16 | 1.2 | 1.35 | 1.18 | 1.22 | 1.16 | 1.48 | 1.62 |
| 6. | Particulate Oxidisable Organic Carbon | mg/L | 1.52 | 1.25 | 0.35 | 0.79 | 1.02 | 0.91 | 0.6 | 0.78 |
| 7. | Secchi Depth | ft | 0.72 | 0.62 | 0.45 | 0.81 | 0.91 | 0.76 | 1.26 | 1.33 |

- **Biomass:**
  With reference to the **Table 39**, the concentration of **Biomass** reported from location ME-1 to ME-6 in range between **55 to 202 mg/L** where lowest biomass presents in ME-3 (Near Coal Berth) and highest biomass present in ME-1 (Near Passenger Jetty One) during sampling period. In Vadinar, the value of biomass was observed **91 mg/L** at ME-7 (Near SPM) and **112 mg/L** in ME-8 (Near Vadinar Jetty) monitoring station.

- **Productivity (Net and Gross)**
  **Gross primary productivity (GPP)** is the rate at which organic matter is synthesised by producers per unit area and time (GPP). The amount of carbon fixed during photosynthesis by all producers in an ecosystem is referred to as gross primary productivity. The monitoring location of Kandla reported GPP value in range between 0.21 to 1.31 mg/L/ Hr where the highest value recorded for ME-4 (khori Creek)) and lowest recorded at ME-1 (Near Passenger Jetty One). In Vadinar, the value of GPP was observed 0.71 at ME-7 (Near SPM) and 1.02 at ME-8 (Near Vadinar Jetty) monitoring station.

  **Net primary productivity**, is the amount of fixed carbon that is not consumed by plants, and it is this remaining fixed carbon that is made available to various consumers in the ecosystem. The Net primary productivity of the monitoring location at Kandla from (ME-1 to ME-6) has been recorded in as **BQL (Below Quantification Limit) except ME-2 and ME-5.** While in Vadinar, the value of **NPP** was observed **BQL (Below Quantification Limit).** at ME-7 (Near SPM) and ME-8 (Near Vadinar Jetty) monitoring station.

- **Pheophytin**
  The level of Pheophytin was detected in the range from **0.62 to 1.29 mg/m$^3$** where the highest value observed at ME-4 (Khori Creek) and the lowest value observed at ME-1 (Near Passenger Jetty One). While in Vadinar, the value of Pheophytin was observed 1.05 mg/m3 at ME-7 and **1.32 mg/m$^3$** at ME-8 monitoring station.

- **Chlorophyll-a**

In the sub surface water, the value of Chlorophyll-a reported in range from **1.16 to 3.16 mg/m$^3$**. The highest value observed at ME-1 (Near Passenger Jetty One) while the lowest value observed at ME-6 (Nakti Creek (near NH - 8A)). In Vadinar, the value of chlorophyll-a was observed **1.48 mg/m$^3$** at ME-7 (Near SPM) and **1.62 mg/m$^3$** in ME-8 (Near Vadinar Jetty) monitoring station.

- **Particulate Oxidisable Organic Carbon**

  During the sampling period, the particulate oxidisable organic carbon falls within the range of **0.35 to 1.52 mg/L** from monitoring location ME-1 to ME-6 at Kandla, whereas for Vadinar, the value of POC observed **0.60 mg/L** at ME-7 (Near SPM) and **0.78 mg/L** in ME-8 (Near Vadinar Jetty) monitoring station.

- **Secchi Depth**

  In monitoring station of Kandla (ME-1 to ME-6) the level of Secchi Depth was observed between **0.45 to 0.91 ft** whereas at Vadinar, the value recorded at ME-7 i.e. Near SPM is **1.26 ft** and in Near Vadinar Jetty is **1.33 ft**.

**Ecological Diversity**

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

The details of variation in abundance and diversity in phytoplankton communities are mentioned in **Table 40**.

**Table 40: Phytoplankton variations in abundance and diversity in sub surface sampling stations**

| Genera | ME-1 | ME-2 | ME-3 | ME-4 | ME-5 | ME-6 | ME-7 | ME-8 |
|---|---|---|---|---|---|---|---|---|
| *Bacillaria sp.* | 156 | 136 | - | - | 212 | - | - | - |
| *Biddulphia sp.* | - | - | 231 | 122 | - | - | 133 | 148 |
| *Chaetoceros sp.* | 185 | - | - | - | 132 | - | - | - |
| *Chlamydomonas sp.* | - | 147 | - | 184 | - | 121 | - | - |
| *Cyclotella sp.* | 172 | - | 194 | - | 156 | - | - | - |
| *Coscinodiscus sp.* | - | 176 | - | 189 | - | 148 | 184 | 200 |
| *Ditylum sp* | 256 | - | 152 | 176 | - | - | - | - |
| *Fragilaria sp.* | - | - | - | - | - | 235 | - | 188 |
| *Bacteriastrum sp.* | 168 | - | 136 | 157 | 185 | - | 238 | 195 |
| *Pleurosigma sp.* | - | 185 | - | - | - | 152 | 182 | - |
| *Navicula sp.* | 212 | - | 189 | - | - | - | - | - |
| *Merismopedia sp.* | - | 201 | - | 158 | - | 174 | - | - |
| *Synedra sp.* | - | - | - | - | 145 | - | - | 141 |
| *Skeletonema sp.* | - | 194 | - | - | - | 222 | - | 166 |
| *Oscillatoria sp.* | - | - | 137 | - | 165 | - | 210 | - |
| *Thallassiosira* | 142 | 169 | - | 198 | - | 201 | - | 232 |
| *Gomphonema sp.* | - | - | 213 | - | 194 | - | 247 | - |
| **Density-Units/L** | **1291** | **1208** | **1252** | **1184** | **1189** | **1253** | **1194** | **1270** |
| **No. of genera** | **7** | **7** | **7** | **7** | **7** | **7** | **6** | **7** |

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

The density of phytoplankton of the sampling stations from ME-1 to ME-6 (Kandla) varying from **1184 to 1291 units/L,** while for Vadinar its density of phytoplankton observed **1194 units/L at ME-7 and 1270 units/L at ME-8.** During the sampling, phytoplankton communities were dominated, *Bacteriastrum sp., Chlamydomonas sp., Cyclotella sp, Thallassiosira , Gomphonema sp, in* Kandla, while *Biddulphia sp., Bacteriastrum sp., Cosinodiscus sp.* in Vadinar.

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

**Table 41: Species richness Index and Diversity Index in Phytoplankton**

| Indices | ME-1 | ME-2 | ME-3 | ME-4 | ME-5 | ME-6 | ME-7 | ME-8 |
|---|---|---|---|---|---|---|---|---|
| Taxa S | 7 | 7 | 7 | 7 | 7 | 7 | 6 | 7 |
| Individuals | 1291 | 1208 | 1252 | 1184 | 1189 | 1253 | 1194 | 1270 |
| Shannon diversity | 1.93 | 1.88 | 1.90 | 1.85 | 1.86 | 1.89 | 1.71 | 1.92 |
| Simpson 1-D | 0.85 | 0.86 | 0.85 | 0.83 | 0.85 | 0.85 | 0.83 | 0.85 |
| Species Evenness | 0.99 | 0.97 | 0.98 | 0.95 | 0.96 | 0.97 | 0.95 | 0.99 |
| Margalef richness | 0.84 | 0.85 | 0.84 | 0.85 | 0.85 | 0.84 | 0.71 | 0.84 |
| Berger-Parker | 0.20 | 0.17 | 0.18 | 0.17 | 0.18 | 0.19 | 0.21 | 0.18 |
| Relative abundance | 0.54 | 0.58 | 0.56 | 0.59 | 0.59 | 0.56 | 0.50 | 0.55 |

- **Shannon- Wiener's Index (H)** of phytoplankton communities was in the range of **1.85 to 1.93** between selected sampling stations from ME-1 to ME-6 with an average value of **1.89** at Kandla creek and its nearby creeks. While for Vadinar, Shannon Wiener's index of phytoplankton communities recorded to be **1.71** at location ME-7 and **1.92** at ME-8 with an average value of **1.82**. The apportionment of the numbers of individuals among the species observed higher stability at all monitoring location of Kandla.

- **Simpson diversity index (1-D)** of phytoplankton communities was ranged between **0.83 to 0.86** at all sampling stations in the Kandla creek and nearby creeks, with an average of **0.85** Similarly, for Vadinar Simpson diversity index (1-D) of phytoplankton communities was **0.83** at location ME-7 and **0.85** at ME-8 with an average of **0.84**.

- **Margalef's diversity index** (Species Richness) of phytoplankton communities in Kandla and nearby creeks sampling stations was varying from **0.84 to 0.85** with an average of **0.85** during the sampling period. While for Vadinar, Margalef's diversity index (Species Richness) of phytoplankton communities observed **0.71** at ME-7 and **0.84** at ME-8 with an average value of **0.78**

- **Berger-Parker Index (d)** of phytoplankton communities was in the range of **0.17 to 0.20** between selected sampling stations from ME-1 to ME-6 with an average value of **0.18** at Kandla creek and nearby creeks. Berger-Parker Index (d) of phytoplankton communities in the sampling stations of Vadinar, was in the range of **0.18 to 0.21** with an average value of **0.20**. All the monitoring station signifies a low diversity with an even distribution among the different species.

- The **Species Evenness** is observed in the range of **0.95 to 0.99** for all the six-monitoring station of Kandla and for the Vadinar the species evenness is observed **0.95** at location ME-7 & **0.99** at ME-8 location.

- During the sampling period, **Relative Abundance** of phytoplankton communities was in range of **0.54 to 0.59** between selected sampling stations from ME-1 to ME-6 with an average value of **0.57** at Kandla creek and nearby creeks. Whereas for Vadinar the Index

value **0.50** at ME-7 and **0.55** at ME-8 with an average value **0.53**, 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 are mentioned in **Table 42**.

**Table 42: Zooplankton variations in abundance and diversity in sub surface sampling stations**

| Genera | ME-1 | ME-2 | ME-3 | ME-4 | ME-5 | ME-6 | ME-7 | ME-8 |
|---|---|---|---|---|---|---|---|---|
| *Acartia sp.* | - | 1 | 1 | - | 2 | 2 | - | 1 |
| *Acrocalanus* | 2 | - | - | 1 | 1 | 1 | 2 | - |
| *Amoeba* | - | 2 | 2 | - | - | 2 | - | - |
| *Brachionus sp.* | 1 | - | - | 2 | 2 | - | - | 1 |
| *Calanus sp.* | 2 | - | - | 1 | - | - | - | 1 |
| *Cladocera sp.* | - | 2 | 1 | - | 2 | - | 2 | - |
| *Cyclopoid sp.* | - | - | 2 | - | 1 | - | - | - |
| *Copepod larvae* | 1 | - | - | 2 | - | 2 | - | 2 |
| *Diaptomus sp.* | 2 | 1 | - | - | - | 1 | 2 | - |
| *Eucalanus sp.* | - | - | 2 | 1 | 1 | - | 1 | 1 |
| *Mysis sp.* | 1 | 2 | 1 | - | - | 1 | - | - |
| *Paracalanus sp.* | - | - | - | 1 | - | - | 2 | 2 |
| **Density Unit/L** | **9** | **8** | **9** | **8** | **9** | **9** | **9** | **8** |
| **No. of genera** | **6** | **5** | **6** | **6** | **6** | **6** | **5** | **6** |

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

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

**Table 43: Species richness Index and Diversity Index in Zooplankton**

| Indices | ME-1 | ME-2 | ME-3 | ME-4 | ME-5 | ME-6 | ME-7 | ME-8 |
|---|---|---|---|---|---|---|---|---|
| Taxa S | 6 | 5 | 6 | 6 | 6 | 6 | 5 | 6 |
| Individuals | 9 | 8 | 9 | 8 | 9 | 9 | 9 | 8 |
| Shannon diversity | 1.74 | 1.49 | 1.74 | 1.65 | 1.74 | 1.74 | 1.58 | 1.65 |
| Simpson (1-D) | 0.92 | 0.89 | 0.92 | 0.93 | 0.92 | 0.92 | 0.89 | 0.93 |
| Species Evenness | 0.97 | 0.93 | 0.97 | 0.92 | 0.97 | 0.97 | 0.98 | 0.92 |
| Margalef | 2.28 | 1.92 | 2.28 | 2.4 | 2.28 | 2.28 | 1.82 | 2.4 |
| Berger-Parker | 0.22 | 0.25 | 0.22 | 0.25 | 0.22 | 0.22 | 0.22 | 0.25 |
| Relative abundance | 66.67 | 62.5 | 66.67 | 75 | 66.67 | 66.67 | 55.56 | 75 |

- **Shannon- Wiener's Index (H)** of zooplankton communities was in the range of **1.49 to 1.74** between selected sampling stations from ME-1 to ME-6 with an average value of **1.68**

at Kandla creek and its nearby creeks. While for Vadinar, Shannon Wiener's index of zooplankton communities recorded to be **1.58** at ME-7 and **1.65** at ME-8 with an average value of 1.61**.** The apportionment of the numbers of individuals among the species observed higher stability at all monitoring location of Kandla and Near SPM (Vadinar).

- **Simpson diversity index (1-D)** of zooplankton communities was ranged between **0.89 to 0.93** at all sampling stations in the Kandla creek and nearby creeks, with an average of **0.91.** Similarly, for Vadinar Simpson diversity index (1-D) of zooplankton communities was **0.89** ME-7 and **0.93** at ME-8 with an average of **0.91.**

- **Margalef's diversity index** (Species Richness) of zooplankton communities in Kandla and nearby creeks sampling stations was varying from **1.92 to 2.40** with an average of **2.24** during the sampling period. While for Vadinar, Margalef's diversity index (Species Richness) of zooplankton communities observed **1.82** at ME-7 and **2.40** at ME-8 with an average value of **2.11**.

- **Berger-Parker Index (d)** of zooplankton communities was in the range of **0.22 to 0.25** between selected sampling stations from ME-1 to ME-6 with an average value of **0.23** at Kandla creek and nearby creeks. Berger-Parker Index (d) of zooplankton communities in the sampling stations of Vadinar, was observed **0.22** at ME-7 and **0.25** at ME-8 with an average value of **0.23**. All the monitoring station signifies a low diversity with an even distribution among the different species.

- The **Species Evenness** is observed in the range of **0.92 to 0.97** for all the six-monitoring station of Kandla whereas, for the Vadinar the species evenness was observed **0.98** at ME-7 and **0.92** at ME-8 the locations**,** during the monitoring month.

- During the sampling period, **Relative Abundance** of zooplankton communities was in range of **62.5 to 75** between selected sampling stations from ME-1 to ME-6 with an average value of **67.36** at Kandla creek and nearby creeks. Whereas for Vadinar the Index value **55.56** at ME-7 and **75** at ME-8 with an average value **65.28**, 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** are mentioned in **Table 44.**

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

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

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

Few benthic organisms were observed in the collected samples using Van-Veen grabs at Deendayal Port (Kandla and Vadinar). The dominant macro-benthic groups included *Thiaridae, Mollusca, Trochidae, Atydae, and Turbinidae,* which were present across multiple stations. *Turbinidae* was observed at all sites (**ME-1 to ME-8**). While *Mollusca sp and Trochidae* occurred at most of the locations, indicating their broad distribution. The number of benthic families/classes varied between 5 to 6 across all stations.

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

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

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

| Indices | ME-1 | ME-2 | ME-3 | ME-4 | ME-5 | ME-6 | ME-7 | ME-8 |
|---|---|---|---|---|---|---|---|---|
| Taxa S | 5 | 5 | 6 | 6 | 5 | 6 | 6 | 5 |
| Individuals | 8 | 7 | 8 | 8 | 6 | 8 | 7 | 8 |
| Shannon diversity | 1.56 | 1.47 | 1.73 | 1.73 | 1.39 | 1.73 | 1.65 | 1.56 |
| Simpson 1-D | 0.89 | 0.9 | 0.93 | 0.93 | 0.93 | 0.93 | 0.95 | 0.89 |
| Species Evenness | 0.97 | 0.91 | 0.97 | 0.97 | 0.86 | 0.97 | 0.92 | 0.97 |
| Margalef's | 1.92 | 2.06 | 2.4 | 2.4 | 2.23 | 2.4 | 2.57 | 1.92 |
| Berger-Parker | 0.25 | 0.29 | 0.25 | 0.25 | 0.33 | 0.25 | 0.29 | 0.25 |
| Relative abundance | 62.5 | 71.43 | 75 | 75 | 83.33 | 75 | 85.71 | 62.5 |

- **Shannon- Wiener's Index (H)** of benthic organism was in the range of **1.39 to 1.73** between selected sampling stations from ME-1 to ME-6 with an average value of **1.60** at Kandla creek and its nearby creeks. While for Vadinar, Shannon Wiener's index of benthic organism recorded to be **1.65** at ME-7 & **1.56** at ME-8 location with an average value of **1.60**. The apportionment of the numbers of individuals among the species observed higher stability at all monitoring location of Kandla and Vadinar.

- **Simpson diversity index (1-D)** of benthic organism was ranged between **0.89 to 0.93** at all sampling stations in the Kandla creek and nearby creeks, with an average of **0.**91. Similarly, for Vadinar Simpson diversity index (1-D) of benthic organism was **0.95** at ME-7 and **0.89** at ME-8 location with an average of **0.92.**

- **Margalef's diversity index** (Species Richness) of benthic organism in Kandla and nearby creeks sampling stations was varying from **1.92 to 2.40** with an average of **2.23** during the sampling period. While for Vadinar, Margalef's diversity index (Species Richness) of benthic organism observed to be **2.57** at ME-7 and **1.92** at ME-8 location with an average of **2.24**.

- **Berger-Parker Index (d)** of benthic organism was in the range of **0.25 to 0.33** between selected sampling stations from ME-1 to ME-6 with an average value of **0.27** at Kandla creek and nearby creeks. Berger-Parker Index (d) of benthic organism in the sampling stations of Vadinar, was observed to be **0.29** at ME-7 and **0.25** at ME-8 location with an average value of **0.27**. All the monitoring station signifies a low diversity with an even distribution among the different species.

- The **Species Evenness** is observed in the range of **0.86 to 0.97** for all the six-monitoring station of Kandla and for the Vadinar the species evenness is observed in the range of **0.92** at ME-7 and 0.97 at ME-8.

- During the sampling period, **Relative Abundance** of Benthic organisms was **62.5 to 83.33** between selected sampling stations from ME-1 to ME-6 with an average value of **73.71** at Kandla creek and nearby creeks. Whereas for Vadinar the Index value **85.71** at ME-7 and **62.5** at ME-8 location, with an average value **74.11**, thus it is concluded that the studied species can be stated as neither highly dominant nor rare.

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

STP Monitoring


Noise Monitoring

Soil Monitoring

Marine Monitoring

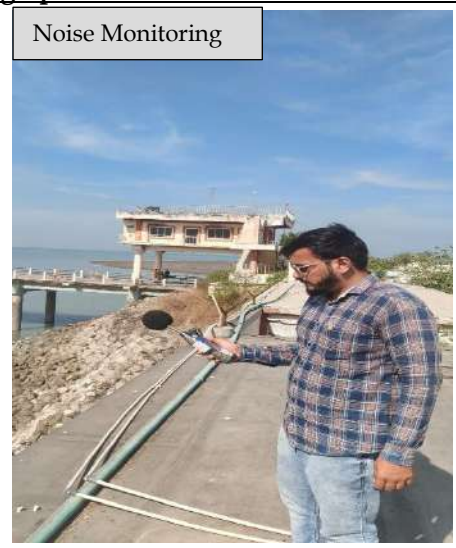
Air Monitoring

Drinking Water Monitoring

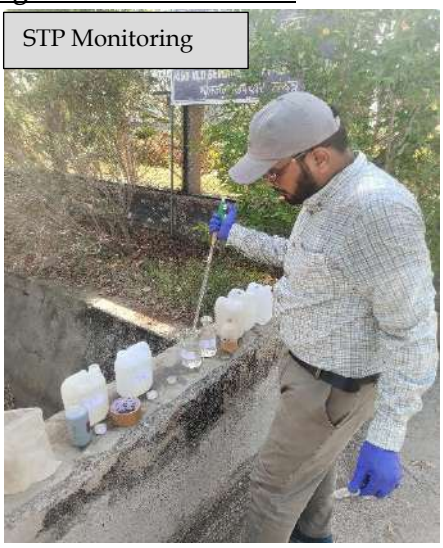
## Annexure 2: Photographs of the Environmental Monitoring conducted at Vadinar

Air Monitoring

Noise Monitoring



STP Monitoring



Drinking water Monitoring

Marine Monitoring

Soil Monitoring

Source: GEMI

# Gujarat Environment Management Institute (GEMI)

**(An Autonomous Institute of Government of Gujarat)**

**'An ISO 9001:2015, ISO 14001:2015 & ISO 45001:2018 Certified Institute**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*"We Provide Environmental Solutions"*

# Annexure–G

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

ISO 9001-2015 &
ISO 14001-2015 Certified Port

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GANDHIDHAM (Kutch).
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CivilEng./Pipeline/4778/CAAQMS/2025/27 Dated:24/06/2025

To,
The Gujarat Institute of Desert Ecology (GUIDE),
P.O.Box No. 83,
Opp. Changleshwar Temple, Mundra Road,
Bhuj (Kachchh)-370 001,
**Gujarat (India).**
**E-mail:** desert_ecology@yahoo.com

**Kind Attention: Dr. V. Vijay Kumar, Director, M/s GUIDE, Bhuj.**

**Sub: "Monitoring of Ambient Air Quality in the Port Area of Deendayal Port Authority through Continuous Ambient Air Quality Monitoring System (CAAQMS)"-Work Order reg.**

**Ref:** GUIDE, Bhuj proposal vide letter No. GUIDE/DPA/CAAQMS/450/2024-25 dated 21/05/2025

Sir,

The proposal submitted by GUIDE, Bhuj for the subject work vide above referred letter dated 21/05/2025 (**copy Attached-Annexure A**) for the work "**Monitoring of Ambient Air Quality in the Port Area of Deendayal Port Authority through Continuous Ambient Air Quality Monitoring System (CAAQMS)**" amounting to **Rs. 9,27,63,504.00 plus applicable GST (Rupees Nine Crores Twenty-Seven Lakhs Sixty-Three Thousand Five Hundred and Four Only)** for the scope of work, time period, including all terms & conditions mentioned in the proposal, has been accepted by the Competent Authority of DPA.

1) **Brief Scope of work**:
   a) To conduct site suitability assessment for installation of two CAAQMS including civil work, power supply, data connectivity in consultation with DPA.
   b) To Install Two CAAQMS at identified locations by DPA with all related components comprising of sensors, analysers, data acquisition system at identified locations, ensuring proper positioning for Accurate Air Quality Monitoring.
   c) To establish a real-time data transmission system to integrate with Pollution Control Boards for continuous remote monitoring.
   d) To conduct routine maintenance schedules and periodic calibrations to ensure uninterrupted operations of the equipment's.
   e) To formulate a detailed inception plan comprising of relevant technical specifications of the equipment's, monitoring frequency, proposed site details for installation of equipment's, connectivity with/to Pollution Control Boards.
   f) To document the monitored data on monthly basis.

g) Data will be transmitted to State and Central Pollution Control Boards
h) Broad Scope of work is as per **Annexure A**

**2) Payment terms:**

* 25% of contract price against submission of Inception Report and successful installation & commissioning of two CAAQMS System at identified Location.
* Balance 75% of contract Price: Monthly payment on Pro Rata basis for a period of 36 months

**3) Deliverables:**

- Inception report comprising of relevant technical specifications of the equipment's, monitoring frequency, proposed site details for installation of equipment's, connectivity with/to Pollution Control Boards.
- Installation of two (2) CAAQMS at proposed site
- Operations and maintenance of two installed CAAQMS for a period of 36 months
- Monthly submission of reports for a period of three years depicting the operations and output of online Continuous Ambient Air Quality Monitoring System including Wind Rose plot.

**4) Time Period:**

1. **For submission of Inception report & successful installation & commissioning of Two CAAQMS system at DPA: –** 60 days from the date of receipt of Work Order

2. **Operations & Maintenance of two CAAQMS:** 36 months after successful commissioning of CAAQMS.

3. Kindly sent the acceptance of this work order & start the work w.e.f 01/07/2025

Kindly send the acknowledgment of this Work Order.

Thanking you.

Yours faithfully,

24/6/25

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

# Annexure–H

**FINAL REPORT**

for the Project entitled

# Mangrove Plantation in an area of 50 Hectares for Deendayal Port Authority, Kandla

(As per EC & CRZ Clearance Dt.01.01.2024. Annexure-B, Specific condition No.7)

DPA Work order No. EG/WK/4751/Part (Revamping-EC onwards)/69. Dt. 10.06.2024


**Submitted by**

Gujarat Institute of Desert Ecology

Mundra Road, Bhuj-370 001

Dist: Kachchh, Gujarat, India


**Submitted to**

Deendayal Port Authority

Gandhidham- 370201

Dist: Kachchh, Gujarat-, India

February
2025

Gujarat Institute of Desert Ecology

## Certificate

This is state that the Final Report for project entitled "**Mangrove Plantation in an area of 50 Hectares for Deendayal Port Authority, Kandla**" has been prepared in line with the Work order issued by the Deendayal Port Authority Vide. Ref. No. EG/WK/4751/Part (Revamping-EC onwards)/69. Dt.10.06.2024. In order to comply with the stipulated condition of the EC & CRZ Clearance dated 1/1/2024 read with CRZ Recommendation dated 25/8/2022 - Condition no.7.

The work order is for a period of Nine months (10.06.2024 - 09.03.2025) for the above-mentioned study.

Authorized Signatory

DIRECTOR
Gujarat Institute of Desert Ecology
Bhuj - Kachchh.

Gujarat Institute of Desert Ecology Bhuj

Institute

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## Project Team

**Project Coordinator: Dr. V. Vijay Kumar, Director**

**Project Personnel**

**Principal Investigator**

Dr. B. Balaji Prasath, Senior Scientist

**Co-Investigator**

Dr. Kapilkumar Ingle, Project Scientist-II

**Team Members**

Dr. L. Prabhadevi, Advisor

Mr. Dayesh Parmar, Senior Scientific Officer

Mr. Ketan Kumar Yogi, Junior Research Fellow

# Contents

**Snapshot of the Project," Mangrove Plantation in an area of 50 Hectares for Deendayal Port Authority, Kandla"**

| S.No | Components of the Study | Remarks |
|---|---|---|
| 1 | Deendayal Port letter sanctioning the project | EG/WK/4751/Part (Revamping-EC onwards)/69, dated 10.06.2024 |
| 2 | Duration of the project | Nine months (10.06.2024 - 09.03.2025) |
| 3. | Location of Mangrove Plantation Site | The location finalized for mangrove plantation is shown in Figure 1. Suitable site was selected based on water and sediment quality, intertidal fauna, and propagules. |
| 4. | Total Area | 50 Hectares |
| 5. | EC & CRZ Clearance Reference | As per EC & CRZ Clearance Dt. 01.01.2024, Annexure-B, Specific condition No. 7 |
| 6 | **Field Studies** | |
| 6a | Site Overview | Inspection to understand site conditions and potential risks (e.g., grazing). |
| 6b | Geographical Patterns | Study existing mangrove species to determine their distribution and identify suitable planting locations. |
| 6c | Landscape Assessment | The stability of the root system of existing mangroves were be examined. |
| 7 | **Plantation Techniques** | |
| 7a | Raised Bed Method (Otla Method) | Create earthen mounts to plant 15-30 seeds; suitable for areas with low to moderate water currents. |
| 7b | Transplantation of Nursery Raised Saplings | Grow saplings in polythene bags; nature for 3-4 months before transplanting; higher success rate |

## 1. Background of the study

Mangroves are among the most productive ecosystems, providing various ecosystem services and resources to both the ocean environment and humankind. This unique ecosystem occurs in the tropics and subtropics, where land meets the oceans, often bordering estuaries and backwaters. Mangrove forests have the remarkable ability to rise upward in place or move landward or seaward in response to sea level changes (Woodroffe *et al*. 2016). Mangroves typically grow on wet, muddy substrates with minimal water fluctuations, specifically in the mudflat regions of tropical and subtropical areas. These are dense forests of trees and shrubs that are tolerant to salt, usually flourishing in tidal areas. The importance derived from these forests is critical, including coastal protection, biodiversity conservation, and climate change mitigation. All mangroves produce fertilizer from rotting litter fall and root growth deceiving ambient water sediment. Mangrove ecosystems support various plant and animal species, breeding, nursery and feeding grounds for numerous marine and terrestrial organisms. Despite their ecological importance, mangrove forests face different threats such as deforestation, pollution, and climate change. Specific measures have been taken towards conserving these valuable ecosystems including them into biosphere reserves and Ramsar sites.

According to the Forest Survey of India (FSI, 2019), the global mangrove cover is approximately 14.79 million hectares. Asia leads with 5.55 million hectares, followed by Africa with 3.24 million hectares, North and Central America with 2.57 million hectares, and South America with 2.13 million hectares. South Asia has the highest mangrove area, constituting about 6.8% of the world's total mangrove cover. Anthropogenic pressures have reduced global range of these forests to less than even half of their original total cover throughout the globe as mentioned by Ragavan *et al.* (2016) while Singh (2020) observed that almost 75% of the tropical coast has been taken up by mangrove forests. India's mangrove ecosystems are incredibly important, covering around 4,992 $km^2$, which makes up about 0.15% of the country's total land area. Despite occupying a relatively small fraction of India's geographical area, mangroves are hotspots of biological activity, supporting a wide range of flora and fauna. They help in sequestering carbon, thus mitigating climate change effects. Major mangrove areas in India include the Sundarbans in West Bengal, which is the largest mangrove forest in the world.

The present study on "Mangrove Plantation in an area of 50 Hectares for Deendayal Port Authority, Kandla" is being conducted to comply with the specific conditions outlined in the EC & CRZ Clearance dated 01.01.2024 and CRZ Recommendation condition no. 7 as given in Annexure B.

## 1.1. Mangrove status in Gujarat and Gulf of Kachchh

Gujarat state has the longest coast (1650 $km^2$) with largest coastal area (28,000 $km^2$) under cover of mangroves. Gujarat mangrove ecosystem is the second largest after Sundarbans in West Bengal (ISFR 2019). Though contentious, around 15 mangrove species are reported from 13 coastal districts of Gujarat. Of these, the southern coast of Gulf of Kachchh and South Gujarat coast are important for mangrove diversity. The species *Avicennia marina* is the most populous along the Gujarat coast. Along the coastal stretch of Gulf of Kachchh (GoK) has the most considerable mangrove extent of 986 $km^2$ out of 1140 $km^2$. Kachchh district, constituting the northern coast (northern shore) of GoK alone has 798 $km^2$ of mangroves constituting 70% of the whole Gujarat mangroves. Waterlogged mud with low oxygen levels supports such vegetation in tropical and subtropical regions. In the Kachchh coast has various habitats such as expansive mudflats and small sandy beaches with different physico-chemical variables like extreme salinity temperature inundation factor. This vibrating ecosystem can allow the species to thrive and exhibit many adaptive modifications.

Biodiversity-oriented planting schemes aim to boost species richness through ongoing plantation and meticulous monitoring activities. Restoring mangrove ecosystems with dominant species like *Avicennia marina, Ceriops tagal,* and *Rhizophora mucronata* plays a crucial role in enhancing species diversity. By increasing the variety of plant species, these schemes not only create a more resilient and productive ecosystem but also help in providing essential resources and services to local populations, such as fish breeding habitats, wood, and other forest products. Continuous planting and monitoring ensure that these ecosystems remain healthy and sustainable, benefiting both the environment and the people living in coastal regions. Mangrove biodiversity seeks attention towards such spots on the Kachchh coast, which require supplementation of plant cover at selected sites. For instance, although successful efforts at restoring mangroves exist, the presence of *A. marina* alone in most parts corroborates the role of high salinity of the water because of limited fresh water influx annually. The arid coastal conditions lack of

continuous freshwater flow through the river inhibits the spread and growth of mangroves which are constantly exposed to tidal inundation. The plantation of mangroves as well as creation of awareness regarding the importance of mangrove and their ecosystem services are the crucial tasks to avoid such loss.

## 1.2. Rationale of the project

Deendayal Port Authority (DPA) has been one of India's largest ports in terms of cargo volume handled. Being located in Gujarat state on the northwest coast of India, the port is one of the biggest creek-based ports in India. In India, it is one among twelve major ports and situated at Gulf of Kachchh's tail end, Gujarat's western part. The greatest advantage of this location is a high semi-diurnal tidal range of about 6 to 7 meters which allows for sufficient draft in the dredged channels at the Port. DPA has been and still is undergoing continuous development and expansion particularly over recent times and is located in the creek environment encompassing mangroves (193.1 $km^2$) and mudflats (312.9 $km^2$).

Over the last seven decades, it should be noted that due to these vast resources available at its doorstep; the port authorities have a desire to conserve, protect and enhance these coastal habitats. The coastal belt in and around Kandla region is characterized by a network of creek systems and mudflats which are covered by sparse halophytic vegetation like scrubby to dense mangroves, creek water and salt encrusted land mass which forms the major land component. The surrounding environment in a radius of 10 km from the Port is mostly built-up areas consisting salt works, human habitations and Port related structures on west and north, creek system, mangrove formations and mudflats in the east and south.

Deendayal Port as part of the expansion of the infrastructure facility has significant movements of materials and people within the area and construction activities as well. Additionally, as part of the environmental policy intended to accomplish 50 ha mangrove plantation and the task is entrusted with the Gujarat institute of Desert ecology, Bhuj, Kachchh district Similar efforts towards conserving and preserving mangrove cover in the prospective areas have been implemented by the Deendayal Port Authority (DPA) to maintain numerous unheralded ecological services by these marine plants. Total mangrove plantation till date by DPA through several implementing agencies at Sat Saida Bet, Nakti Creek and Kantiyajal.. To ensure the project follows the

most contemporary standards and practices in the field. In accordance with the CRZ Recommendation Condition, Mr. Nischal Joshi of the Gujarat Ecology Commission (GEC) was consulted for his expert opinion during the initial stages of the work.

## 2. Objectives

Within the overall objective of mangrove plantation in the DPA port limits the following activity wise objectives are envisaged.

- Assess the technical suitability of the proposed land for mangrove plantation
- Assess the physico-chemical properties of soil and nearby water and tidal pattern in the proposed plantation site.
- Formulate site specific plantation strategy and execute it with the adopting appropriate techniques.

## 3. Study Area

The location finalized for mangrove plantation is shown in Figure 1, as per their suitability including water and sediment quality characteristics, occurrence of intertidal fauna, availability of propagules, signs of natural regeneration etc. Further, based on the water quality characteristics reported elsewhere, the site is better choice for the plantation of mangrove species, *A. marina*. In the studies conducted earlier, the salinity levels of this area is reported to be ranging between 35 - 40 ppt which is suitable for the selected species. The pH of the pour water is recorded to be in the range of 6.0 - 8.5. In addition to the above said criteria, plantation in general should be established in Intertidal areas where a good tidal flushing is happening atleast 15 days in a month.


**Figure.1** Proposed location for Mangrove plantation activities at DPA area

# 4. Methodology

## 4.1. Field Studies

4.1.1. Site Overview:

- The inspection were provide an overall understanding of the site, not only for the plantation but also for potential risks (such as camel or cattle grazing).
- Accessibility for post-plantation monitoring were be evaluated to ensure ease of assessment.

4.1.2. Geographical Patterns:

- Existing mangrove species in the area were be studied to understand their presence and distribution.
- Geographical patterns were be analyzed to identify suitable locations for planting mangroves.

4.1.3. Landscape Assessment:

- Rainwater runoff into the creeks and the influencing zones were be observed to assess its impact on the mangrove ecosystem.
- The stability of the root system of existing mangroves were be examined.
- Sources of freshwater within the area were also be considered.

## 4.2. Plantation Techniques

Three methods preferred for the sake of mangrove plantation which were be as follows in this study period:

4.2.1. Raised bed method (Otla method)

- This is popular method of mangrove plantation in Gujarat useful for a few species such as *A. marina* and provide better result compare to other methods.
- In this method, earthen mounts of a specific height were be made which support to plant 15 to 30 seeds/ propagules.
- This method is suitable in the areas where the current of water is low and moderate (Plate 1).

4.2.2. Transplantation of nursery raised saplings (Poly bag method).

- This technique has higher success rate unlike other methods and therefore, nursery of the various species is required to grow the saplings (Plate 2).
- This technique is time consuming and laborious compared to direct dibbling and raised bed methods.
- On the open intertidal mudflats, the saplings were be grown in polythene bags through sowing the matured seeds or propagules.
- The saplings were be nurtured 3-4 months before transplantation and after attaining a height 30-45 cm in polythene bags.
- Site specific conditions were determining the number of saplings to be transplanted, however, 2500 saplings per ha is generally followed.
- In some occasions also nursery raised saplings were be used for gap filling and thereby increasing the survival rate of the plants table1.

After being successfully raised in the nursery, saplings between 30 and 45 cm tall should be chosen at different times to be transplanted at the intended location. Below are the specifics of the plantation's sapling height and germination period (plate 3). A total of 46 nursery beds were established, with each bed containing 800 to 1,200 polybags. Each polybag is sown with 3 to 4 seeds, facilitating optimal seedling production (Figures 8-13). In addition, otla raised method, in each bed sown 5 – 6 seeds were raised in plantation site (Figures 15-17)

**Table 1: Details of sapling for plantation**

| Species | Germination period (days) | Germination percentage | Height (cm)of saplings |
|---|---|---|---|
| *Avicennia marina* | 6-10 | 70-80 | 30-45 |
| *Rhizophora mucronata* | 30-35 | 50-60 | 60 |

With these methods, the extra seeds were also spreaded in the plantation area where the older trees are present and generally the area where natural regeneration of seeds happens.

## 5. Site visit

Before the initiation of mangrove plantation activity, a through pre-project survey was conducted to examine the proposed plantation site. In this survey, the crucial technical factors like land elevation, tidal pattern, physical and chemical properties of soil and water (by laboratory analysis), access to the site, level of protection such as cattle grazing, human disturbance and other potential risks, etc. were observed. This survey helps to decide the suitability of site for mangrove plantation in DPA port limit.

### 5.1. On-site observations

- The indicators of regular flooding of site by tide water was observed in on-site visit. The site area was wet and with plenty of mud which is required for plantation.
- There was no presence of very hard, dried soil surface in the site was observed anywhere.
- The presence of a few natural mangrove (*A. marina*) trees was observed around and in the plantation site which denotes the site is suitable for the plantation.
- The presence of crab holes and mudskippers holes is the indicator that the soil of the site is soft and regularly get wet due to tides.
- The pneumatophores of nearby mangroves were found in the nearby area which indicate that there is no sediment deposition and buried pneumatophores in this area.
- Nearby area also shows the presence of halophytic/ salt marsh plants such as *Sesuvium* and also *Salicornia* nearby creek.
- The *Sesuvium* leaves were green and fresh, also not thicker which represent the good condition of the site.
- The presence of sub-creek system may ensure the availability of tidal water which were be primary need of the plantation.
- A few natural regeneration plants were also observed in the site.
- The presence of the jackal foot marks observed which denotes the overall area have a good ecosystem and where the jackal food (crabs) sources are available.

## 5.2. Analysis of water and sediment samples

### 5.2.1. Water analysis

The water samples were collected from the plantation site in pre-cleaned polyethene bottles and rinsed with sample water, and transported to the laboratory in icebox for further analysis such as pH analysis by pH meter, salinity was determined by refractometer. The pH of water sample was found 7.25 and salinity 18 psu. Although there is no domestic freshwater source, and tidal water salinity generally higher, due to the rainy season the salinity shows lower values. However, the lower salinity is also in favour of germination of mangrove seeds.

### 5.2.2. Sediment/ soil analysis

Sediment samples were collected by using a non-metallic plastic spatula from random locations; three from each transect to cover the whole study area. The collected samples were air-dried at room temperature (Jackson, 1958), homogenized using an agate mortar and pestle, sieved through a standard sieve of 2 mm mesh (Tandon, 2005). The particles with size less than 2mm were retained in pre cleaned plastic bottles for further analysis for various parameters. Total Organic Carbon (TOC), pH, texture, bulk density, etc were analysed.

Texture of sediment: The texture of soil/sediment is one of the key factors when choosing a site for plantation mangroves. Generally, mangrove ecosystems typically have the types of soils which includes muds or clay or sandy mud, etc. The texture of soil significantly impacts the survival and growth of mangroves. The presence of clay texture which makes soil muddy may expected to offer a stable base for mangrove roots to flourish under tidal conditions. Thus, evaluating the soil conditions at the plantation site is crucial before starting mangrove planting activities. Here we collected 3 samples, and all shows good amount of clay percentage in them which may be favourable for the plantation.

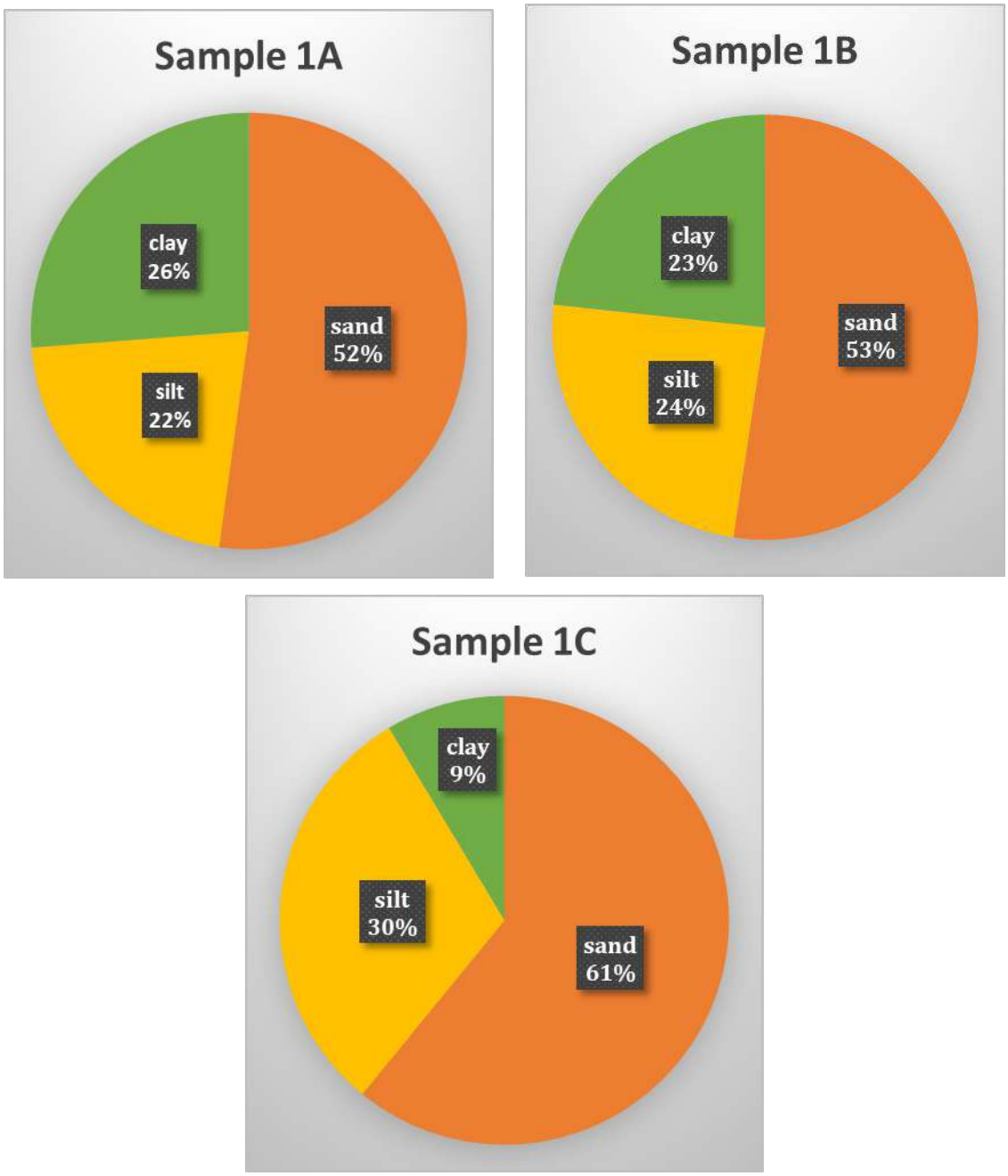



**Figure 2:** Sediment textural composition in the sampling sites

Bulk density of soil: It refers to the amount of soil organic matter within a given volume of soil. This property can vary significantly and is influenced by the soil's texture, structure, and organic matter content. Soils with high organic matter tend to have lower bulk density, while compacted soils exhibit higher bulk density.

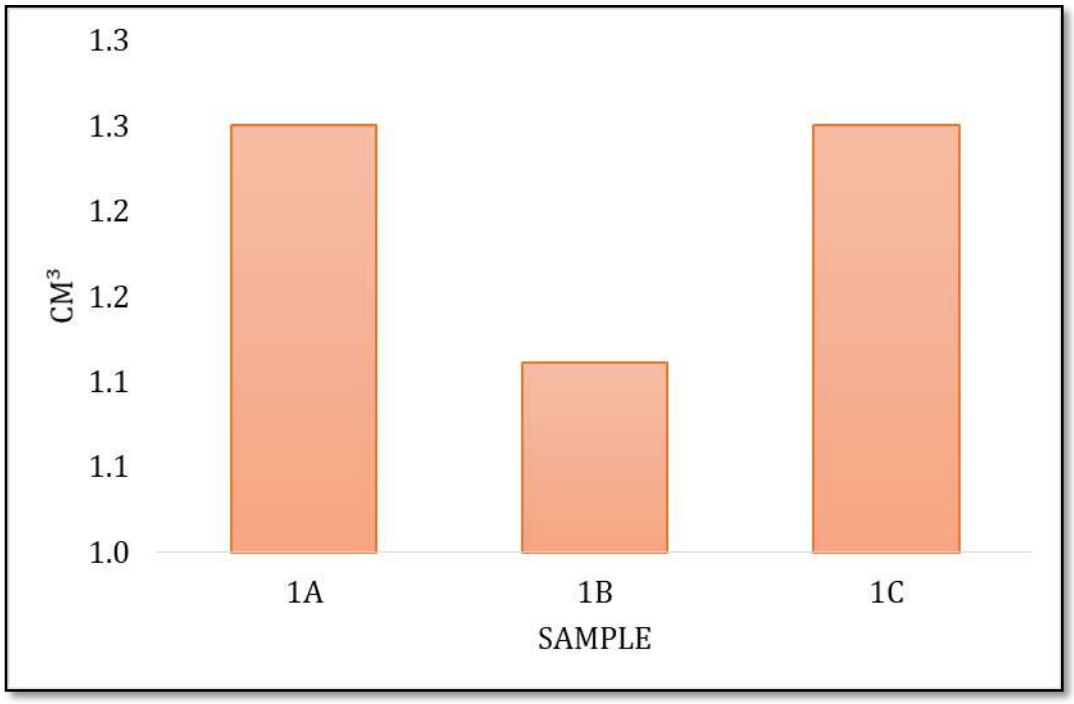



**Figure 3:** Bulk density of sediment samples

Total Organic Carbon: Organic carbon levels are influenced by living organisms, and the diversity of life forms in mudflats affects the total organic carbon (TOC) estimates. In all samples, the TOC percentage was ranged from 2.7 % to 2.85%

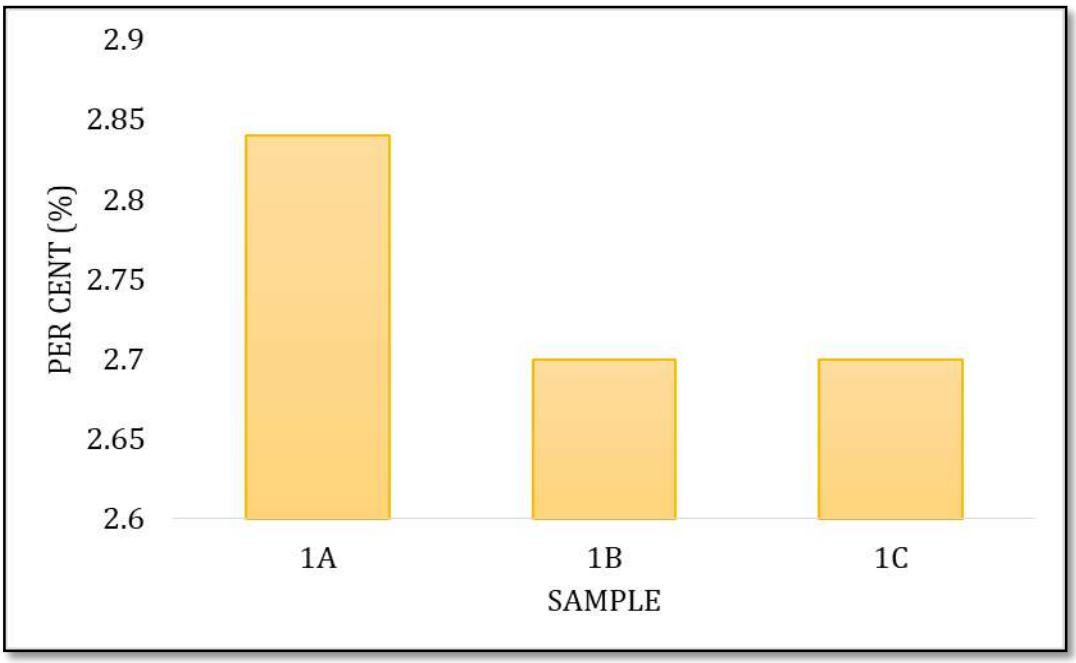



**Figure 4:** Total Organic Carbon content of sediment samples

**Plate 1:** Selection of suitable sites for mangrove plantation in DPA area based on sediment characteristics, tidal pattern, cattle grazing etc

**Plate 2**: Site identification, planning and field observation at mangrove plantation site on July 17th to 31st, 2024

**Plate 3:** Mangrove Seed Collection at Kandla on 1st to 07th August, 2024

**Plate 4:** Team involved in collection and separation of healthy mangrove seeds on 8th to 17th August, 2024

**Plate 5:** Women involved in processing of mangrove seeds on 17th to 25th August, 2024

**Plate 6**: Preparation and filling of bags for submerged Nursery Development Activity on 25th to 30th August, 2024

**Plate 7:** Labour Involvement in filling of bags for nursery preparation at Kandla on 25$^{th}$August to 5$^{th}$ September, 2024

**Plate 8:** Seed sowing of *Avicennia marina* in polybags at nursery at Kandla on 6th to15th September, 2024

**Plate 9:** Site submerged during high tide on 15th September, 2024

**Plate 10:** Germination of *A. marina* seeds in polybags and germination during visit of GUIDE team at Kandla on 15th to 25th September, 2024

**Plate 11:** Nursery of *A. marina* saplings in natural tidal inundation at Kandla on 5th to 25th October, 2024

**Plate 12:** Insect pests and diseases in *A. marina* leaf and stem in saplings during visit of GUIDE team at Kandla on 25th October to 5th November, 2024

**Plate 13:** Labour Involvement in Otla bed raised method at Kandla 1st to 07th September, 2024

**Plate 14:** Seed sowing of *A. marina* in Otla beds at nursery at Kandla on 10th to 25th September, 2024

**Plate 15:** Germination of *A. marina* in Otla beds observed during visit of GUIDE team at Kandla on 5th to 25th October,

**Plate 16:** Mangrove Growth of *A. marina* prior to Transplanting from Nursery to Plantation Site by the GUIDE Team at Kandla on 30th November

**Plate 17:** Labour Participation in Loading Nursery Bags onto Boats for Transportation to Plantation Sites at Kandla on 1st December to 15th December, 2024

**Plate 18:** Labour Involvement plantation the *A. marina* at Kandla on 1st December, 2024 to 31st January, 2025

**Plate 19:** Labour Involvement plantation the *A. marina* at Kandla on 1st December, 2024 to 31st January, 2025

**Plate 20:** Labour Involvement in *A. marina* Plantation during GUIDE Team Visit to Kandla on 15th January, 2025

**Plate 21:** *A. marina* Plantation during GUIDE Team and DPA Team Visit to Kandla on 15th January, 2025

**Plate 22:** Mangrove outplanting, including row establishment and saplings placing inside hole, levelling soil surface at Kandla on 10th February, 2025

## 6. Summary of the Report

The aim of the report is to assess the situation of growing mangrove saplings at DPA Gulf of Kutch. In order to comply with the stipulated condition of the EC & CRZ Clearance dated 1/1/2024 accorded by the MoEF&CC, GoI read with CRZ Recommendation dated 25/8/2022 for "Augmentation of Liquid Cargo Handling capacity from 8 to 23.8 MMTPA through modernization of existing Pipeline network at Oil Jetty area of DPA, Kandla"), DPA assigned work of "Mangrove Plantation in an area of 50 Hectares for Deendayal Port Authority reg.", to GUIDE, Bhuj vide work order dated 10/6/2024.

The DPA has initiated a program for plantation of mangroves to improve these ecosystems within the limits of its port. The general focus of this project is to evaluate mangrove plantation in an area of 50 Hectares for Deendayal Port Authority, site conditions for planting, study the soil and water characteristics, and formulate and execute a site-specific planting plan utilizing nursery grown transplant, otla method and other forms. The objective is to increase the mangrove species, improve the resilience of the ecosystem and provide the local population with valuable resources and services, all while ensuring the sustainability of mangrove cover over the long term. The increased ecological stability and productivity of the region, and provide necessary resources and services to the local and marginalized communities throughout the work in a selected, defined and timetabled manner to observe the speed of the work done. The Mangrove Plantation in an area of 50 Hectares of *Avicennia marina* and *Rhizophora mucronata* at scientifically identified location (Satsaida bet) is completed.

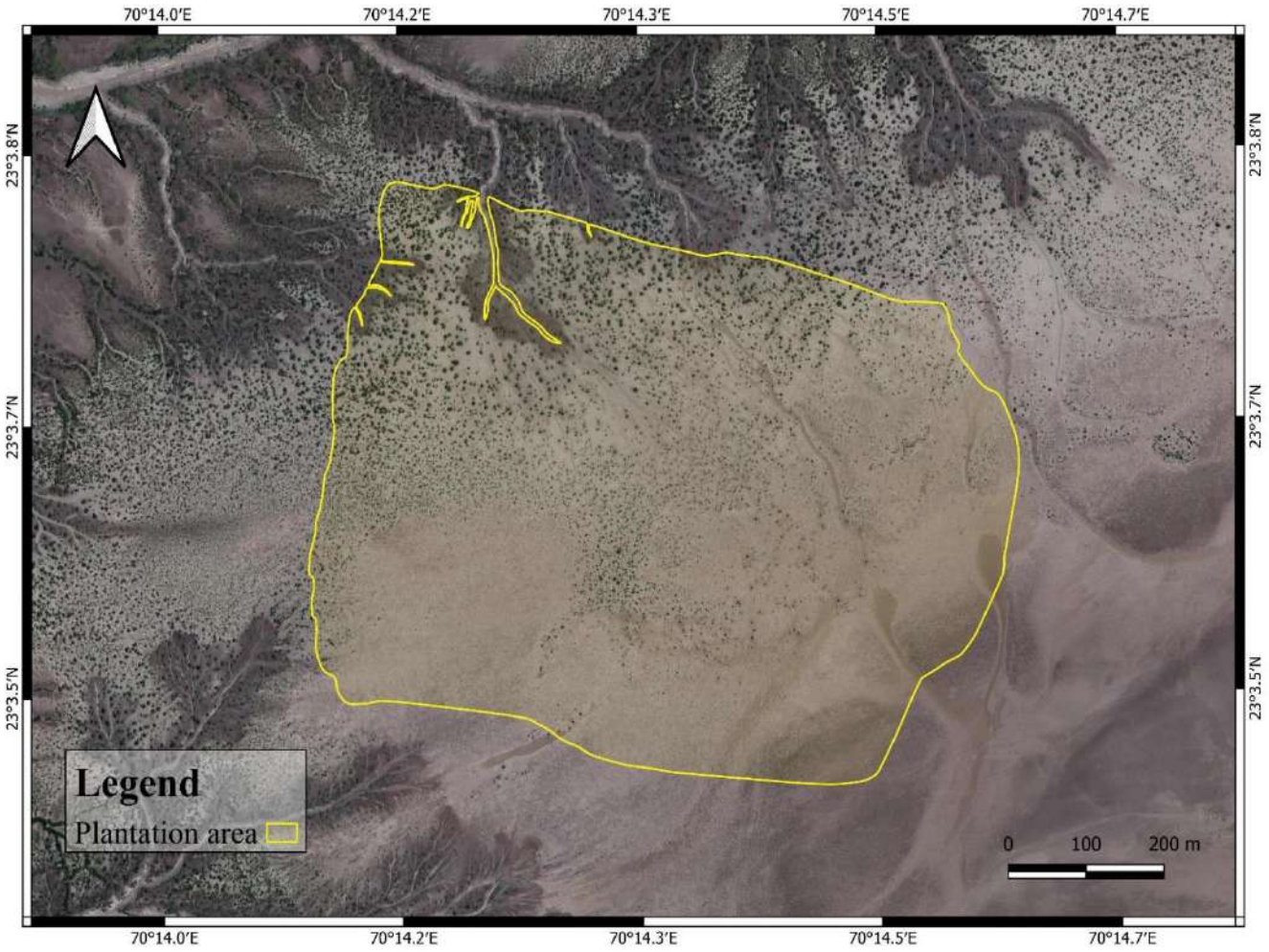



**Figure 5:** Mangrove plantation site area at Kandla, Gujarat, India

**Plate 24:** Growing saplings during GUIDE Team Visit to Kandla on 10th February, 2025

**Plate 25:** Labour Involvement plantation the *Rhizophora mucronata* at Kandla on 31st January to 28th March, 2025

Table: 2 GPS Points of Mangrove Project Site at Kandla, Gujarat, India

| No | Point No. | Longitude | Latitude |
|---|---|---|---|
| **1** | **K-18** | 70.243 | 23.062 |
| **2** | **K-19** | 70.244 | 23.06 |
| **3** | **K-23** | 70.243 | 23.058 |
| **4** | **K-25** | 70.241 | 23.057 |
| **5** | **K-27** | 70.239 | 23.057 |
| **6** | **K-28** | 70.235 | 23.058 |
| **7** | **K-31** | 70.235 | 23.061 |
| **8** | **K-33** | 70.235 | 23.062 |
| **9** | **K-35** | 70.237 | 23.064 |
| **10** | **K-37** | 70.24 | 23.063 |

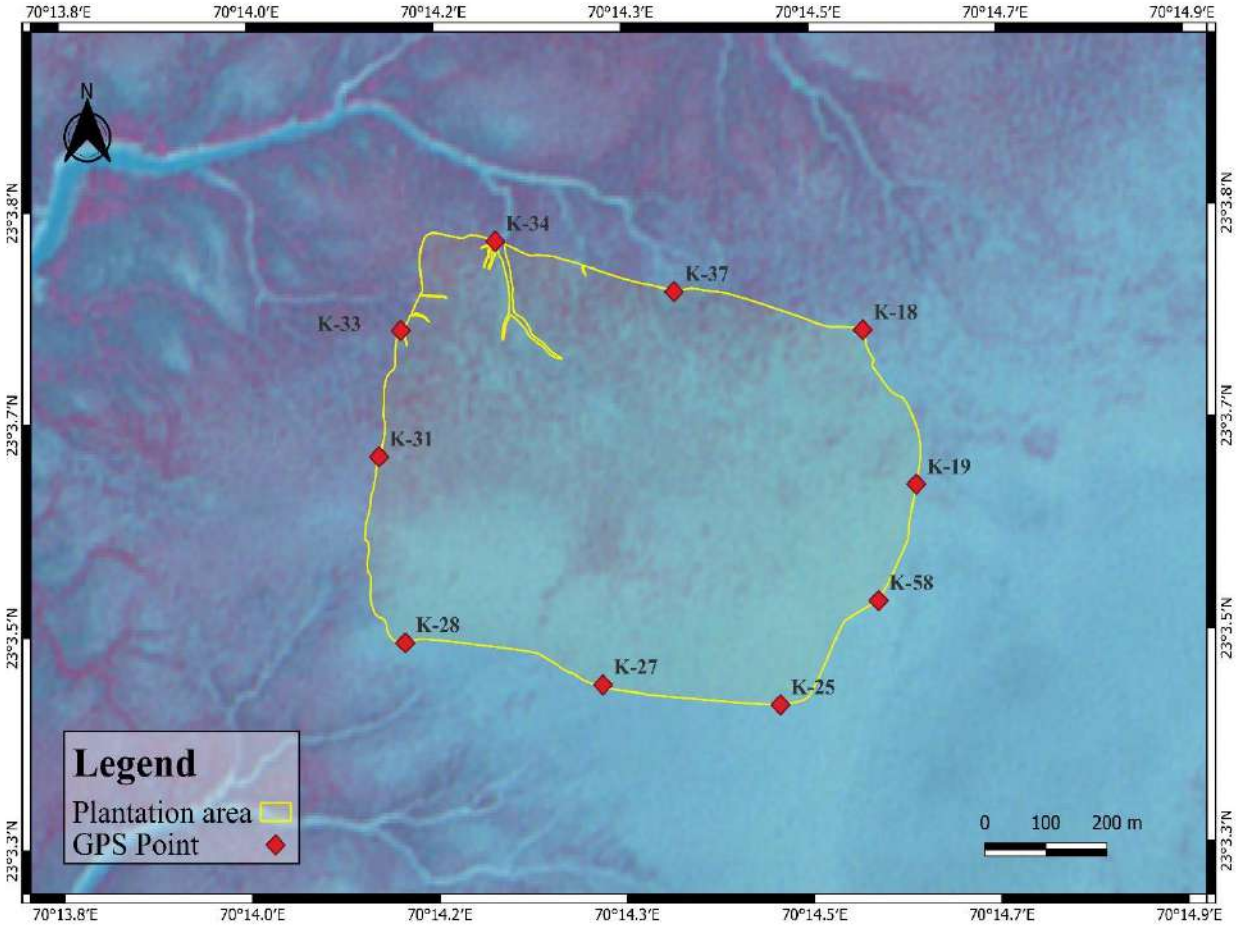



**Figure 6:** Mangrove plantation site area with GPS location points at kandla, Gujarat, India

## 7. Future Considerations for Mangrove Plantation

DPA needs to focus on the mangrove plantation project in Kandla. In ensuring that, this report puts forward the steps that need monitoring for the future.

### 7.1. Carry out regular monitoring of mangrove plantation

The regular monitoring of mangrove plantations is must in the plantation site to ensure growth status of the planted mangroves. It will also help in detection of any signs of disease or damage early. Regular monitoring also helps to understand any threats to mangrove such as potential erosion or grazing etc, also help to protect the local ecosystem and biodiversity. It will useful in the measurement of effectiveness of conservation efforts.

### 7.2. Regular gap filling to be done

Maintenance of the plantation is crucial for its continued success. Regular upkeep is needed, including filling in gaps where plants may have failed to establish. In addition to *Avicennia marina*, it's important to plant a variety of mangrove species to boost biodiversity. This increased diversity enhances the ecosystem's resilience to environmental changes, such as fluctuations in salinity, temperature, and sea level rise. Regular monitoring and management practices ensure the plantation's long-term health and ecological stability, contributing to the protection of coastal areas and marine life habitats.

## 8. References

ISFR (2019) India state of forest report. Ministry of Environment Forest and Climate Change Dehradun

Ragavan P, Saxena A, Jayaraj RSC, Mohan PM, Ravichandran K, Saravanan S, Vijayaraghavan A (2016) A review of the mangrove floristics of India. Taiwania 61(3)

Singh JK (2020) Structural characteristics of mangrove forest in different coastal habitats of Gulf of Khambhat arid region of Gujarat, west coast of India. Heliyon 6(8):e04685. https://doi.org/10.1016/j.heliyon.2020.e04685

Woodroffe CD, Rogers K, McKee KL, Lovelock CE, Mendelssohn IA, Saintilan N (2016) Mangrove sedimentation and response to relative sea-level rise. Annual review of marine science 8(1):243–266

APHA (2017). Standard Methods for the Examination of Water and Wastewater, 23nd edition. American Public Health Association, 1546.

Strickland, J.D.H. and Parsons, T.R. (1972) A Practical Handbook of Seawater Analysis. 2nd edition. Ottawa, Canada, Fisheries Research Board of Canada, 310pp. (Bulletin Fisheries Research Board of Canada, Nr. 167 (2nd ed)). DOI: http://dx.doi.org/10.25607/OBP-1791

Tandon, V.R. (2005) Medicinal Uses and Biological Activities of Vitex negundo. Natural Product Radiance, 4, 162-165.

Jackson, M.L. (1958) Soil Chemical Analysis. Prentice-Hall Inc., Englewood Cliffs, NJ, 498 p.

# Annexure–I

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

दीनदयाल पत्तन प्राधिकरण
DEENDAYAL PORT AUTHORITY

ISO 9001-2015 &
ISO 14001-2015 Certified Port

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

www.deendayalport.gov.in

EG/WK/EMC/CCA/ Part(III)/51

Date: 23/07/2025

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

**Sub:** Submission of Annual Return of Hazardous waste in format form IV for the financial year 2024-25 reg.

**Ref.:** 1) KPT letter no. EG/WK/4660(EC)/549 dated 20/6/2012
2) KPT letter no. MR/GN/1527(Part I)/2012 dated 20/5/2013
3) KPT letter no. MR/GN/1527(Part I)/336 dated 17/05/2014
4) KPT letter no. MR/GN/1527/ (Part I)/dated 27/04/2015
5) KPT letter no. EG/WK/EMC/CCA (Part II)/217 dated 27/6/2016
6) KPT letter no. EG/WK/EMC/CCA (Part II)/213 dated 19/6/2017
7) DPT letter no. EG/WK/EMC/CCA (Part II)/294 dated 13/6/2018
8) DPT letter no. EG/WK/EMC/CCA (Part II) dated 27/5/2019
9) DPT letter no. EG/WK/4751 (CCA Renewal) dated 22/5/2020
10) DPT letter no. EG/WK/4751 (CCA Renewal)/13 dated 30(4)/4(5)/2021
11) DPA letter no. EG/WK/4751 (CCA Renewal)/131 dated 06/07/2022
12) DPA letter no. EG/WK/EMC/CCA/Part III/325 dated 19/06/2023
13) DPA letter no. EG/WK/EMC/CCA/Part III/91 dated 19/07/2024

Sir,

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

In this connection, it is to state that, the Deendayal Port Authority had obtained renewal of consent order from the GPCB Vide order no. AWH – 110594 dated 22/01/2021 valid up to 21/07/2025 for Deendayal Port Authority area and correction to consent order done dated 09/04/2021 and its further amendment dated 11/01/2024. Further Renewal of the consent order issued by the GPCB to the DPA vide consent order no. AWH – 143399 letter no. PC/CCA-KUTCH-812(6)/GPCB ID 28494/864889 dated 16/06/2025 valid upto 21/07/2030

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

Now please find the enclosed herewith Annual Return of Hazardous Waste in Form IV for the year 2024-25.

This is for kind information and record please.

Encl: As above

yours faithfully

XEN (EMC)
Deendayal Port Authority

# GUJARAT POLLUTION CONTROL BOARD

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

GPCB


**By R.P.A.D**

In exercise of the power conferred under section-25 of the Water (Prevention and Control of Pollution) Act-1974, under section-21 of the Air (Prevention and Control of Pollution)-1981 and Authorization under rule 6(2) of the Hazardous and Other Waste (Management and Transboundary) Rules, 2016 framed under the Environmental (Protection) Act-1986.

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

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

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

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

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

**Subject to specific condition:**

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

6. Industry shall not withdraw groundwater without prior NOC from CGWA as per Hon. National Green Tribunal order.
7. Industry shall manage Solid Wastes generated from industrial activities as per Solid Waste Management Rules-2016 (solid waste as defined in Rule-3(46)).
8. Applicant shall ensure that there shall be no damage to the existing mangrove patches near site and also ensure the free flow of water to avoid damage to the mangroves.
9. Applicant shall ensure as per EC condition that no creeks or rivers are blocked due to any activities at the site and free flow of water is maintained.
10. Applicant shall provide proper system for collection, storage & treatment & disposal of waste water generated by vessel as per MARPOL& maintain records.
11. Applicant shall install storm drainage catch basin to avoid directly discharge into surface water.
12. Waste effluent accumulated with port activities including storm water & sewage from port operation including sewage ballast water, bilge water &clean waste water from ships shall be as per MARPOL norms.
13. Applicant shall make separate records regarding generation, collection, transportation& disposal of waste generation from ship & maintain its records.
14. Applicant shall made necessary arrangement for the plastic Waste, Solid Waste or other waste generation due to port activities & for facilitation of reception facilities under MARPOL & Environment (Protection) Act-1986 rules etc.
15. Ports shall obtain approval of their oil spill contingency plan (OSCP) as required under national oil spill disaster contingency plan (NOS-DCP) of coast guard, ministry of defence, govt. of India.
16. Best environmental practices by ports maybe uploaded on "Indian ports Association" as well as the same maybe linked to websites of CPCB and respective SPCBs.
17. Manually handling of cargo should be converted into mechanized system, in time bound manner.
18. Industry shall comply with circular of the Board dated 27/08/2021 regarding retrofitting of emission control/ equipment in D.G. Set of capacity 125 KVA and above as per system & procedure for emission compliance testing of Retrofit Emission Control Devices (RECD) for D.G. Set issued by CPCB dated 01/02/2022 at the earliest and submit compliance.

**3. <u>CONDITIONS UNDER THE WATER ACT:</u>**

3.1 Water Source: - GWIL.

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

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

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

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

| PARAMETERS | GPCB NORMS |
|---|---|
| pH | 5.5-9.0 |
| Biochemical Oxygen Demand (BOD) | 10 mg/L |
| Total suspended solids (TSS) | 20 mg/L |
| Chemical Oxygen Demand (COD) | 50 mg/L |

| | |
|---|---|
| Nitrogen –Total | 10 mg/L |
| Phosphorous-Total (for discharge into Ponds, Lakes) | 1.0 mg/L |
| Fecal Coliform | Desirable-100 MPN/100ml<br>Permissible -230 MPN/100 ml |

3.6 Treated domestic effluent conforming to above standard shall be discharged on land for gardening and plantation purpose within premises. In no case waste water shall be discharged outside premises.

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

3.8 Disposal system for storm water shall be provided separately, in no circumstances storm water shall be mixed with the industrial effluent in any case.

**4. Conditions under the Air Act-1981:**

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

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

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

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

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

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

4.5. The concentration of the following parameters in the ambient air within the premises of the industry shall not exceed the limits specified hereunder as per National Ambient Air Quality Standards issued by MoEF & CC dated 18th November-2009.In addition to following parameters Industry shall also carry out AAQ monitoring of all other applicable parameter as per MoEF notification dated 18/11/2009 and submit the report to the Board.

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

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

4.6. The applicant shall provide portholes, ladder, platform etc. at chimney(s) for monitoring the air emissions and the same shall be open for inspection to/and for use of Board's staff. The chimney(s) vents attached to various sources of emission shall be designed by numbers such as S-1, S-2, etc. and these shall be painted/ displayed to facilitate identification.

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

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

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

**D.G. Sets standards:-**

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

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

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

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

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

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

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

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

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

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

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

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

| Sr. No. | Waste | Quantity per Annum | Schedule & Category | Facility |
|---|---|---|---|---|
| 1. | Used Oil | 4250 MT | I-5.1 | Collection, Storage, Transportation, and send to registered recycler processors. |
| 2. | Waste Residue containing oil | 8500 MT | I-5.2 | |

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

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

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

5.6 **TERMS AND CONDITIONS OF AUTHORISATION**

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

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

wastewater and air emissions and solid hazardous wastes generated within the factory premises.

6. **SPECIFIC CONDITIONS:-**

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

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

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

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

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

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

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

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

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

7. **GENERAL CONDITIONS: -**

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

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

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

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

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

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

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

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

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

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

**For and on behalf of**
**GUJARAT POLLUTION CONTROL BOARD**

**(T.C. Patel)**
**Unit Head**

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

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

**"FORM-IV"**

[(See rule 6(%), 13(8), 16(6) and 20(21)

(To be submitted to State Pollution Control Board by 30th day of June of every year for the preceding period April 24 to March 25)

| Sr. No. | Particulars | Details |
|---|---|---|
| 1. | Name and Address of the Facility | **Deendayal Port Authority**<br>Administrative Office Building<br>Post Box No. 50 Gandhidham<br>Dist.: Kutch- 370201 Gujarat State<br>Tel. No.: 02836-233192<br>Fax No.: 02836-220050 |
| 2. | Authorization No. and Date of issue | Consent order no. AWH – 110594 granted by the GPCB dated 22/01/2021 and correction to consent order done dated 09/04/2021 and its further amendment dated 11/01/2024. |
| 3. | Name of Authorized Person and full address with telephone, Fax number and E-Mail | **Mr. Raveendra Reddy**<br>**Chief Engineer**<br>**Deendayal Port Authority**<br>Administrative Office Building<br>Post Box No. 50 Gandhidham<br>Dist.: Kutch- 370201 Gujarat State<br>Tel. No.: 02836-233192<br>Fax No.: 02836-220050 |
| 4. | Production during the year (product wise) wherever applicable | NA<br>Deendayal Port Authority has only loading & unloading activities for dry cargo and liquid cargo.<br><br>During FY 2024-25 Total Cargo Handled is **150.15 MMTPA** |

**PART A. To be filled by Hazardous Waste Generator**

| | | |
|---|---|---|
| 1. | Total quantity of waste generated category wise | Used oil/Waste residue containing oil<br>**1. Used Spent Oil: 4498.91**<br>**2. Waste residue containing oil: 13496.72** |
| 2. | Quantity Dispatched<br>a. To disposal Facility<br>b. To recycler or co-processor or pre-processor<br>c. Others | Used Oil/Waste residue containing oil has been disposed of through CPCB/GPCB authorized vendor **(Annexure-II)** |
| 3. | Quantity utilized inhouse -if any | NA |
| 4. | Quantity in storage at the end of the year | NA |

**Enclosure – A**

Annual Return of Hazardous waste Return (Form IV)
For Deendayal Port Authority, Kandla
For the FY @ 2024-2025

**PART B To be filled Treatment, Storage and Disposal Facility Operator**

| | | |
|---|---|---|
| 1. | Total Quantity Received<br>1. Direct Landfill<br>2. Incineration<br>3. Land fill after treatment | NA |
| 2. | Quantity at stock at the beginning of the year<br>1. Direct Landfill<br>2. Incineration<br>3. Land fill after treatment | |
| 3. | Quantity treated (Landfill)<br>Land fill after Treatment | |
| 4. | Quantity disposed in landfill as such and after treatment<br>1. Direct Landfill<br>2. Land fill after treatment<br>3. Incineration Ash<br>4. Salts from Spray Dryer<br>5. Total | |
| 5. | Quantity incinerated (if applicable) | |
| 6. | Quantity processed other than specified above | |
| 7. | Quantity in storage at the end of the year<br>1. Incineration<br>2. Landfill after treatment | |

**PART C To be filled by recyclers or co-processor or other users**

| | | |
|---|---|---|
| 1. | Quantity of the waste received during the year<br>1. Domestic sources<br>2. Imported (if applicable) | NA |
| 2. | Quantity in stock at the beginning of the year | |
| 3. | Quantity recycled or co processed or used | |
| 4. | Quantity of products dispatched (wherever applicable) | |
| 5. | Quantity of waste generated | |
| 6. | Quantity of waste disposed | |
| 7. | Quantity re-exported (wherever Applicable) | |
| 8. | Quantity in storage at the end of the year | |

Date: 25/07/2025

Place: Gandhidham

XEN (EMC)
Deendayal Port Authority

# MARINE DEPARTMENT

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

With reference to the above subject, the annual return showing the collection and disposal of Hazardous and Non-Hazardous Wastes carried out by various parties for the period from 01-04-2024 to 31-03-2025 of Marine Department is enclosed herewith.

Encl : As above

Deputy Conservator
Deendayal Port Authority

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

## Deendayal Port Authority
## Marine Department

**Statement of Hazardous and Non hazardous Waste disposal from the Vessels at Kandla Port for the Period April 2024 to March 2025 – For the Whole Port Area**

**(PCB ID 28494)**

| Sr.No. | Month | Year | Hazardous Waste Generation in MT | | | Solid Waste Generated in MT |
|---|---|---|---|---|---|---|
| | | | Total Quantity | Used Oil | Waste Residue Containing Oil | |
| 1. | April | 2024 | 1124.53 | 281.13 | 843.40 | 170.96 |
| 2. | May | 2024 | 1004.00 | 251.00 | 753.00 | 265.01 |
| 3. | June | 2024 | 2194.23 | 548.56 | 1645.67 | 174.14 |
| 4. | July | 2024 | 1330.64 | 332.66 | 997.98 | 247.80 |
| 5. | August | 2024 | 2333.80 | 583.45 | 1750.35 | 302.37 |
| 6. | September | 2024 | 2055.17 | 513.79 | 1541.38 | 285.17 |
| 7. | October | 2024 | 2198.00 | 549.50 | 1648.50 | 405.24 |
| 8. | November | 2024 | 1024.58 | 256.15 | 768.44 | 368.41 |
| 9. | December | 2024 | 1283.96 | 320.99 | 962.97 | 404.33 |
| 10. | January | 2025 | 1214.05 | 303.51 | 910.54 | 245.46 |
| 11. | February | 2025 | 1328.61 | 332.15 | 996.46 | 294.38 |
| 12. | March | 2025 | 904.06 | 226.01 | 678.04 | 111.33 |
| Total | | | **17995.63** | **4498.91** | **13496.72** | **3274.60** |

Deputy Conservator
Deendayal Port Authority

# Marine Department

(IN MT)

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

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

**Copy to : GPCB, Gandhidham / Harbour Master**

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

दीनदयाल पत्तन प्राधिकरण
DEENDAYAL PORT AUTHORITY

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

www.deendayalport.gov.in

EG/WK/4751 (CCA Renewal)/50

Date: 23/07/2025

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

**Sub:** Submission of Environmental statement in format form V for the financial year 2024-25 reg.

**Ref.:**
1) KPT letter no. MR/GN/1527(Part I)/535 dated 16/6/2012
2) KPT letter no. MR/GN/1527(Part I)/2011 dated 20/5/2013
3) KPT letter no. MR/GN/1527(Part I)/337 dated 17/05/2014
4) KPT letter no. MR/GN/1527/ (Part I)/dated 27/04/2015
5) KPT letter no. EG/WK/EMC/CCA (Part II)/218 dated 27/6/2016
6) KPT letter no. EG/WK/EMC/CCA (Part II)/214 dated 19/6/2017
7) DPT letter no. EG/WK/EMC/CCA (Part II)/294 dated 13/6/2018
8) DPT letter no. EG/WK/EMC/CCA (Part II) dated 27/5/2019
9) DPT letter no. EG/WK/4751 (CCA Renewal) dated 22/5/2020
10) DPT letter no. EG/WK/4751 (CCA Renewal)/14 dated (30)04/(4)5/2021
11) DPA letter no. EG/WK/4751 (CCA Renewal)/132 dated 06/07/2022
12) DPA letter no. EG/WK/4751 (CCA Renewal)/326 dated 19/06/2023
13) DPA letter no. EG/WK/EMC/CCA/Part III/91 dated 19/07/2024

Sir,

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

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

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

Now please find the enclosed herewith Environmental Statement in Form V for the year 2024-25

This is for kind information and record please.

Encl : As above

Yours faithfully

XEN (EMC)
Deendayal Port Authority

GPCB

# GUJARAT POLLUTION CONTROL BOARD

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

## Annexure I

**By R.P.A.D**

In exercise of the power conferred under section-25 of the Water (Prevention and Control of Pollution) Act-1974, under section-21 of the Air (Prevention and Control of Pollution)-1981 and Authorization under rule 6(2) of the Hazardous and Other Waste (Management and Transboundary) Rules, 2016 framed under the Environmental (Protection) Act-1986.

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

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

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

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

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

**Subject to specific condition:**

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

6. Industry shall not withdraw groundwater without prior NOC from CGWA as per Hon. National Green Tribunal order.
7. Industry shall manage Solid Wastes generated from industrial activities as per Solid Waste Management Rules-2016 (solid waste as defined in Rule-3(46)).
8. Applicant shall ensure that there shall be no damage to the existing mangrove patches near site and also ensure the free flow of water to avoid damage to the mangroves.
9. Applicant shall ensure as per EC condition that no creeks or rivers are blocked due to any activities at the site and free flow of water is maintained.
10. Applicant shall provide proper system for collection, storage & treatment & disposal of waste water generated by vessel as per MARPOL& maintain records.
11. Applicant shall install storm drainage catch basin to avoid directly discharge into surface water.
12. Waste effluent accumulated with port activities including storm water & sewage from port operation including sewage ballast water, bilge water &clean waste water from ships shall be as per MARPOL norms.
13. Applicant shall make separate records regarding generation, collection, transportation& disposal of waste generation from ship & maintain its records.
14. Applicant shall made necessary arrangement for the plastic Waste, Solid Waste or other waste generation due to port activities & for facilitation of reception facilities under MARPOL & Environment (Protection) Act-1986 rules etc.
15. Ports shall obtain approval of their oil spill contingency plan (OSCP) as required under national oil spill disaster contingency plan (NOS-DCP) of coast guard, ministry of defence, govt. of India.
16. Best environmental practices by ports maybe uploaded on "Indian ports Association" as well as the same maybe linked to websites of CPCB and respective SPCBs.
17. Manually handling of cargo should be converted into mechanized system, in time bound manner.
18. Industry shall comply with circular of the Board dated 27/08/2021 regarding retrofitting of emission control/ equipment in D.G. Set of capacity 125 KVA and above as per system & procedure for emission compliance testing of Retrofit Emission Control Devices (RECD) for D.G. Set issued by CPCB dated 01/02/2022 at the earliest and submit compliance.

**3. <u>CONDITIONS UNDER THE WATER ACT:</u>**

3.1 Water Source: - GWIL.

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

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

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

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

| PARAMETERS | GPCB NORMS |
|---|---|
| pH | 5.5-9.0 |
| Biochemical Oxygen Demand (BOD) | 10 mg/L |
| Total suspended solids (TSS) | 20 mg/L |
| Chemical Oxygen Demand (COD) | 50 mg/L |

| | |
|---|---|
| Nitrogen –Total | 10 mg/L |
| Phosphorous-Total (for discharge into Ponds, Lakes) | 1.0 mg/L |
| Fecal Coliform | Desirable-100 MPN/100ml<br>Permissible -230 MPN/100 ml |

3.6 Treated domestic effluent conforming to above standard shall be discharged on land for gardening and plantation purpose within premises. In no case waste water shall be discharged outside premises.

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

3.8 Disposal system for storm water shall be provided separately, in no circumstances storm water shall be mixed with the industrial effluent in any case.

**4. Conditions under the Air Act-1981:**

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

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

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

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

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

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

4.5. The concentration of the following parameters in the ambient air within the premises of the industry shall not exceed the limits specified hereunder as per National Ambient Air Quality Standards issued by MoEF & CC dated 18th November-2009.In addition to following parameters Industry shall also carry out AAQ monitoring of all other applicable parameter as per MoEF notification dated 18/11/2009 and submit the report to the Board.

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

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

4.6. The applicant shall provide portholes, ladder, platform etc. at chimney(s) for monitoring the air emissions and the same shall be open for inspection to/and for use of Board's staff. The chimney(s) vents attached to various sources of emission shall be designed by numbers such as S-1, S-2, etc. and these shall be painted/ displayed to facilitate identification.

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

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

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

**D.G. Sets standards:-**

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

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

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

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

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

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

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

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

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

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

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

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

| Sr. No. | Waste | Quantity per Annum | Schedule & Category | Facility |
|---|---|---|---|---|
| 1. | Used Oil | 4250 MT | I-5.1 | Collection, Storage, Transportation, and send to registered recycler processors. |
| 2. | Waste Residue containing oil | 8500 MT | I-5.2 | |

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

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

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

5.6 **TERMS AND CONDITIONS OF AUTHORISATION**

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

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

wastewater and air emissions and solid hazardous wastes generated within the factory premises.

6. **SPECIFIC CONDITIONS:-**

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

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

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

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

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

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

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

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

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

7. **GENERAL CONDITIONS: -**

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

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

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

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

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

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

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

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

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

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

**For and on behalf of**
**GUJARAT POLLUTION CONTROL BOARD**

**(T.C. Patel)**
**Unit Head**

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

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

**Annexure II**

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

**"FORM-V"**
(See rule -14)

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

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

**Environmental statement for the financial year ending the 31st March, 2025**

**"PART-A"**

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

**"PART-B"**

**WATER AND RAW MATERIAL CONSUMPTION**

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

**I. Water Consumption**

| Sr. No. | Name of Products | Process Water Consumption per unit of products output | |
|---|---|---|---|
| | | **During the current financial year 2023-24** | **During the current financial year 2024-25** |
| 01. | Dry Cargo Handling | **132.37 MT** | **150.15 MT** |
| 02. | Liquid Cargo Handling | | |
| Deendayal Port Authority has only loading & unloading activities for dry cargo and liquid cargo. Hence consumption of process water consumption per unit of output with respective to production is not applicable.<br><br>During FY 2024-25 Total Cargo Handled is **150.15** MMTPA<br><br>However, Details of the Domestic water consumption for the financial year 2024-25 please refer **Annexure-A** | | | |

**II. Raw material Consumption**

| Sr.No. | Name of Raw Material | Name of Products | Consumption of Raw material per unit of output | |
|---|---|---|---|---|
| | | | **During the current financial year 2023-24** | **During the current financial year 2024-25** |
| 1. | Deendayal Port Authority has only loading & unloading activities for dry cargo and liquid cargo. Hence consumption of raw material per unit of output with respective to production is not applicable | | | |

**"PART-C"**

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

| Pollutant | Quantity of Pollutant Discharged (mass/day) | Concentration of Pollution in Discharge (mass/volume) | % of Variation from prescribed standard with reasons |
|---|---|---|---|
| Please Refer **Annexure -B** for Environmental Monitoring Reports of<br>• Ambient Air Quality Monitoring<br>• Drinking Water Quality Monitoring<br>• Marine Water Monitoring<br>• Noise Level Monitoring | | | |

**"PART-D"**

**HAZARDOUS WASTE**

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

| Sr.No. | Hazardous Waste | Total Quantity in MT/Year | |
|---|---|---|---|
| | | During the current financial year 2023-24 | During the current financial year 2024-25 |
| 1. | 5.1- Used Spent Oil | 2431.39 | 4498.91 |
| 2. | 5.2- Waste Residue Containing Oil | 7294.17 | 13496.72 |
| • Details of Hazardous Waste generated during the financial year 2024-25 please refer **Annexure-C** | | | |
| a. From Process: NA<br>b. From Pollution Control facility: NA | | | |

**"PART-E"**

**SOLID WASTE**

| Sr.No. | Solid Waste | Total Quantity in MT/year | |
|---|---|---|---|
| | | **During the current financial year 2023-24** | **During the current financial year 2024-25** |
| 1. | From Process | Nil | Nil |
| 2. | From pollution Control Facility | Nil | Nil |
| a. | Quantity Recycled or Reutilized within the unit | Nil | Nil |
| b. | Sold | Nil | Nil |
| c. | Disposed Off | **2572.94** | **3274.60** |
| Details of Solid Waste (Non-Hazardous Waste) generated during the financial year 2024-25 please refer **Annexure-C** | | | |

## "PART-F"

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

**Hazardous Waste:**

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

**Solid Waste:**

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

## "PART-G"

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

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

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

1. Regular Monitoring of Mangrove Plantation.

2. Preparation of detailed marine Biodiversity management plan for the impact of the project activities as per the requirement of EC & CRZ Clearance accorded by the MoEF&CC, GOI for the project "Creation of water front facilities (Oil jetties 8,9,10,11) and development of land of area 554 acres for associated facilities for storage at old Kandla, Gandhidham, kutch, Gujarat by M/s Deendayal Port Authority"

3. Regular monitoring of marine ecology in and around the Deendayal Port Authority area and continuous monitoring programme covering all season on various aspects of the coastal environ covering physico-chemical parameters of marine sediments samples coupled with biological indices, as per the requirement of EC & CRZ clearance accorded by the MoEF&CC,GOI to the various projects of the Deendayal port Authority.

4. Study on dredged material for presence of contaminant as per EC and CRZ clearance accorded by the MoEF&CC, GOI dated 19/12/2016 – specific condition vii

## "PART-H"

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

The allocation made under the scheme of "Environmental Services & Clearance there of other related Expenditure" during BE 2026-2026 is Rs. 545 Lakhs

## "PART-I"

## ANY OTHER PARTICULAR FOR IMPROVING THE QUALITY OF THE ENVIRONMENT

1. DPA is ISO 14001:2015 certified port for "Providing port facility and related maritime services for vessel and Cargo handling including storage
2. DPA has appointed M/s GEMI, Gandhinagar for the work "Making Deendayal Port a Green Port– Intended Sustainable Development under the Green Port Initiatives". M/s GEMI, Gandhinagar had submitted the Final Report on 10/03/2021
3. DPA has accorded the work of Afforestation project in Deendayal Port Area to Forest Department, GoG which includes plantation and maintenance work of 1100 plants per ha.
4. DPA has planted 7500 trees in Deendayal port trust area during the year 2014-15 6000 trees during financial year 2016-17 and the same has been regularly maintained
5. DPA has planted 4000 trees at A.O building, Gopalpuri residential colony and along the road side at Kandla. Further, approximately 885 no. of trees have been planted since September 2015 onwards
6. It is also relevant to mention here that, DPA entrusted work to Forest Department, GoG (Social Forestry Division, Bhuj) during August, 2019 for green belt development in and around port area 31.942 hectares (approx. 35200 plants at various locations) at a cost of Rs. 352.32 lakhs
7. DPA has accorded the work of green belt development in Deendayal port Authority and its Surrounding areas charcoal site to GUIDE for the plantation of 5000 saplings of suitable species.
8. DPA has accorded the work of green belt development in Deendayal port Authority and its Surrounding areas to GUIDE for the plantation of 10000 saplings of suitable species
9. Continuous water sprinkling has been carried out on the top of the heap of coal, at regular intervals to prevent dusting, fire and smoke. DPA already installed sprinkling system inside Cargo Jetty area for coal dust suppression in coal yard (40 Ha. Area) at the cost of Rs. 14.44 crores.
10. DPA has installed Mist Canon at the Port area to minimize the coal dust.
11. Deendayal port Authority (traffic department) issued a Circular (SOP) to the trade with regard to control of dust pollution arising out of coal handling and ensuring safety in coal handling. In case of any violations of SOP, provision of impose of penalty of Rs. 10000/- has been made and if violation is repeated thrice, the same will lead to ban of concerned party into port area. The DPA is taking all the measures to reduce coal dust by implementing the coal handling guidelines through port users.
12. All trucks before leaving the storage yard have been covered with tarpaulin and also trucks are also not over loaded as well as there is no spillage during

transportation and there is adequate space for movement of vehicles at the surrounding area.

13. DPA has constantly improving the house keeping in the dry cargo storage yard and nearby approved areas leading to roads. Adequate steps under the Provisions of air prevention and control of pollution Act 1981, Environmental Protection Act 1986 are taken.
14. DPA commissioned STP of capacity 1.5 MLD for treatment of domestic waste water for entire DPA area. (Details of domestic waste water generation is attached herewith as **Annexure D**)
15. Deendayal Port Authority had carried out mangrove plantation in an area of 1650 ha. through various government agencies like Gujarat Ecology Commission, State Forest Department, GUIDE, Bhuj etc.
16. DPA is involved in various CER activities like providing the proper sanitation and development of better roads for connectivity
17. DPA is managing its plastic waste as per Plastic Waste Management Rules – 2016 and amendments made therein. In order to strictly implement the said rules, DPA had issued a circular regarding plastic waste minimization, source segregation, recycling etc. vide its Circular no. EG/WK/4751/Part 243(A) dated 03/09/2021
18. DPA has entrusted the work to GEMI, Gandhinagar for "Preparation of Plan for Management of Plastic Waste, Solid Waste, C&D Waste, E-waste, Hazardous Waste including Bio-medical Waste and Non-hazardous waste in the Deendayal Port Authority Area
19. DPA has assigned the work to TERI, New Delhi for "Transition of Business Operations to Water Neutrality – Water Neutrality of Deendayal Port, Kandla (Phase I- Study and assessment)
20. Recently, DPA has entrusted the work to GEMI, Gandhinagar for "Study of $CO_2$ Emission Estimation and Reduction Strategy under Maritime India Vision 2030.
21. DPA has assigned the work for Installation of Continuous Ambient Air Quality Monitoring System (CAAQMS) for monitoring of Air quality at DPA Kandla to GUIDE, bhuj.

# ANNEXURE A

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

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

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

XEN (PL)

# ANNEXURE B

Environmental Monitoring Report

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

**(Monitoring Period: March-April 2025)**

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

## Submitted to:

## Deendayal Port Authority (DPA), Kandla


## Gujarat Environment Management Institute (GEMI)

**(An Autonomous Institute of Government of Gujarat)**

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

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

# Certificate

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

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

S. S. O. & Lab Head
**Authorized Signatory**

# About this Document

Gujarat Environment Management Institute (GEMI) has been assigned with the work of "Preparing and monitoring of Environmental monitoring and Management plan for Deendayal Port Authority (DPA) at Kandla and Vadinar for a period of 3 years" by DPA, Kandla. Under the said project the report titled *"Environment Monitoring Report (March-April 2025)"* is prepared.

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

## Table of Contents

## List of Tables

# List of Maps



# List of Figures



# List of Graphs

# List of Abbreviations

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

# CHAPTER 1: INTRODUCTION

## 1.1 Introduction

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

## 1.2 Green Ports Initiative

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

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

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

## 1.3 Importance of EMP

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

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

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

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

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

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

This document presents the Environmental Monitoring Report (EMR) for Kandla and Vadinar for the environmental monitoring done during the period from 17th March-16th April 2025.

## 1.4 Objectives and scope of the Study

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

The scope of work includes not limited to following:

1. To review the locations/stations of Ambient Air, Ambient Noise, drinking water, and Marine Water, Soil and Sediments monitoring within the impacted region in-and-around DPA establishment, in view of the developmental projects.
2. To assess the Ambient Air quality, quality at 6 stations at Kandla and 2 at Vadinar in terms of gases and particulate matter.
3. To assess the DG stack emissions (gases and particulate matter).
4. To assess Drinking water quality at twenty locations (18 at Kandla and 2 at Vadinar) in terms of Physical, Chemical and Biological parameters viz., Color, Odor, turbidity, conductivity, pH, Total Dissolved Solids, chlorides, Hardness, total iron, sulfate, $NH_4$, $PO_4$, and bacterial count on a monthly basis.
5. To assess the Marine water quality in terms of aquatic Flora and Fauna and Sediment quality in terms of benthic flora and fauna.
6. To assess Marine Water Quality and sediment in term of physical and chemical parameter.
7. To assess the trends of water quality in terms of Marine ecology by comparing the data collected over a specified time period.
8. Weekly sample collection and analysis of inlet & Outlet points of the Sewage Treatment Plant (STP) to check the water quality being discharged by DPA as per the CC&A.
9. Carrying out monthly Noise monitoring; twice a day at the representative stations for a period of 24 hours.
10. Meteorological parameters are very important from air pollution point of view, hence precise and continuous data collection is of utmost importance. Meteorological data on wind speed, wind direction, temperature, relative humidity, solar radiation and

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

11. To suggest mitigation measures, based on the findings of this study and also check compliance with Environmental quality standards, Green Port Initiatives, MIV 2030, and any applicable Statutory Compliance.
12. To recommend Environment Management Plans based on Monitoring programme and findings of the study.

# CHAPTER 2: METHODOLOGY

## 2.1 Study Area

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

### a. Kandla

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

- **Climatic conditions of Kandla**

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

### b. Vadinar

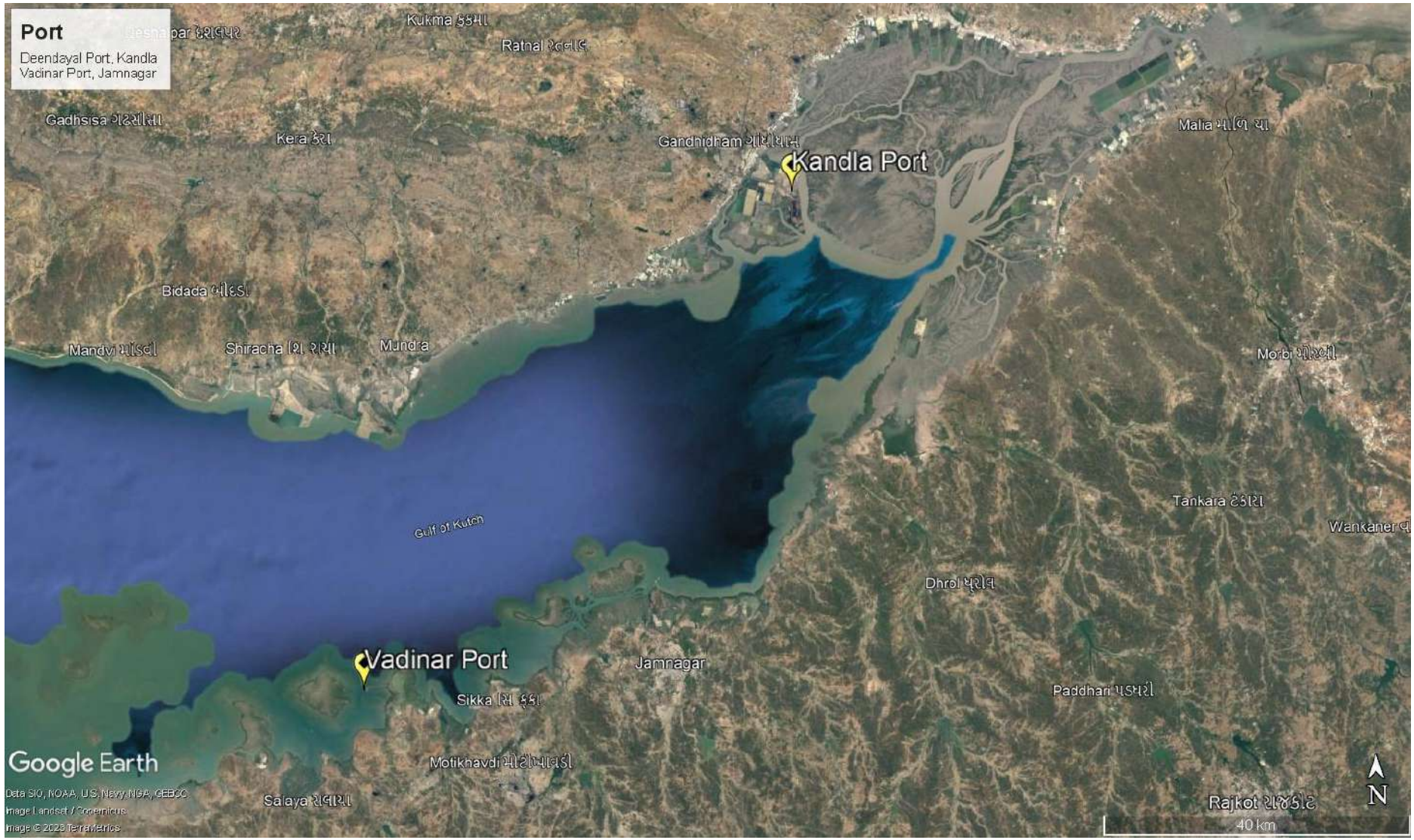
**Vadinar** is a small coastal town located in Devbhumi Dwarka district of the Gujarat state in India located at coordinates 22° 27' 16.20" N - 069° 40' 30.01". DPA had commissioned the Off Shore Oil Terminal (OOT) facilities at Vadinar in the year 1978, for which M/s. Indian Oil Corporation Limited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

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

- **Climatic conditions of Vadinar**

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

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




**Map 1: Locations of Kandla and Vadinar Port**


**Map 2: Locations of Kandla Port**


**Map 3: Locations of Vadinar Port**

## 2.2 Environmental Monitoring at Kandla and Vadinar

Regular monitoring of environmental parameters is of immense importance to assess the status of environment during project operation. With the knowledge of baseline conditions, the monitoring programme will serve as an indicator for identifying any deterioration in environmental conditions, thereby assist in recommending suitable mitigatory steps in time to safeguard the environment. Monitoring is as important as that of control of pollution since the efficiency of control measures can only be determined by a well-defined monitoring program. Environmental Monitoring is vital for monitoring the environmental status of the port for sustainable development. The list of main elements for which Environmental monitoring is to be carried out have been mentioned below:

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

GEMI has been entrusted by DPA to carry out the monitoring of the various aforementioned environmental aspects at the port, so as to verify effectiveness of prevailing Environment Management plan, if it confirms to the statutory and/or legal compliance; and identify any unexpected changes. Standard methods and procedures have been strictly adhered to in the course of this study. QA/QC procedures were strictly followed which covers all aspects of the study, and includes sample collection, handling, laboratory analyses, data coding, statistical analyses, interpretation and communication of results. The analysis was carried out in GEMI's NABL/MoEF accredited/recognized laboratory.

**Methodology adopted for the study**

Methodology is a strictly defined combination of practices, methods and processes to plan, develop and control a project along the continuous process of its implementation and successful completion. The aim of the project management methodology is to allow the control of whole process of management through effective decision-making and problem solving. The methodology adopted for the present study is shown in **Figure 1** as given below:

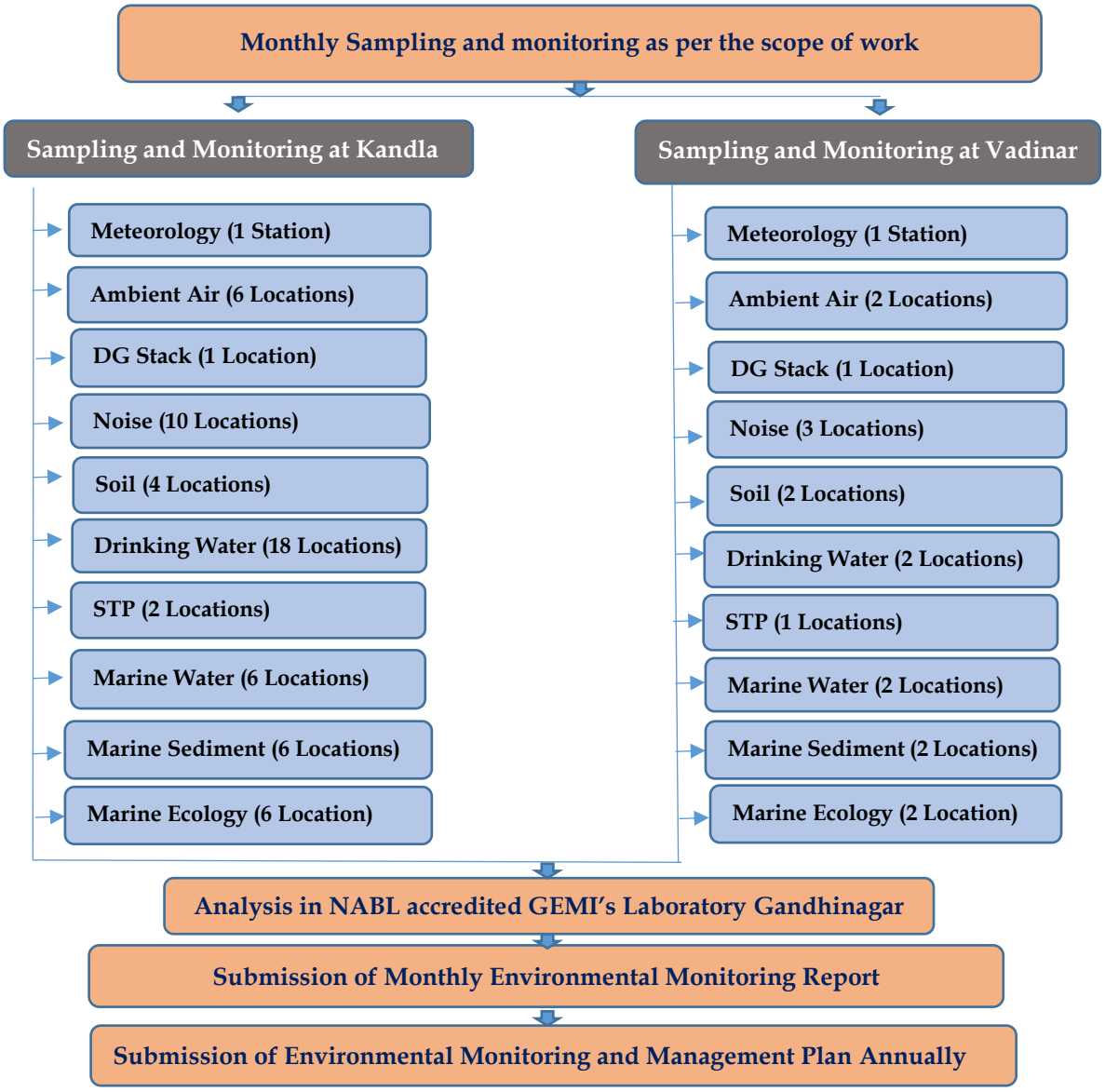



**Figure 1: Methodology flow chart**

The details of various sectors of Environment monitoring are described in subsequent chapters.

# CHAPTER 3: METEOROLOGY MONITORING

## 3.1 Meteorology Monitoring

Meteorological conditions play a crucial role in dispersion of air pollutants as well as in environmental pollution studies particularly in pollutant transport irrespective of their entry into the environment. The wind speed and direction play a major role in dispersion of environment pollutants. In order to determine the prevailing micro-meteorological conditions at the project site an Automatic Weather Monitoring Stations (AWS) of Envirotech make (Model: WM280) were installed at both the sites of Kandla and Vadinar at 10 m above the ground. The details of the AWS installed have been mentioned in **Table 1** as follows:

**Table 1: Details of Automatic Weather Station**

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

**Methodology**

During the study, a continuous automatic weather monitoring station was installed at both the sites to record climatological parameters such as Wind speed, Wind Direction, Relative Humidity, Solar Radiation, Rainfall and Temperature to establish general meteorological regime of the study area. The methodology adopted for monitoring meteorological data shall be as per the standard norms laid down by Bureau of Indian Standards (BIS) and the India Meteorological Department (IMD). The details of Automatic Weather Monitoring Station have been mentioned in **Table 2**.

**Table 2: Automatic Weather Monitoring Station details**

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

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

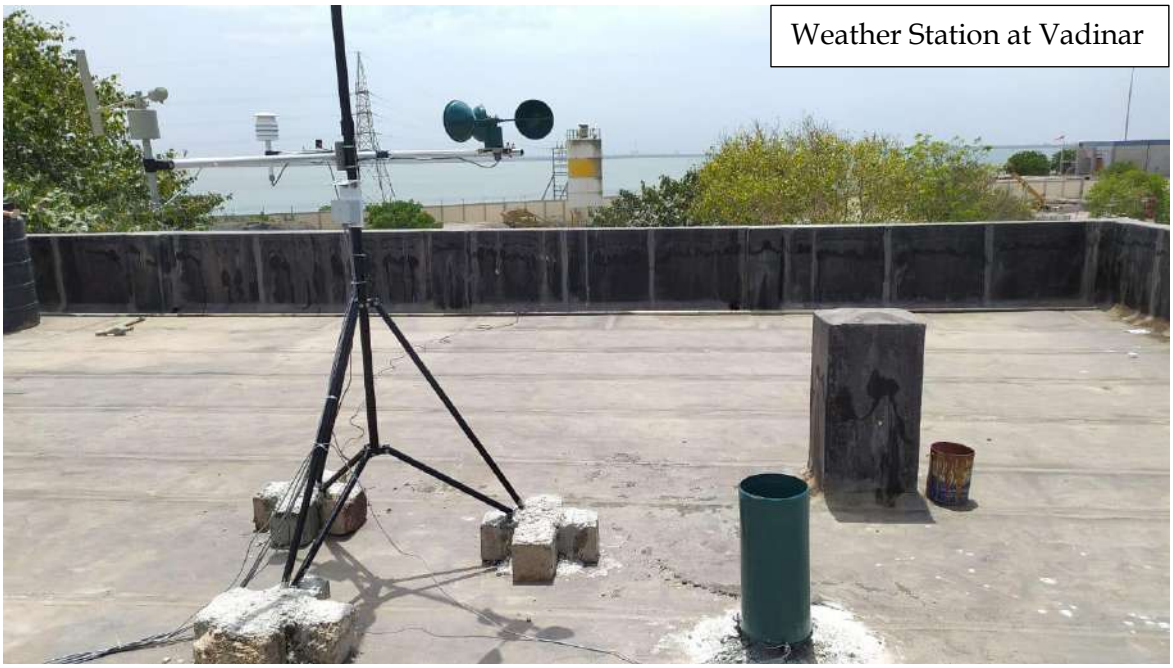




**Figure 2: Photographs of Automatic Weather Monitoring Station at Kandla and Vadinar**

## 3.2 Results and discussion

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

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

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

### 3.3 Data Interpretation and Conclusion

- **Temperature**

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

- **Relative Humidity**

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

- **Rainfall**

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

- **Wind Speed**

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

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

- **Solar Radiation:**

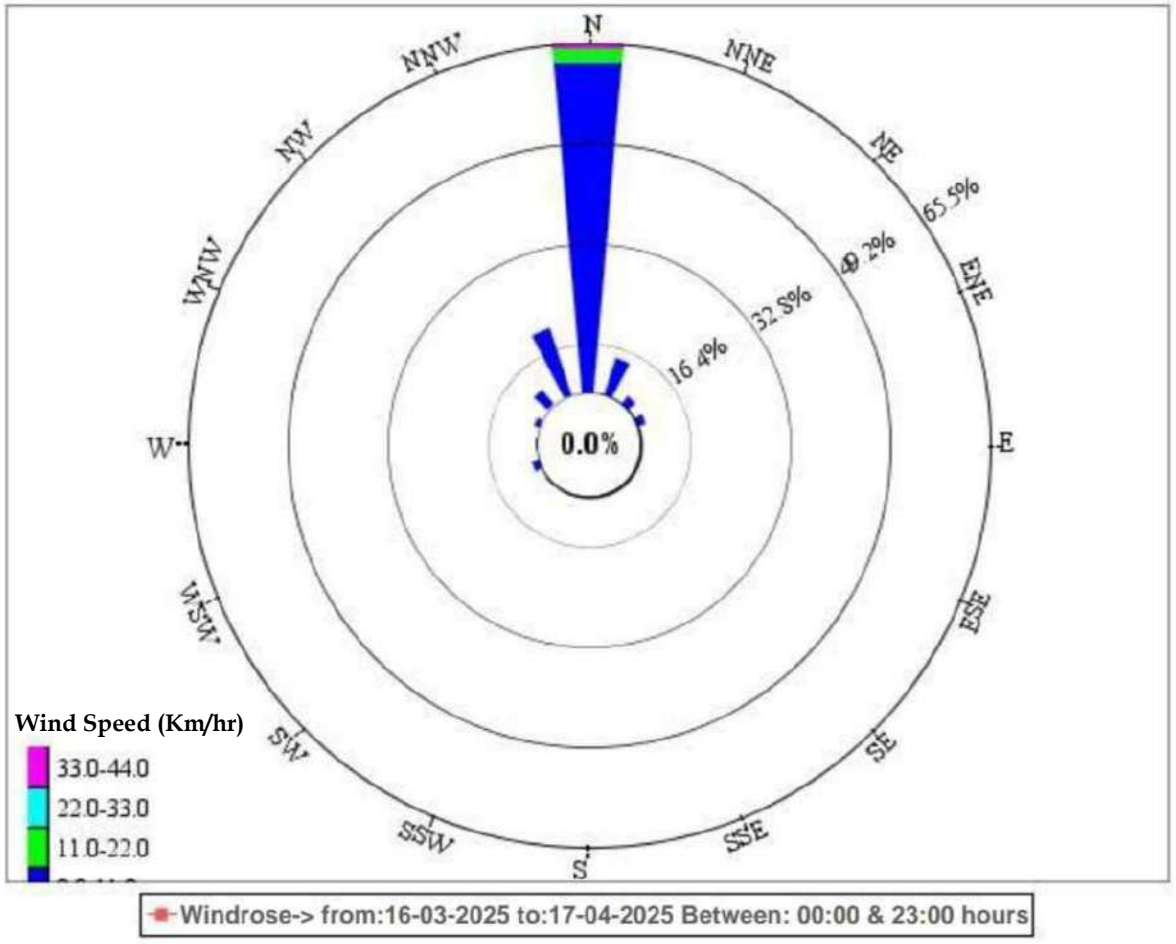
a. **Kandla:** The average Solar Radiation for the monitoring period was recorded as 92.27 W/m$^2$.
b. **Vadinar:** The average Solar Radiation was recorded as 110.30 W/m$^2$.

- **Wind rose diagram -**

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

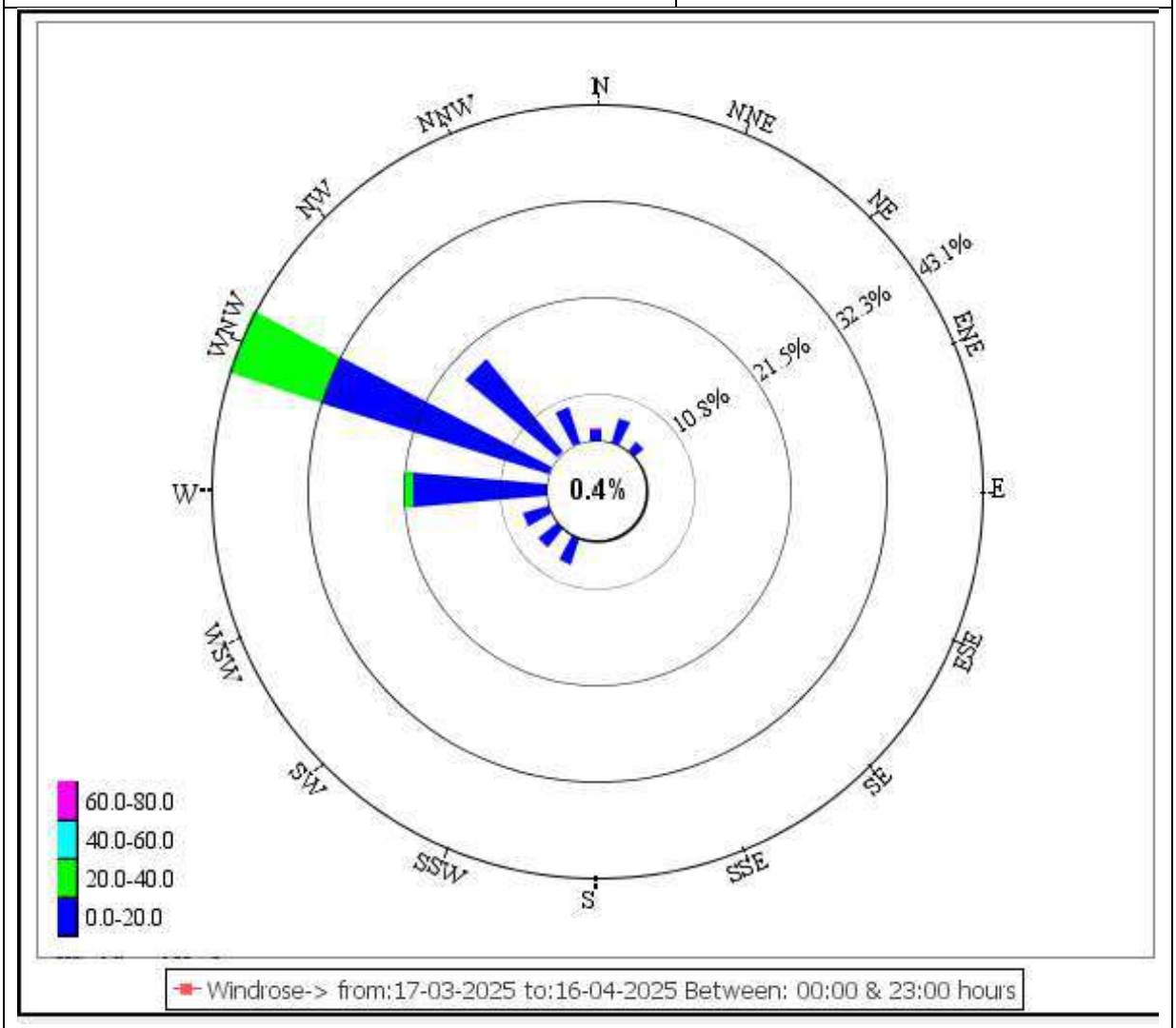
This Wind Rose Diagram reveals that at Kandla and Vadinar, during the monitoring period, the prevailing winds predominantly blow from the North direction at Kandla. whereas, At Vadinar, the winds were observed to blow from West-North-West direction.

| | |
|---|---|
| **Wind Rose Plot**<br>**M/s Deendayal Port Authority**<br>**Site: Kandla Port (Environment Laboratory)** | **Display: Wind Direction**<br>**Wind Speed (Km/hr)** |




Modeler: Envirotech Instruments Pvt. Ltd. Delhi.

| | |
|---|---|
| **Wind Rose Plot**<br>**M/s Deendayal Port Authority**<br>**Site: Vadinar Port (Canteen Area)** | **Display: Wind Direction**<br>**Wind Speed (Km/hr)** |




Modeler: Envirotech Instruments Pvt. Ltd. Delhi.

# CHAPTER 4: AMBIENT AIR QUALITY MONITORING

## 4.1 Ambient Air Quality

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

**Methodology**

The study area represents the area occupied by DPA and its associated Port area. The sources of air pollution in the region are mainly vehicular traffic, fuel burning, loading & unloading of dry cargo, fugitive emissions from storage area and dust arising from unpaved village roads. Considering the below factors, under the study, as per the scope specified by DPA eight locations wherein, 6 stations at Kandla and 2 at Vadinar have been finalized within the study area

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

The description of various air quality stations monitored at Kandla and Vadinar have been specified in **Table 4**.

**Table 4: Details of Ambient Air monitoring locations**

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

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

Ambient Air monitoring photos

**Kandla**

A-1: Oil Jetty No. 1

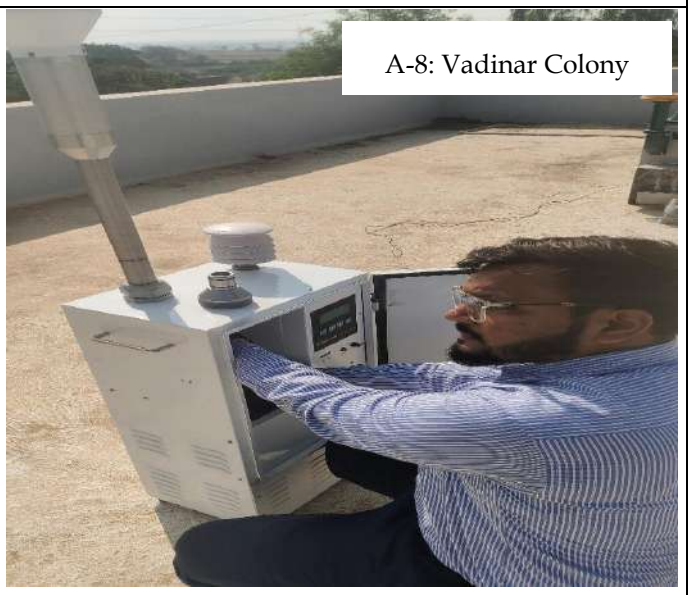
A-2: Oil Jetty No. 7

A-3: Kandla Port Colony

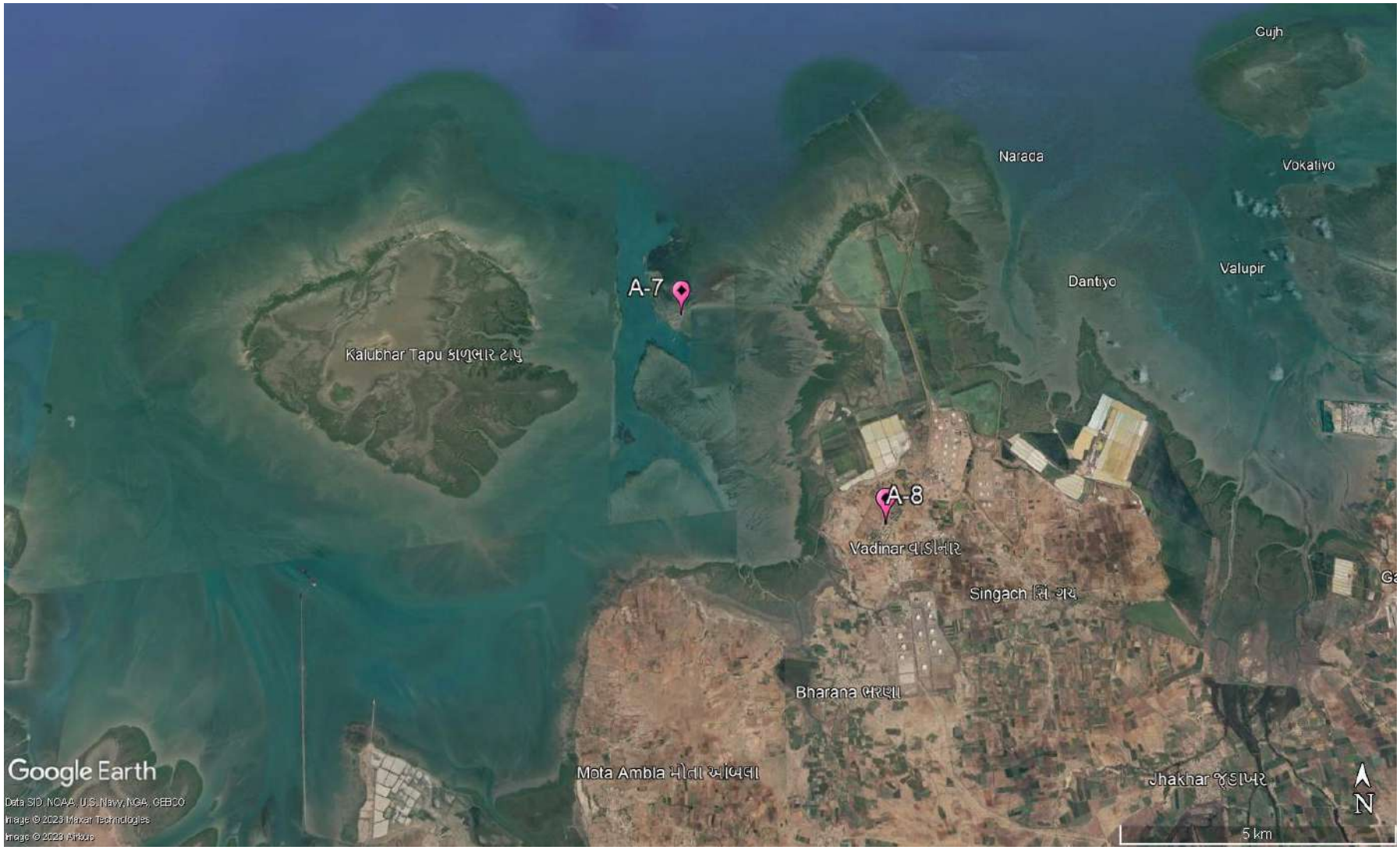
A-4: Marine Bhavan

A-5: Coal Storage Area

A-6: Gopalpuri Hospital

| Vadinar | |
|---|---|
|  A-7: Admin Building |  A-8: Vadinar Colony |


**Map 4: Locations for Ambient Air Monitoring at Kandla**




**Map 5: Locations for Ambient Air Monitoring at Vadinar**

**Frequency**

The sampling for Particulate matter i.e. $PM_{10}$ and $PM_{2.5}$ and the gaseous components like $SO_x$, $NO_x$, CO as well as the Total VOCs were monitored twice in a week for a period of 24 hours a day. Whereas, the sampling for the components of PAH, Benzene and non-Methane VOCs was conducted on monthly basis.

**Sampling and Analysis**

The Sampling of the Ambient Air Quality parameters and analysis is conducted as per the CPCB guidelines of National Ambient Air Quality Monitoring. The sampling was performed at a height of 3.5 m (approximately) from the ground level. For the sampling of $PM_{10}$, calibrated 'Respirable Dust Samplers' were used, where Whatman GF/A microfiber filter paper of size 8"x 10" were utilized, where the Gaseous attachment of the make Envirotech instrument was attached with Respirable Dust Sampler for the measurement of $SO_x$ and $NO_x$. The Fine Particulate Sampler for collection of $PM_{2.5}$ was utilized for the particulate matter of size <2.5 microns. A known volume of ambient air is passed through the cyclone to the initially pre-processed filter paper. The centrifugal force in cyclone acts on particulate matter to separate them into two parts and collected as following:

- Particles <10 µ size (Respirable): GF/A Filter Paper
- Particles <2.5 µ size (Respirable): Polytetrafluoroethylene (PTFE)

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

Data has been compiled for $PM_{10}$, $PM_{2.5}$, $SO_x$ and $NO_x$ samples of 24-hour carried out twice a week. In case of CO, one hourly sample were taken on selected monitoring days using the sensor-based CO Meter. For the parameters Benzene, Methane & Non-methane and Volatile Organic Carbons (VOCs), the Low Volume Sampler is used, where the charcoal tubes are used as sampling media. The sampling in the Low Volume Sampler (LVS) is carried out as per IS 5182 (Part 11): 2006 RA: 2017, where the ambient air flow rate is maintained at 200 cc/min, the volume of air that passes through the LVS during two hours monitoring is approx. 24 L.

The sampling of PAHs is carried out as per IS: 5182 (Part 12): 2004. Where, the EPM 2000 Filter papers are utilized in the Respirable Dust Sampler (RDS). For the parameters, Benzene, PAH & Non-methane VOC's, monthly monitoring is carried out. The details of the parameters with their frequency monitored are mentioned in **Table 5:**

**Table 5: Parameters for Ambient Air Quality Monitoring**

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

## 4.2 Result and Discussion

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

**Table 6: Summarized results of $PM_{10}$, $PM_{2.5}$, $SO_2$, $NO_x$, VOC and CO for Ambient Air quality monitoring**

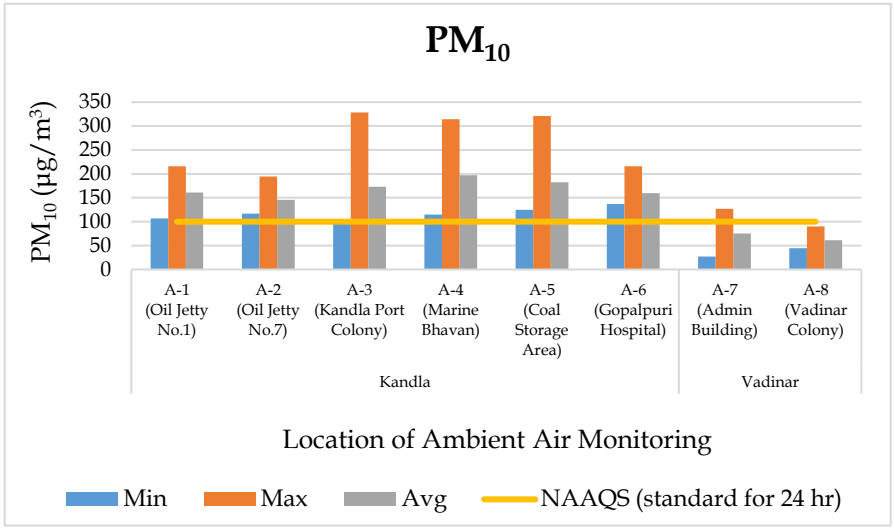
| Station Code & Name | Unit of Average Concentration | Average Pollutant Concentration | | | | | |
|---|---|---|---|---|---|---|---|
| | Pollutants | $PM_{10}$ (µg/m³) | $PM_{2.5}$ (µg/m³) | $SO_2$ (µg/m³) | $NO_X$ (µg/m³) | VOC (µg/m³) | CO (mg/m³) |
| | Duration | (24 hr) | | | | (2 hr) | (1 hr) |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

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

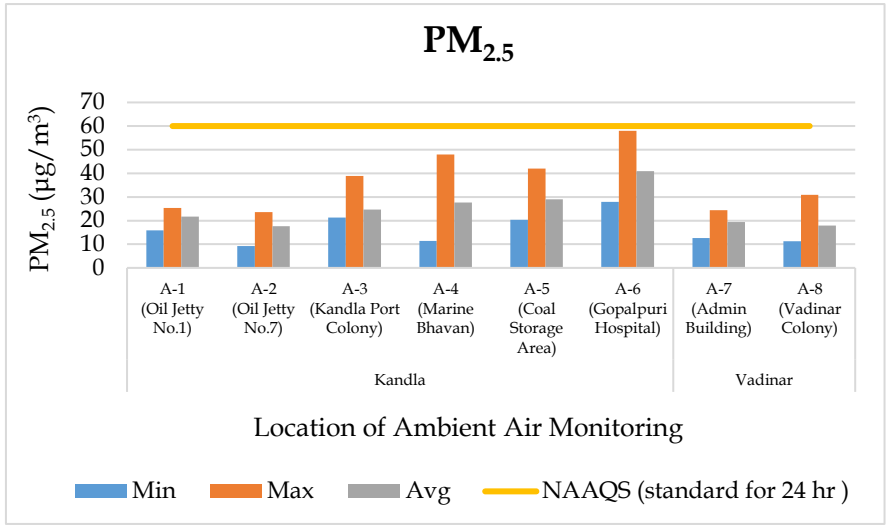
| Station Code & Name | Unit of Average Concentration | Average Pollutant Concentration | | | | | |
|---|---|---|---|---|---|---|---|
| | Pollutants | $PM_{10}$ (µg/m³) | $PM_{2.5}$ (µg/m³) | $SO_2$ (µg/m³) | $NO_X$ (µg/m³) | VOC (µg/m³) | CO (mg/m³) |
| | Duration | (24 hr) | | | | (2 hr) | (1 hr) |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

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

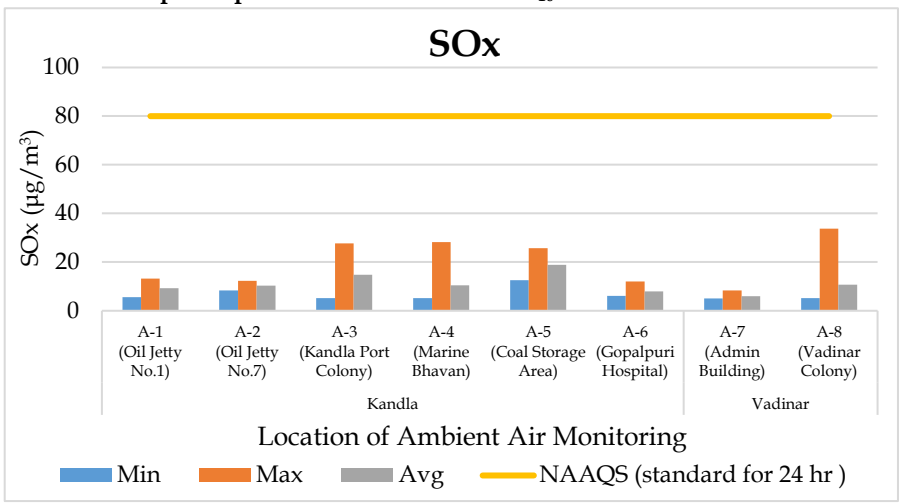
**Graphs 1-6** shows spatial trend of ambient air parameter at all the eight-monitoring location (six at Kandla and 2 at Vadinar)



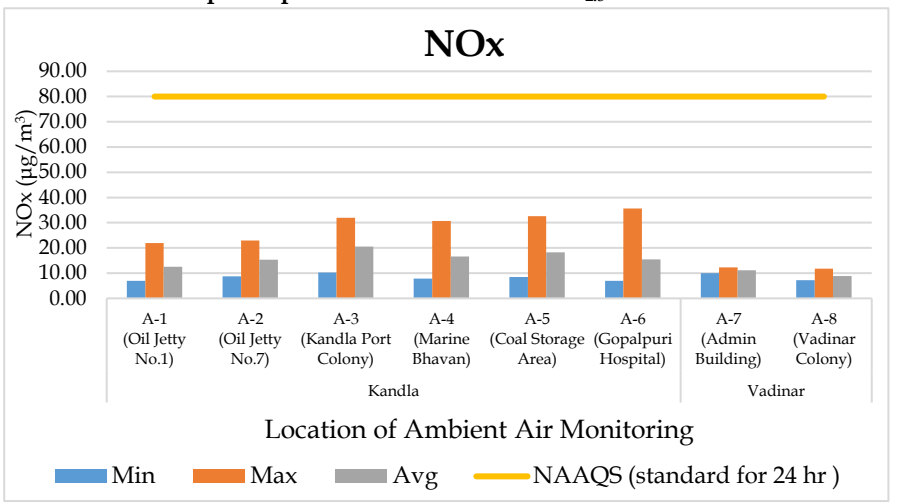

**Graph 1: Spatial trend in Ambient $PM_{10}$ Concentration**



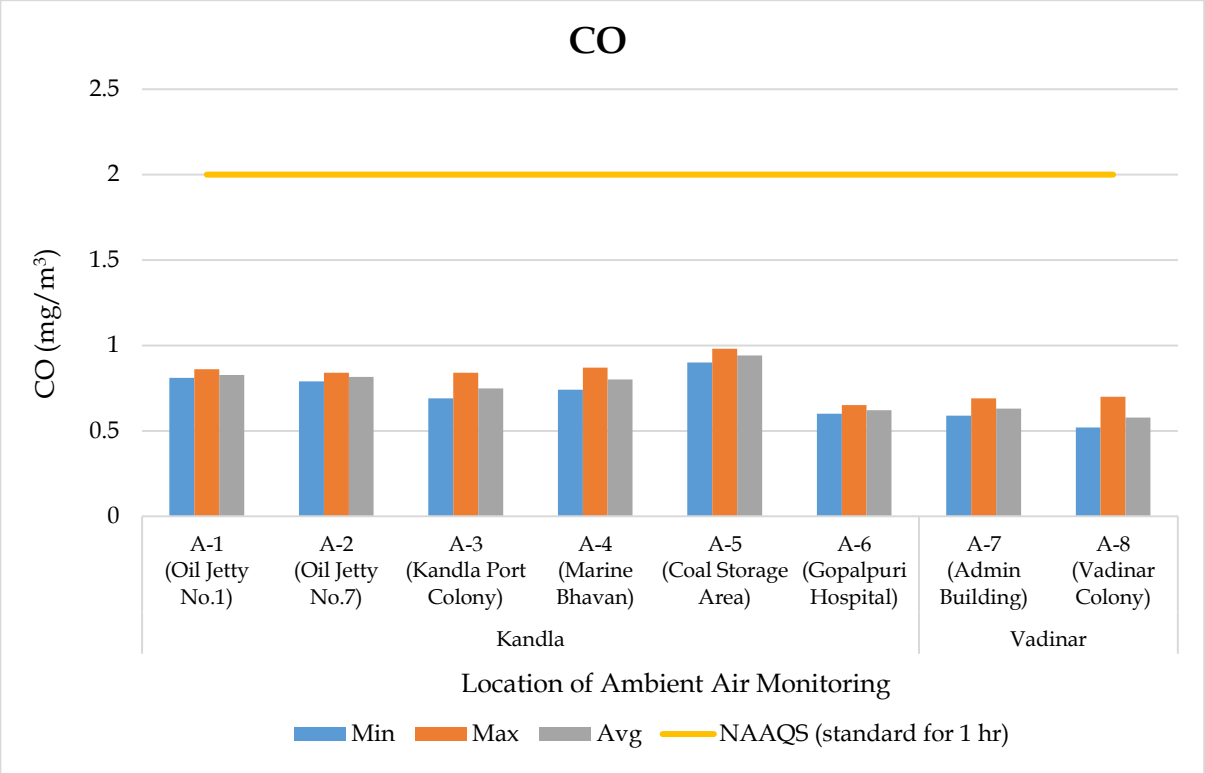

**Graph 2: Spatial trend in Ambient $PM_{2.5}$ Concentration**



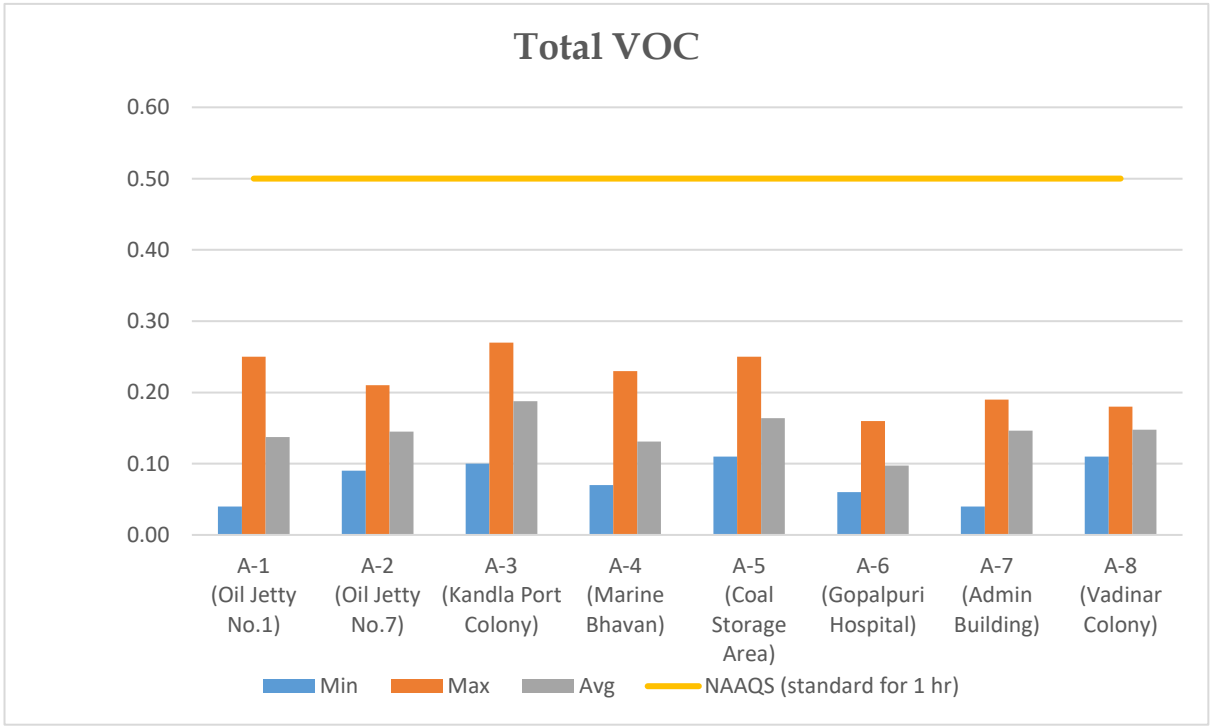

**Graph 3: Spatial trend in Ambient SOx Concentration**




**Graph 4: Spatial trend in Ambient NOx Concentration**




**Graph 5: Spatial trend in Ambient CO Concentration**




**Graph 6: Spatial trend in Ambient Total VOCs**

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

| Benzene (µg/m³) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Sr. No | Kandla | | | | | | Vadinar | | NAAQS standards (24 hr) |
| | A-1 | A-2 | A-3 | A-4 | A-5 | A-6 | A-7 | A-8 | |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 µg/m³ |

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

| Sr. No. | Components in ng/m³ | Kandla | | | | | | Vadinar | |
|---|---|---|---|---|---|---|---|---|---|
| | | A-1 | A-2 | A-3 | A-4 | A-5 | A-6 | A-7 | A-8 |
| 1 | Napthalene | 1.10 | 1.52 | 0.02 | 1.53 | 1.2 | 0.01 | 0.46 | 0.41 |
| 2 | Acenaphthylene | 0.59 | 0.72 | 0.07 | 0.87 | 0.31 | 0.01 | 0.00 | 0.00 |
| 3 | Acenaphthene | 0.58 | 0.61 | 0.18 | 0.19 | 0.26 | 0.14 | 0.00 | 0.00 |
| 4 | Fluorene | 0.05 | 0.45 | 0.01 | 0.54 | 0.62 | 0.58 | 0.00 | 0.01 |
| 5 | Anthracene | 0.11 | 0.05 | 0.01 | 0.21 | 0.23 | 0.01 | 0.02 | 0.02 |
| 6 | Phenanthrene | 0.05 | 0.02 | 0.03 | 0.01 | 0.00 | 0.10 | 0.00 | 0.00 |
| s7 | Fluoranthene | 0.02 | 0.41 | 0.05 | 0.25 | 0.02 | 0.36 | 0.00 | 0.01 |
| 8 | Pyrene | 0.16 | 0.59 | 0.42 | 0.29 | 0.48 | 0.06 | 0.00 | 0.00 |
| 9 | Chrycene | 1.22 | 0.98 | 0.25 | 0.40 | 0.02 | 1.20 | 0.00 | 0.00 |
| 10 | Banz(a)anthracene | 0.22 | 0.26 | 0.36 | 0.27 | 0.02 | 0.15 | 0.00 | 0.00 |
| 11 | Benzo[k]fluoranthene | 3.7 | 0.20 | 2.6 | 0.2 | 1.02 | 1.68 | 0.00 | 0.04 |
| 12 | Benzo[b]fluoranthene | 0.02 | 0.06 | 0.02 | 0.02 | 0.05 | 0.03 | 0.00 | 0.02 |
| 13 | Benzopyrene | 1.74 | 0.93 | 3.56 | 0.01 | 0.63 | 0.05 | 0.00 | 0.00 |
| 14 | Indeno [1,2,3-cd] fluoranthene | 0.52 | 0.75 | 0.71 | 0.55 | 0.98 | 1.49 | 0.00 | 0.11 |
| 15 | Dibenz(ah)anthracene | 0.00 | 0.01 | 0.25 | 0.00 | 0.18 | 0.05 | 0.00 | 0.00 |
| 16 | Benzo[ghi]perylene | 1.3 | 8.9 | 28.1 | 13.2 | 9.3 | 12.8 | 0.00 | 0.00 |

**Table 9: Summarized results of Non-methane VOC**

| Sr No | Kandla | | | | | | Vadinar | |
|---|---|---|---|---|---|---|---|---|
| | A-1 | A-2 | A-3 | A-4 | A-5 | A-6 | A-7 | A-8 |
| 1 | 0.56 | 0.51 | 0.82 | 0.59 | 1.21 | 0.32 | 0.00 | 0.00 |

## 4.3 Data Interpretation and Conclusion

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

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

- The highest concentration of $PM_{10}$ at locations **A-3 i.e. Kandla Port Colony** Area could be attributed to the presence of heavy vehicular traffic in upwind areas which bring higher impact causing the dispersion of emitted particulate matter in the ambient air. The unloading of coal directly in the truck, using grabs causes the coal to disperse in the air as well as coal dust to fall and settle on the ground. This settled coal dust again mixes with the air while trucks travel through it. Also, the coal-loaded trucks are generally not always covered with tarpaulin sheets and this might result in increased suspension of coal from trucks/dumpers during its transit from vessel to yard or storage site. This might increase the $PM_{10}$ in and around the Coal storage area and Marine bhavan.
- The **$PM_{2.5}$** concentrations at Kandla varies from **9.31** to **57.93** µg/m³ with average **26.95** µg/m³. The **$PM_{2.5}$** concentration falls within the NAAQS limit for all locations of Kandla. Whereas, at Vadinar its concentration varies from **11.25** to **30.95** µg/m³ with average **18.65** µg/m³ which falls within the limit of NAAQS of 60 µg/m³.
- The concentration of **$SO_x$** varies from **5.24** to **28.19** µg/m³ with average concentration as **11.94** µg/m³ at Kandla and **5.10** to 33.79 µg/m³ with average as **8.35** µg/m³ at Vadinar. The average concentration of $SO_x$ complies with the prescribed limit of NAAQS (80 µg/m³) for both the monitoring site.
- The concentration of **$NO_x$** varies from **6.93** to 35.66 µg/m³ with average **16.43** µg/m³ at Kandla and **7.17** to **12.25** µg/m³ with average **9.96** µg/m³ at Vadinar. The concentration of **$NO_x$** falls within the prescribed limit of NAAQS i.e. 80 µg/m³ at both the monitoring site of Kandla and Vadinar.
- The concentration of **CO** varies from **0.60** to **0.98** µg/m³ with average **0.79** µg/m³ at Kandla and **0.52** to **0.70** µg/m³ with average 0.61 µg/m³ at Vadinar. The concentration falls within the norm of **2** mg/m³ specified by NAAQS at both the monitoring sites
- The concentration of **Total VOCs** levels was recorded in range of **0.04** to **0.27** µg/m³ and **0.04 to 0.19** µg/m³ at Kandla and Vadinar respectively. The main source of VOCs in the ambient air may be attributed to the burning of Gasoline and Natural gas in Vehicle exhaust and burning fossil fuels, and garbage that release VOCs into the atmosphere. During the monitoring period, the wind flows towards South direction at Kandla, and hence the wind direction and speed also contribute to increased dispersion of pollutants from the upward areas towards the downward areas.
- **Benzene** was not detected at any of locations of Kandla and Vadinar.
- **Polycyclic Aromatic Hydrocarbons (PAHs)** are ubiquitous pollutants in urban atmospheres. Anthropogenic sources of total PAHs in ambient air emissions are greater than those that come from natural events. These locations are commercial areas where Vehicular activity and dust emission is common. PAHs are a class of chemicals that occur naturally in coal, crude oil, and gasoline. The higher concentration which results from burning coal, oil, gas, road dust, etc. Other outdoor sources of PAHs may be the industrial plants in-and-around the DPA premises.

- The Ambient air Monitoring location of Kandla recorded the **Non-methane VOC** (NM-VOC) concentration in the range of **0.32** to **1.21** µg/m$^3$. While at Vadinar, the concentration of NM-VOC not detected.

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

1. **Port Machinery:** Port activities involve the use of various machinery and equipment, including cranes, for lifts, tugboats, and cargo handling equipment. These machines often rely on diesel engines, which can emit pollutants such as $NO_x$, Particulate matter, and CO. Older or poorly maintained equipment tends to generate higher emissions.
2. **Port Vehicles:** Trucks and other vehicles operating within port and port area contributes to air pollution. Similar to port machinery, diesel-powered vehicles can emit $NO_x$, PM, CO, and other pollutants such as PAH, VOCs etc. Vehicle traffic and congestion in and around port areas can exacerbate the air quality issues.

## 4.4 Remedial Measures:

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

- Practice should be initiated for using mask as preventative measure, to avoid Inhalation of dust particle-Mask advised in sensitive areas. Covering vehicles with tarpaulin during transportation will help to reduce the suspension of pollutants in air.
- Ensuring maintenance of engines and machinery to comply with emission standards.
- Frequent water sprinkling on roads to reduce dust suspension due to vehicular movement, this can be use during transporting coal to avoid suspension of coal dust.
- Use of proper transport methods, such as a conveyor belt, for excavated material and screens around the construction site.
- Temporary pavement of roads in construction site could considerably reduce dust emission. Prohibition of use of heavy diesel oil as fuel could be possibly reduce pollutants. Encouraging use of low-sulfur fuels (viz. Marine Gas Oil (MGO)/Liquefied Natural Gas (LNG), can significantly reduce sulfur and PM emissions from ships.

- Retrofitting ships with exhaust gas cleaning systems can help reduce sulfur emissions. Engine upgrades, such as optimizing fuel combustion and improving engine efficiency, can reduce overall emissions.
- Investing in infrastructure for cold ironing allows ships to connect to the electrical grid while docked, reducing the need for auxiliary engines and associated emissions.
- Implementing efficient cargo-handling processes, optimizing logistics to reduce congestion and idling times, and encouraging use of cleaner port machinery and vehicles can all contribute to reducing air pollution in port areas.

# CHAPTER 5: DG STACK MONITORING

## 5.1 DG Stack Monitoring

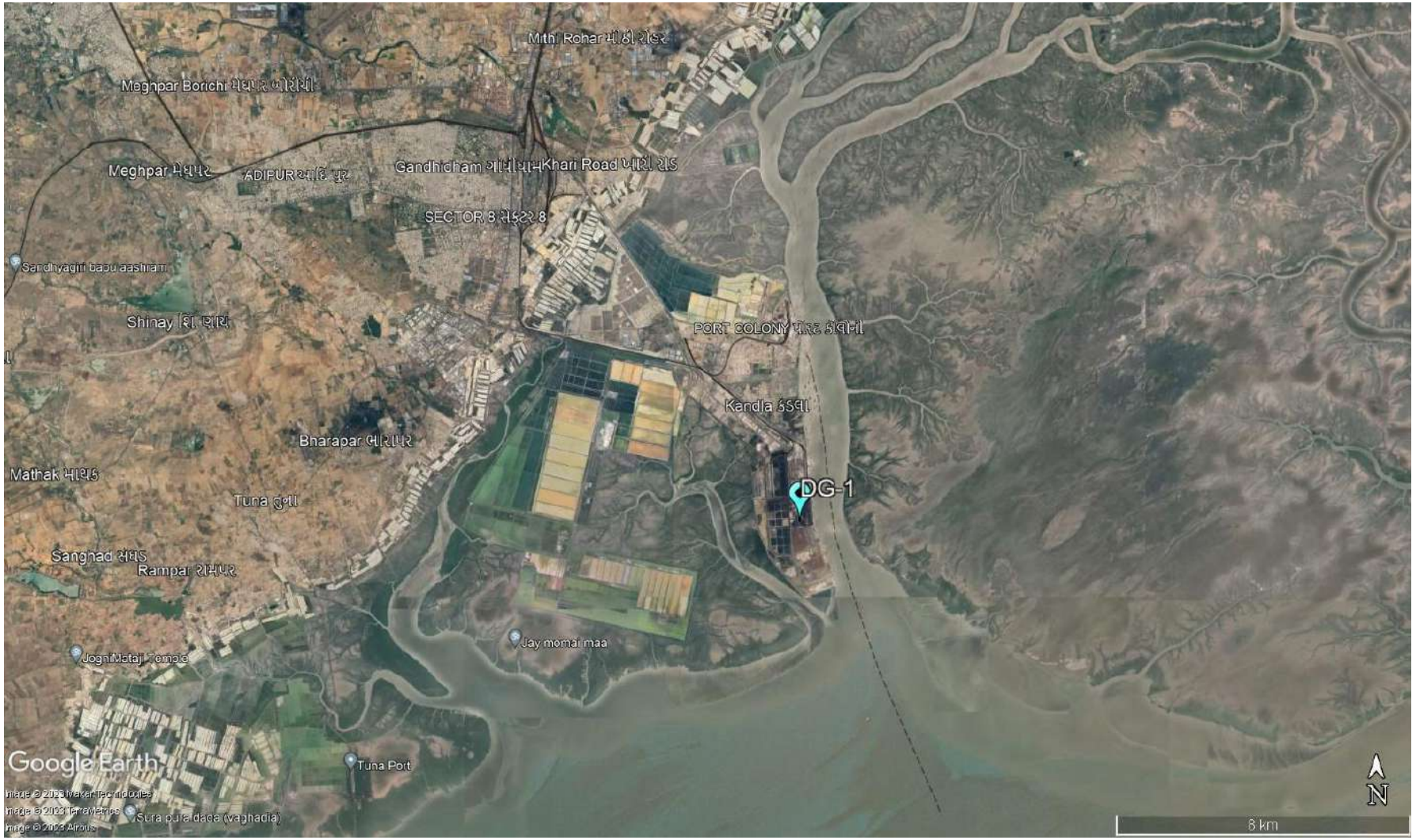
A diesel generator is a mechanical-electrical machine that produces electrical energy (electricity) from diesel fuel. They are used by the residential, commercial, charitable and governmental sectors to provide power in the event of interruption to the main power, or as the main power source. Diesel generating (DG) sets are generally used in places without connection to a power grid, or as an emergency power supply if the grid fails. These DG sets utilize diesel as fuel and generate and emit the air pollutants such as Suspended Particulate Matter, $SO_2$, $NO_x$, CO, etc. from the stack during its functioning. The purpose of stack sampling is to determine emission levels from plant processes to ensure they are in compliance with any emission limits set by regulatory authorities to prevent macro environmental pollution. The stack is nothing but chimney which is used to disperse the hot air at a great height, emissions & particulate matters that are emitted. Hence, monitoring of these stacks attached to DG Sets is necessary in order to quantify the emissions generated from it.

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

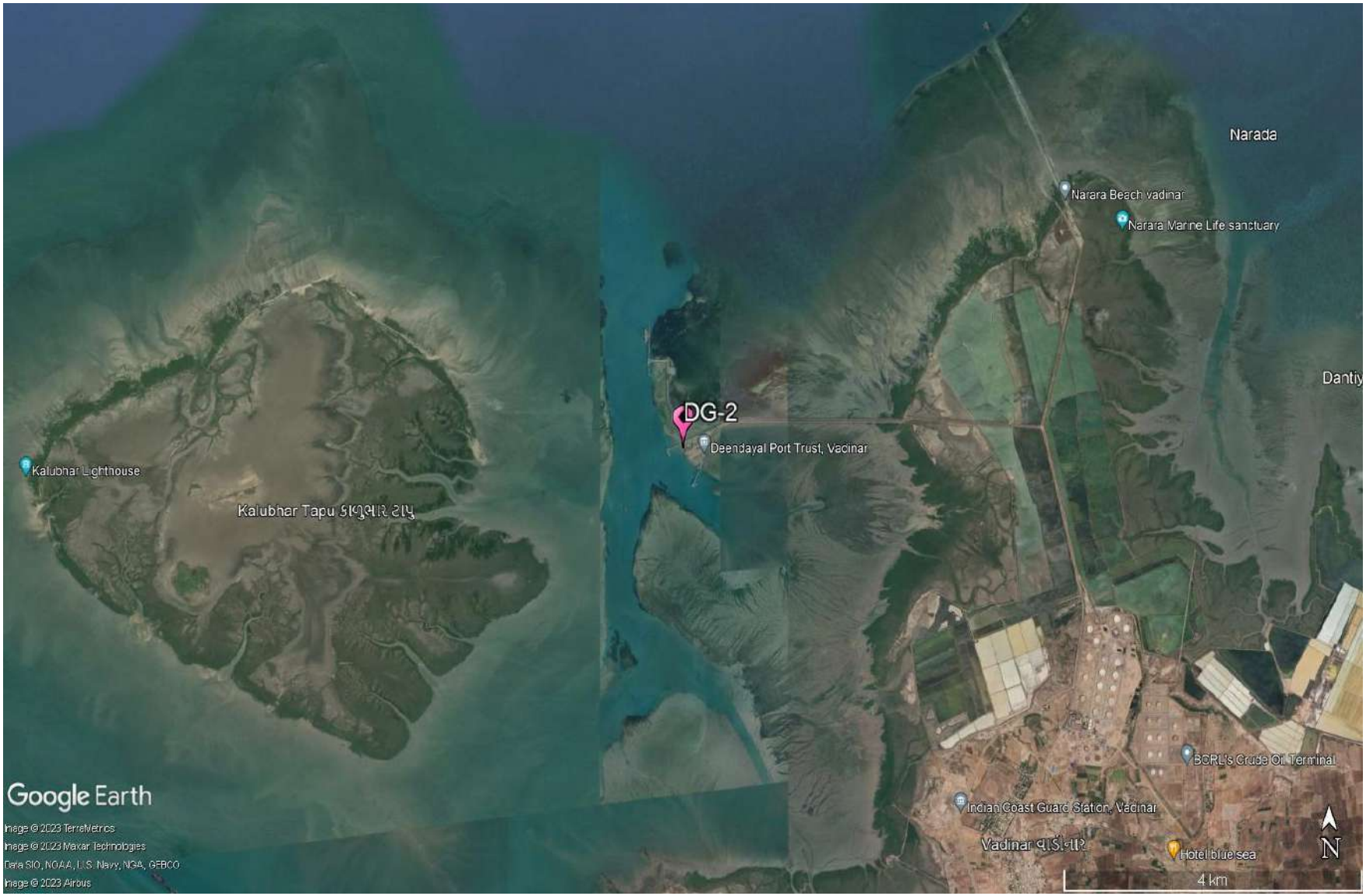
**Table 10: Details of DG Stack monitoring locations**

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

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




**Map 6: Locations for DG Stack monitoring at Kandla**




**Map 7: Locations for DG Stack monitoring at Vadinar**

### Methodology:

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

**Table 11: DG stack parameters**

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

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

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

**Frequency**

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

## 5.2 Result and Discussion

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

**Table 12: DG monitoring data**

| Sr. No. | Stack Monitoring Parameters for DG Sets | Stack Monitoring Limits / Standards As per CPCB | DG- 1 (Kandla) | DG-2 (Vadinar) |
|---|---|---|---|---|
| 1. | Suspended Particulate Matter (SPM) (mg/Nm$^3$) | 150 | 79.52 | 25.04 |
| 2. | Sulphur Dioxide ($SO_2$) (PPM) | 100 | 4.11 | 3.14 |
| 3. | Oxides of Nitrogen ($NO_x$) (PPM) | 50 | 8.6 | 6.88 |
| 4. | Carbon Monoxide (CO) (%) | 1 | 0.29 | 0.15 |
| 5. | Carbon Dioxide ($CO_2$) (%) | - | 2.27 | 2.09s |

## 5.3 Data Interpretation and Conclusion

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

# CHAPTER 6: NOISE MONITORING

## 6.1 Noise Monitoring

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

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

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

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


**Map 8: Locations for Noise Monitoring at Kandla**


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

**Methodology:**

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

**Frequency**

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

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

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

**Standard for Noise**

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

**Table 15: Ambient Air Quality norms in respect of Noise**

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

## 6.2 Result and Discussion

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

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

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

## 6.3 Data Interpretation and Conclusion

The noise level at both the locations (Kandla and Vadinar) was compared with the standard limits specified in NAAQS by CPCB. During the Day Time, the average noise level at all 10 locations at Kandla ranged from **33.8** dB(A) **to 77.4** dB(A), while at Vadinar, the noise levels for the three-location ranged from **35.5** dB(A) **to 73.4** dB(A). Whereas, during Night Time the average Noise Level ranged from **31.2** dB(A) **to 77.4** dB(A) at Kandla and **33.8** dB(A) to **73.4** dB(A) at Vadinar, which was within the permissible limits for the industrial and commercial area. Overall, the noise levels at Kandla and Vadinar fall within the prescribed norms for both Day and Night times.

## 6.4 Remedial Measures

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

# CHAPTER 7: SOIL MONITORING

## 7.1 Soil Quality Monitoring:

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

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

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

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

### Methodology

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

The samples of soil collected from the locations of Kandla and Vadinar and analyzed for the various physico-chemical parameter. Collection and analysis of these samples was carried out as per established standard methods and procedures. The samples were analyzed for selected parameters to get the present soil quality status and environmental risks associated with various practices prevalent at the location. GEMI has framed its own guidelines for collection of soil samples titled as ***'Soil Sampling Manual'***. Soil samples were collected from 30 cm depth below the surface using scrapper, filled in polythene bags, labelled on-site with specific location code and name and sent to GEMI's laboratory, Gandhinagar for further detailed analysis. The samples collected from all locations are homogeneous representative of each location. The list of parameters to be monitored under the projects for the Soil Quality Monitoring been mentioned in **Table 18** as follows:

### Frequency

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

**Table 18: Soil parameters**

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

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


**Map 10: Locations for Soil Quality Monitoring at Kandla**


**Map 11: Locations for Soil Quality Monitoring at Vadinar**

## 7.2 Result and Discussion

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

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

| Sr. No | Location / Parameters | Unit | Kandla | | | | Vadinar | |
|---|---|---|---|---|---|---|---|---|
| | | | S-1 (Oil Jetty 7) | S-2 IFFCO Plant) | S-3 (Khori Creek) | S-4 (Nakti Creek) | S-5 (Near SPM) | S-6 (Near Vadinar Jetty) |
| 1 | pH | - | 8.4 | 8.73 | 8.1 | 8.21 | 8.37 | 8.33 |
| 2 | Conductivity | µS/cm | 14970 | 1000 | 9120 | 13860 | 147.7 | 257 |
| 3 | Inorganic Phosphate | Kg/ha | 0.9 | 1.3 | 1.39 | 0.99 | 0.62 | 1.15 |
| 4 | Organic Carbon | % | 0.56 | 0.5 | 0.62 | 0.44 | 1.33 | 0.51 |
| 5 | Organic Matter | % | 0.97 | 0.86 | 1.07 | 0.76 | 2.3 | 0.88 |
| 6 | SAR | meq/L | 17.64 | 0.27 | 6.71 | 14.03 | 0.68 | 0.73 |
| 7 | Aluminium | mg/Kg | 18845.62 | 13886.25 | 9503.7 | 16874.4 | 30421.22 | 44431.53 |
| 8 | Chromium | mg/Kg | 85.69 | 62.38 | 53.36 | 90.14 | 83.15 | 106.83 |
| 9 | Nickel | mg/Kg | 31.35 | 28.26 | 27.62 | 29 | 39.82 | 49.62 |
| 10 | Copper | mg/Kg | 80.24 | 34.86 | 54.71 | 87.77 | 85.11 | 94.12 |
| 11 | Zinc | mg/Kg | 90.75 | 43.34 | 53.88 | 105.23 | 57.28 | 54.64 |
| 12 | Cadmium | mg/Kg | BQL | BQL | BQL | BQL | BQL | BQL |
| 13 | Lead | mg/Kg | 4.12 | 2.93 | 3.75 | 7 | BQL | BQL |
| 14 | Arsenic | mg/Kg | BQL | 1.94 | 2.13 | BQL | 0.55 | 0.37 |
| 15 | Mercury | mg/Kg | BQL | BQL | BQL | BQL | BQL | BQL |
| 16 | Water Holding Capacity | % | 55.98 | 54 | 46 | 50 | 70 | 72 |
| 17 | Sand | % | 50.24 | 64.24 | 60.24 | 54.24 | 72.24 | 66.24 |
| 18 | Silt | % | 34.16 | 18.16 | 32.16 | 34.16 | 24.16 | 26.16 |
| 19 | Clay | % | 15.60 | 17.60 | 7.6 | 11.6 | 3.6 | 7.6 |
| 20 | Texture | - | Loam | Sandy loam | Sandy loam | Sandy loam | Loamy sand | Sandy loam |

## 7.3 Data Interpretation and Conclusion

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

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

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

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

- At Kandla, the concentration of **Inorganic Phosphate** varied from **0.9 to 1.39 Kg/ha**, with average **1.145** Kg/ha. Whereas, at the locations of Vadinar, the Inorganic Phosphate was observed as **0.62** Kg/ha at S-5 (Near SPM) and **1.15** Kg/ha at S-6 (near Jetty Area), with the average **0.885** Kg/ha. The phosphorus availability in soil solution is influenced by a number of factors such as Organic matter, clay content, pH, temperature, etc.

- The concentration of **Total Organic Carbon** ranges from **0.44** % to **0.62** % while the average TOC at Kandla was detected as **0.53** %. Whereas, at Vadinar the average TOC was found to be **0.92** % where the observed TOC value found at S-5 and S-6 to be **1.33**% and **0.51**% respectively.

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

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

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

**Heavy Metals**

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

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

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

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

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

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

- The concentration of **Arsenic** varied from **1.94 to 2.13 mg/kg** at Kandla with average value **2.03** mg/Kg, whereas for Vadinar, the values recorded **0.37 to 0.55** at both S-5 and S-6 location.
- While other heavy metals in the Soil i.e., **Mercury and Cadmium** were observed "Below Quantification Limit" for the soil samples collected at Kandla and Vadinar.

# CHAPTER 8: DRINKING WATER MONITORING

## 8.1 Drinking Water Monitoring

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

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

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

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


**Map 12: Locations for Drinking Water Monitoring at Kandla**


**Map 13: Locations for Drinking Water Monitoring at Vadinar**

## Methodology

The water samples were collected from the finalized sampling locations and analyzed for physico-chemical and microbiological parameter, for which the analysis was carried out as per APHA, 23rd Edition and Indian Standard method in GEMI's NABL Accredited Laboratory, Gandhinagar. GEMI has followed the CPCB guideline as well as framed its own guidelines for the collection of water/wastewater samples, under the provision of Water (Preservation and Control of Pollution) Act 1974, titled as '**Sampling Protocol for Water & Wastewater**'; approved by the Government of Gujarat vide letter no. ENV-102013-299-E dated 24-04-2014. The samples under the study were collected and preserved as per the said Protocol. The parameters finalized to assess the drinking water quality have been mentioned in **Table 21** as follows:

**Table 21: List of parameters for Drinking Water Quality monitoring**

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

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

## 8.2 Result and Discussion

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

**Table 22: Summarized results of Drinking Water quality**

| Sr. No. | Parameters | Units | Standard values as per IS | | Kandla | | | | | | | | | | | | | | | | | Vadinar | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | P | DW-1 | DW-2 | DW-3 | DW-4 | DW-5 | DW-6 | DW-7 | DW-8 | DW-9 | DW-10 | DW-11 | DW-12 | DW-13 | DW-14 | DW-15 | DW-16 | DW-17 | DW-18 | DW-19 | DW-20 |
| 1. | pH | - | **6.5-8.5** | **-** | 7.68 | 7.99 | 7.63 | 8.32 | 8.42 | 7.57 | 7.74 | 7.56 | 7.52 | 7.02 | 6.77 | 7.06 | 7.31 | 7.02 | 7.41 | 7.54 | 7.45 | 7.17 | 8.12 | 8.32 |
| 2. | Colour | Hazen | **5** | **15** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 3. | EC | µS/ cm | **-** | **-** | 225 | 260 | 24.04 | 23.4 | 48.3 | 142 | 19.10 | 22.4 | 27.5 | 136 | 108.6 | 135.6 | 121.3 | 263 | 89.1 | 22.8 | 21.8 | 54.9 | 461 | 55.4 |
| 4. | Salinity | PSU | **-** | **-** | 0.12 | 0.13 | 0.07 | 0.02 | 0.05 | 0.05 | 0.02 | 0.02 | 0.02 | 0.07 | 0.07 | 0.07 | 0.06 | 0.13 | 0.05 | 0.02 | 0.02 | 0.03 | 0.22 | 0.03 |
| 5. | Turbidity | NTU | **1** | **5** | BQL | BQL | 0.65 | BQL | 0.65 | 0.63 | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 6. | Chloride | mg/L | **250** | **1000** | 58.62 | 53.32 | 8.77 | 8.80 | 13.64 | 112.63 | 5.87 | 7.34 | 7.34 | 23.97 | 107.99 | 23.97 | 29.35 | 53.32 | 20.06 | 8.32 | 7.83 | 13.21 | 51.37 | 11.25 |
| 7. | Total Hardness | mg/L | **200** | **600** | 2 | 35 | 2 | BQL | 9 | 12 | 3 | 2.5 | 8 | 26 | 56 | 30 | 2.5 | 36 | 6 | 3 | 2.5 | 4 | 135 | 8 |
| 8. | Ca Hardness | mg/L | **-** | **-** | 1 | 20 | 1 | 1 | 5 | 7 | 2.5 | 2 | 6 | 14 | 26 | 16 | 2 | 20 | 3 | 2 | 1.5 | 3 | 65 | 4 |
| 9. | Mg Hardness | mg/L | **-** | **-** | 1 | 15 | 1 | BQL | 4 | 5 | BQL | BQL | 2 | 12 | 30 | 14 | BQL | 16 | 3 | 1 | 1 | 1 | 70 | 4 |
| 10. | Free Residual Chlorine | mg/L | **0.2** | **1** | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 11. | TDS | mg/L | **500** | **2000** | 120 | 142 | 16 | 14 | 23 | 332 | 12 | 14 | 16 | 74 | 128 | 74 | 68 | 144 | 48 | 12 | 12 | 30 | 246 | 30 |
| 12. | TSS | mg/L | **-** | **-** | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | 2 | BQL | BQL | 2 | BQL | 2 | 2 | BQL | BQL | BQL | BQL |
| 13. | Fluoride | mg/L | **1.0** | **1.5** | BQL | BQL | BQL | BQL | BQL | 0.345 | BQL | BQL | BQL | BQL | 0.439 | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 14. | Sulphate | mg/L | **200** | **400** | BQL | BQL | BQL | BQL | BQL | 37.82 | BQL | BQL | BQL | BQL | 12.62 | BQL | BQL | BQL | BQL | BQL | BQL | BQL | 35.02 | BQL |
| 15. | Nitrate | mg/L | **45** | **-** | 5.862 | 2.668 | BQL | BQL | 1.400 | 8.551 | BQL | BQL | BQL | 1.626 | 5.740 | 1.512 | 2.719 | 2.622 | 1.029 | BQL | BQL | BQL | 2.522 | BQL |
| 16. | Nitrite | mg/L | **-** | **-** | BQL | BQL | BQL | BQL | BQL | 0.23 | BQL | BQL | BQL | BQL | 0.623 | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 17. | Sodium | mg/L | **-** | **-** | 42.32 | 36.56 | BQL | 6.07 | 6.27 | 77.96 | 4.28 | 4.90 | 3.62 | 14.19 | 78.19 | 12.62 | 19.56 | 35.59 | 13.59 | BQL | BQL | 9.13 | 32.59 | 7.56 |
| 18. | Potassium | mg/L | **-** | **-** | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | 1.49 | BQL |

| Sr. No. | Parameters | Units | Standard values as per IS | | Kandla | | | | | | | | | | | | | | | | | | Vadinar | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | P | DW-1 | DW-2 | DW-3 | DW-4 | DW-5 | DW-6 | DW-7 | DW-8 | DW-9 | DW-10 | DW-11 | DW-12 | DW-13 | DW-14 | DW-15 | DW-16 | DW-17 | DW-18 | DW-19 | DW-20 |
| 19. | Hexavalent Chromium | mg/L | - | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 20. | Odour | TON | Agreeable | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 21. | Arsenic | mg/L | 0.01 | 0.05 | BQL | BQL | BQL | BQL | BQL | 0.007 | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 22. | Cadmium | mg/L | 0.003 | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 23. | Copper | mg/L | 0.05 | 1.5 | BQL | 0.007 | BQL | BQL | 0.007 | BQL | BQL | BQL | 0.006 | 0.027 | BQL | 0.24 | BQL | 0.02 | BQL | BQL | BQL | BQL | BQL | 0.011 |
| 24. | Iron | mg/L | 0.3 | - | BQL | 0.164 | BQL | BQL | BQL | BQL | BQL | BQL | BQL | 0.104 | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 25. | Lead | mg/L | 0.01 | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 26. | Manganese | mg/L | 0.1 | 0.3 | BQL | 0.1 | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 27. | Mercury | mg/L | 0.001 | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 28. | Total Chromium | mg/L | 0.05 | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 29. | Zinc | mg/L | 5 | 15 | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 30. | Total Coliform* | MPN/ 100ml | Shall not be detected | | BQL | BQL | BQL | BQL | BQL | BQL | 40 | BQL | 285 | BQL | BQL | 20 | BQL | BQL | BQL | BQL | BQL | 90 | BQL | BQL |

A: Acceptable, P:Permissible, BQL: Below Quantification limit Turbidity (QL=0.5 NTU), Free Residual Chlorine (QL=2 mg/L), Total Suspended Solids (QL=2 mg/L), Fluoride (QL=0.3 mg/L), Sulphate (QL=10 mg/L), Nitrate as $NO_3$ (QL=1 mg/L), Nitrite as $NO_2$ (QL=0.1mg/L), Sodium as Na (QL=5mg/L), Potassium as K (QL=5mg/L), Hexavalent Chromium (QL=0.01 mg/L), Arsenic (QL=0.005 mg/L), Cadmium (QL=0.002 mg/L), Copper (QL=0.005 mg/L), Iron (QL=0.1mg/L), Lead (QL=0.002 mg/L), Manganese (QL=0.04 mg/L), Mercury (QL=0.0005 mg/L), Total Chromium (QL=0.005 mg/L), Zinc (QL=0.5 mg/L), Total Coliforms (QL=1 MPN/ 100ml)

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

## 8.3 Data Interpretation and Conclusion

Drinking water samples were taken from 19 locations (17 at Kandla and 2 at Vadinar), and their physical and chemical properties were analyzed. The analysis's results were compared with standard values as prescribed in IS 10500:2012 Drinking Water Specification.

- **pH:** The pH values of drinking water samples in Kandla were reported to be in the range of **6.77 to 8.42**, with an average pH of **7.51**. In Vadinar, its values ranged from **8.12 to 8.32**, with an average pH of **8.22**. Notably, the pH levels at both project sites fall within the acceptable range of 6.5 to 8.5 for all the locations of Kandla and Vadinar, as specified under IS:10500:2012.
- **Colour:** The colour varies from 1 to 5 at the monitoring locations of Kandla. Only location DW-11 showed the value of 5 Hazen, whereas, all the other locations showed a value of 1 in Hazen at Kandla. At Vadinar, the color was observed to be 1 Hazen at both the monitoring locations.
- **Electrical Conductivity (EC):** It is a measure of the ability of a solution to conduct electric current, and it is often used as an indicator of the concentration of dissolved solids in water. During the monitoring period, the EC values for samples collected in Kandla were observed to range from **19.1 to 263 µS/cm**, with an average value of **96.94** µS/cm. In Vadinar, the EC values showed variation from **55.4 to 461 µS/cm**, with an average value of **258.20** µS/cm. It's important to regularly monitor EC levels in drinking water as it can provide valuable information about water quality and presence of dissolved substances.
- **Salinity:** Salinity at Kandla varies from **0.02 to 0.13 PSU** with an average of **0.06** PSU, while at Vadinar, salinity was observed to be **0.22** and **0.03 PSU** for locations DW-19 & DW-20 respectively.
- **Turbidity:** At the drinking water locations of Kandla, most of the locations were found BQL except locations DW-3 (with value **0.65** NTU), DW-5 (with value of **0.65** NTU) & DW-6 (with value of **0.63** NTU). Whereas, at Vadinar the value of turbidity was reported BQL at both the locations.
- **Chlorides:** The chloride concentrations in Kandla varied from **5.87 to 112.63 mg/L**, with an average value of **31.35** mg/L. At Vadinar the locations DW-19 and DW-20, the chloride concentration was observed as **51.37** mg/L and **11.25** mg/L, with an average value of **31.31** mg/L. Thus, the chloride levels at both project sites fall within the acceptable limit of 250 mg/L, as specified under IS:10500:2012.
- **Total Hardness (TH):** The concentration of Total Hardness varies from **2 to 56 mg/L**, with an average concentration of **14.09** mg/L. While at Vadinar, the observed values were **135** & **8** mg/L; at locations DW-19 & D-20, with an average concentration of **71.50** mg/L. which was found to be within the acceptable norm of 200 mg/L as specified by IS:10500:2012 and is not harmful for local inhabitants.
- **Total Dissolved Solids (TDS):** Monitoring TDS is crucial because it provides an indication of overall quality of the water. During the monitoring period, the TDS concentrations in Kandla were observed to vary in a wide range i.e., between **12** to **332** mg/L, with an average concentration of **71.06** mg/L. While in Vadinar, it ranged from **30** to **246** mg/L, with an average of **138** mg/L. It is important to note that the TDS

concentrations in both Kandla and Vadinar fall well within the acceptable limit of 500 mg/L.

- **Fluoride:** The concentration was found BQL, at all of the monitoring location except for locations DW-6 (with value of 0.345 mg/L), DW-11 (with value 0.439 mg/L) at Kandla. While at Vadinar Fluoride concentration was reported BQL at both of the monitoring location.
- **Sulphate:** At the monitoring locations of Kandla, the sulphate concentrations were recorded BQL for majority of the locations except the locations DW-6 (with value of 37.82), DW-11 (12.62 mg/L) and In Vadinar, the sulphate concentration was observed 35.02 at DW-19 & BQL at DW-20. During monitoring period in Kandla and Vadinar, the sulphate concentrations were found to be within the acceptable limits i.e., 200 mg/L as per the specified norms.
- **Nitrate:** During the monitoring period, at Kandla & Vadinar variation in the concentration of Nitrate was observed to be in the range of **1.029 to 8.55 mg/L,** with the average concentration of **3.37** mg/L and locations DW-3, DW-4, DW-7, DW-8,DW-9, DW-16, DW-17, DW-18, were recorded as "BQL". While at Vadinar, the concentration recorded **2.522** at location DW-19 and **BQL** at location DW-20.
- **Nitrite:** All monitoring locations showed the Nitrite concentration as BQL at Kandla except DW-6 (with value of 0.23 mg/L) & DW-11 (with value of 0.623 mg/L) While at Vadinar Nitrite concentration was reported BQL at both of the monitoring location.
- **Sodium:** During the monitoring period, at Kandla variation in the concentration of Sodium was observed to be in the range of **3.62 to 78.19 mg/L**, with the average concentration of **24.32** mg/L and Location DW-3, DW-16 and DW-17 showed the BQL concentration for Sodium. While at Vadinar, the concentration recorded **32.59** mg/L at DW-19 and **7.56** mg/L at DW-20.
- **Odour:** Odour values recorded 1 TON at all monitoring locations of Kandla and Vadinar.
- **Arsenic:** The Arsenic concentrations were recorded BQL for all of the locations except DW-6 (with value of **0.006 mg/L**) at Kandla & In Vadinar, the Arsenic concentrations were recorded BQL for both the locations.
- **Copper:** In Kandla & Vadinar, the Copper concentrations were recorded BQL except **DW-2, DW-5, DW-9, DW-10, DW-12, DW-14 and DW-20** (0.007, 0.007, 0.006, 0.027, 0.024, 0.020 respectively).
- **Iron:** Except for locations **DW-2 (0.164 mg/L) and DW-10 (0.104 mg/L)** the other locations were observed to have concentrations Below the detection Limit at Kandla. Whereas, at Vadinar the concentrations were recorded BQL for both locations DW-19 and DW-20 respectively.
- **Lead:** In Kandla & Vadinar, the Lead concentrations were recorded BQL at all locations.
- **Potassium:** All of locations observed to have BQL concentration for both the monitoring locations at Kandla and Vadinar except the location DW-19 (1.49 mg/L).\
- **Total Suspended Solids:** All of locations observed to have BQL concentration for the monitoring locations at kandla except **DW-10 (2 mg/L), DW-13 (2 mg/L), DW-15 (2**

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

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

## 8.4 Remedial Measures

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

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

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

# CHAPTER 9: SEWAGE TREATMENT PLANT MONITORING

## 9.1 Sewage Treatment Plant (STP) Monitoring:

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

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

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

The Consolidated Consent and Authorization (CC&A) issued by the GPCB were referred for the details of the STP for Kandla and Gopalpuri. The CC&A of Kandla and Gopalpuri entails that the treated domestic sewage should conform to the norms specified in **Table 24**. The treated effluent conforming to the norms shall be discharged on the land within the premises strictly for the gardening and plantation purpose. Whereas, no sewage shall be disposed outside the premises in any manner.

**Table 24: Treated effluent Standards (as per CC&A of Kandla STP)**

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

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

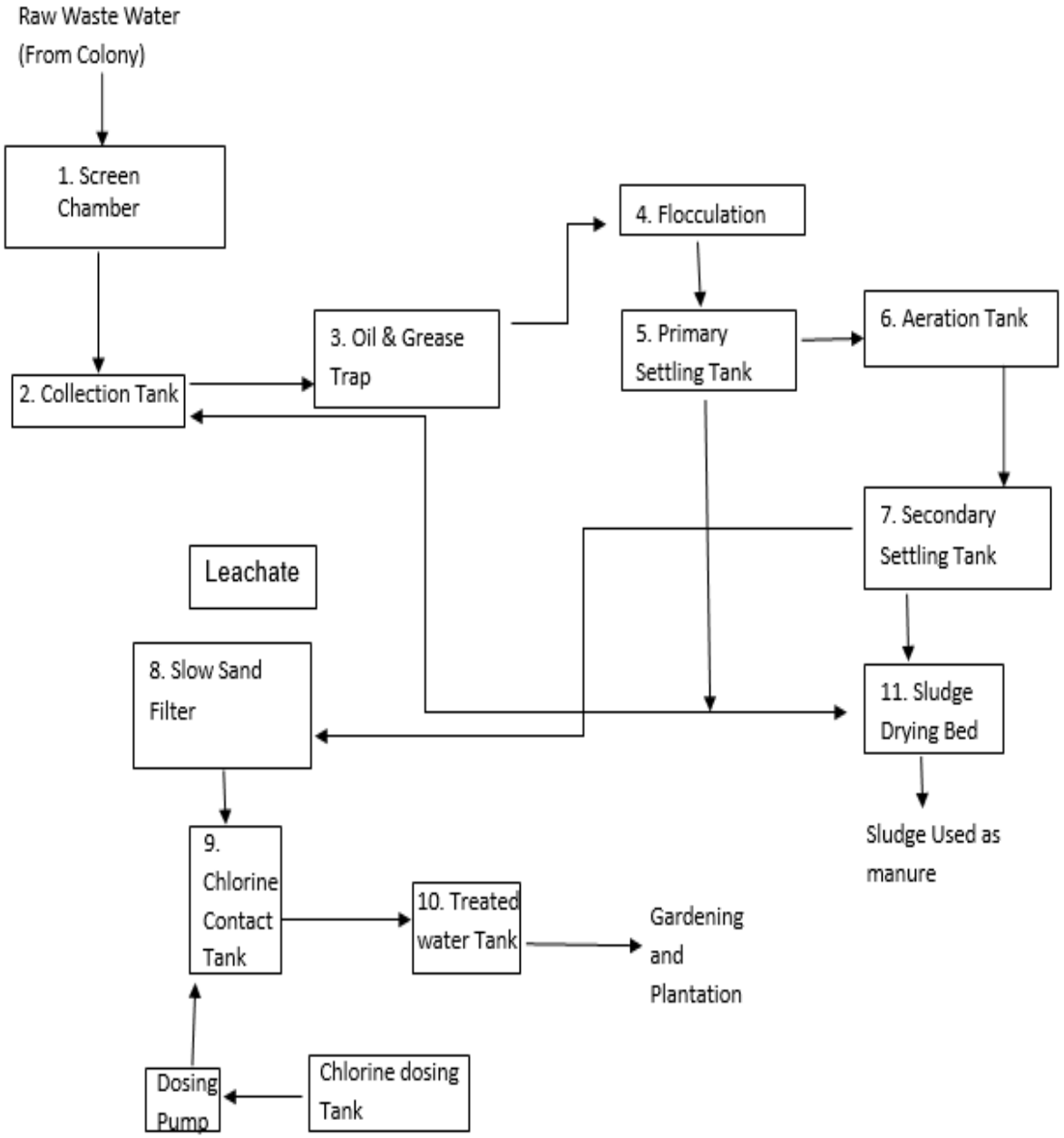



**Figure 3: Process flow diagram of STP at Kandla**

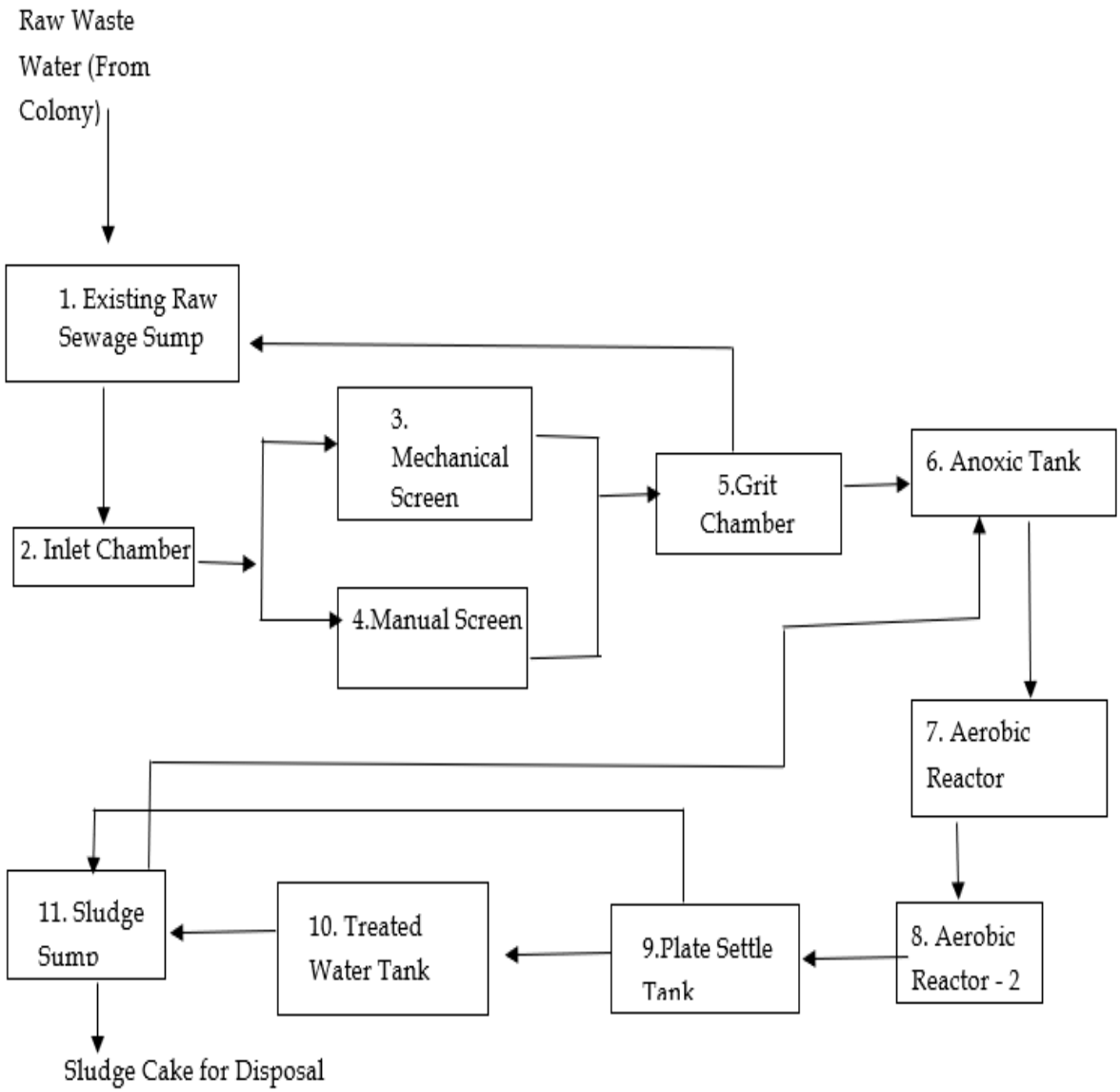



**Figure 4: Process flow diagram of STP at Gopalpuri**

**STP at Vadinar**

The STP at Vadinar has been built with a treatment capacity of 450 KLD/day. The Consolidated Consent and Authorization (CC&A) issued by the GPCB has been referred for the details of the said STP. The CC&A of the Vadinar STP suggests that the domestic effluent generated shall be treated as per the norms specified in **Table 25**. The treated effluent conforming to the norms shall be discharged on the land within the premises strictly for the gardening and plantation purpose. Whereas, no sewage shall be disposed outside the premises in any manner.

**Table 25: Norms of treated effluent as per CC&A of Vadinar STP**

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

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

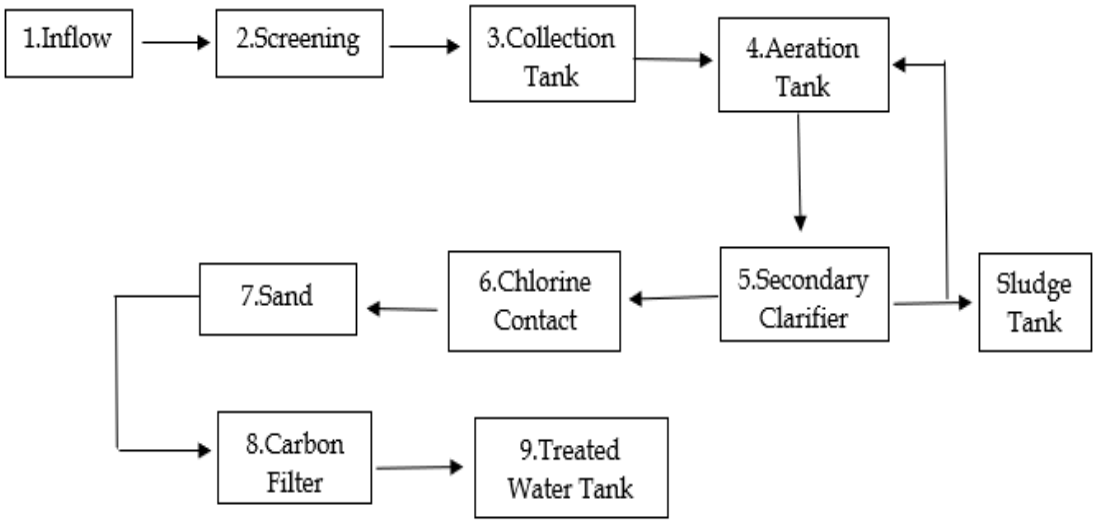
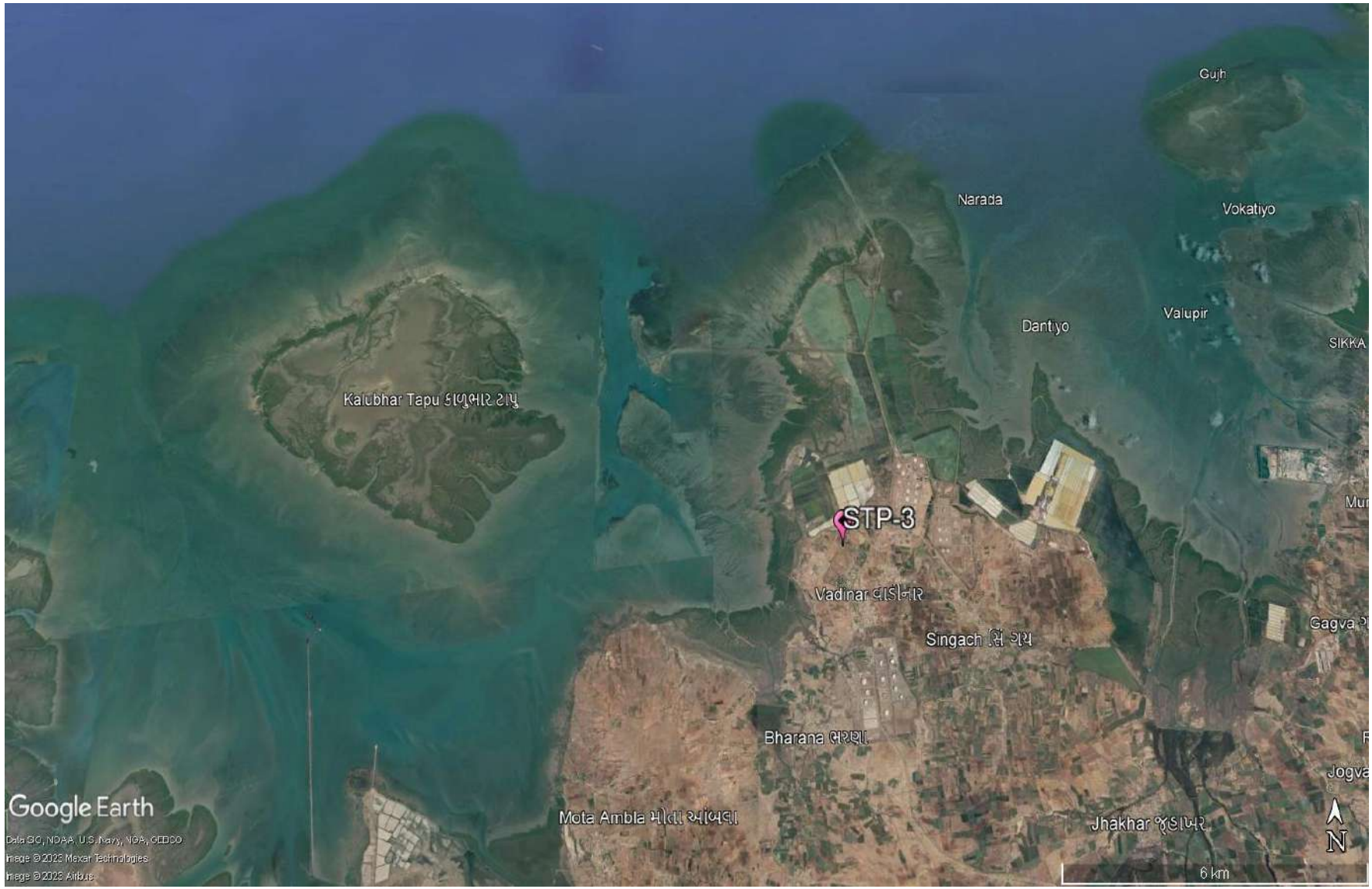



**Figure 5: Process flowchart for the STP at Vadinar**

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


**Map 14: Locations for STP Monitoring at Kandla**




**Map 15: Locations for STP Monitoring at Vadinar**

### Methodology

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

The water samples were collected from inlet and the outlet of the STP's and analyzed for physico-chemical and microbiological parameter. Collection and analysis of these samples was carried out as per established standard methods and procedures for the examination of water. The samples were analyzed for selected parameters to establish the existing water quality of the inlet and outlet points of the STP. GEMI has framed its own guidelines for collection of water/wastewater samples titled as 'Sampling Protocol for Water & Wastewater'; which has been approved by the Government of Gujarat vide letter no. ENV-102013-299-E dated 24-04-2014 under the provision of Water (Preservation and Control of Pollution) Act 1974. The sample collection and preservation are done as per the said Protocol. Under the project, the list of parameters to be monitored for the STP have been mentioned in **Table 26** as follows:

### Frequency

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

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

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

## 9.2 Result and Discussion

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

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

| Sr No. | Parameter | Units | GPCB Norms (Kandla) | Kandla | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Week 3 of March | | | | Week 4 of March | | | | Week 1 of April | | | | Week 2 of April | | | |
| | | | | STP-1 (Inlet) | STP-1 (Outlet) | STP-2 (Inlet) | STP-2 (Outlet) | STP-1 (Inlet) | STP-1 (Outlet) | STP-2 (Inlet) | STP-2 (Outlet) | STP-1 (Inlet) | STP-1 (Outlet) | STP-2 (Inlet) | STP-2 (Outlet) | STP-1 (Inlet) | STP-1 (Outlet) | STP-2 (Inlet) | STP-2 (Outlet) |
| **1.** | pH | - | **6.5-8.5** | 7.15 | 6.48 | 6.96 | 7.12 | 7.32 | 6.42 | 6.96 | 7.12 | 7.14 | 7.12 | 7.19 | 6.17 | 7.45 | 7.16 | 7.08 | 7.11 |
| **2.** | TDS | mg/L | - | 1325 | 1311 | 998 | 978 | 1459 | 1384 | 998 | 978 | 1352 | 1284 | 1345 | 1328 | 1467 | 1364 | 912 | 886 |
| **3.** | TSS | mg/L | **100** | 57 | 14 | 164 | 16 | 63 | 19 | 164 | 16 | 31 | 20 | 168 | 19 | 48 | 12 | 212 | 18 |
| **4.** | COD | mg/L | - | 186 | 67 | 276.0 | 68.0 | 156 | 51 | 276.0 | 68.0 | 180 | 73.2 | 341.0 | 56.2 | 196.0 | 56.0 | 353.2 | 58.3 |
| **5.** | DO | mg/L | - | BQL | 2.1 | BQL | 2.5 | BQL | 3.5 | BQL | 2.5 | BQL | 3.2 | BQL | 1.1 | BQl | 2.5 | BQL | 4.0 |
| **6.** | BOD | mg/L | **30** | 53.26 | 7.2 | 82.80 | 6.80 | 68.17 | 9.6 | 82.80 | 6.80 | 42.58 | 26.8 | 128.45 | 6.59 | 45.34 | 8.40 | 110.38 | 7.29 |
| **7.** | SAR | meq/L | - | 14.57 | 6.32 | 6.00 | 5.43 | 13.24 | 6.18 | 6.00 | 5.43 | 11.15 | 9wsss .30 | 13.5 | 8.65 | 12.32 | 10.10 | 3.15 | 3.07 |
| **8.** | Total Coliforms | MPN/ 100ml | **<1000** | 1600 | 230 | 1600 | 360 | 1600 | 280 | 1600 | 280 | 1600 | 240 | 1600 | 320 | 1600 | 160 | 1600 | 300 |

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

| Sr No. | Parameter | Units | GPCB Norms (Vadinar) | Vadinar | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Week 3 of March | | Week 4 of March | | Week 1 of April | | Week 2 of April | |
| | | | | STP-3 (Inlet) | STP-3 (Outlet) | STP-3 (Inlet) | STP-3 (Outlet) | STP-3 (Inlet) | STP-3 (Outlet) | STP-3 (Inlet) | STP-3 (Outlet) |
| **1.** | pH | - | **5.5-9** | 7.28 | 7.44 | 7.15 | 7.20 | 6.52 | 7.12 | 7.03 | 7.16 |
| **2.** | TDS | mg/L | - | 408 | 382 | 488 | 374 | 418 | 362 | 424 | 358 |
| **3.** | TSS | mg/L | **20** | 8 | 4 | 72 | 10 | 90 | 6 | 38 | 4 |
| **4.** | COD | mg/L | **50** | 168.0 | 56.0 | 293.2 | 52.2 | 498.0 | 32.4 | 196.8 | 36.1 |
| **5.** | DO | mg/L | - | 1.2 | 8.4 | 0.7 | 7.0 | BQL | 6.0 | 1.5 | 6.9 |
| **6.** | BOD | mg/L | **10** | 50.40 | 5.60 | 91.63 | 6.53 | 149.40 | 3.24 | 59.04 | 3.61 |
| **7.** | SAR | meq/L | - | 2.21 | 2.60 | 1.37 | 2.31 | 2.13 | 2.21 | 2.45 | 1.96 |
| **8.** | Total Coliforms | MPN/100ml | **100-230** | 1600 | 160 | 1600 | 140 | 1600 | 300 | 1600 | 100 |

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

## 9.3 Data Interpretation and Conclusion

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

- The **pH** of treated effluent from STPs at Kandla (STP-1 and STP-2) and Vadinar (STP-3) conform to their respective stipulated norms of, pH values vary in the range of **6.17-7.16** at Kandla and **7.12–7.44** at Vadinar respectively.
- The **TDS** of treated sewage at Kandla was ranges from **886** to **1384** mg/L, whereas for Vadinar it ranges from **358** to **382** mg/L.
- The **TSS** of the Treated effluent for the STP-1 and STP-2 at Kandla and STP-3 at Vadinar falls within the stipulated norms of 100 and 20 mg/L respectively as mentioned in their respective CCA.
- **COD** value for Kandla was observed in the range of **51** to **73.2** mg/L. Whereas for Vadinar the value of COD falls within the range of **32.4 to 56** mg/L.
- The value of **DO** was observed in the range of **1.10** to **4** mg/L, whereas for Vadinar it was observed in the range of **6.0** to **8.4** mg/L.
- The **BOD** of the outlet for the STPs of Kandla and Vadinar falls within the stipulated norms.
- The value of **SAR** for Kandla was observed in the range of **3.07** to **10.10** meq/L, whereas for Vadinar, it was observed in the range of **1.96** to **2.6** meq/L.
- The **Total Coliforms** was observed to exceed the norms at the locations of the STP-3 for the treated effluent at Vadinar.

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

## 9.4 Remedial Measures:

- The quantum of raw sewage (influent) entering the STP should be monitored by installation of the flow meter. If the quantity of the sewage exceeds the treatment capacity of the treatment plant, then provision of additional capacity of collection sump should be provided.
- The adequacy and efficacy of the stages of Sewage treatment units shall be conducted.
- The results show the presence of total coliforms; hence the method of disinfection (Chlorination) sodium or calcium Hypochlorite can be used.
- Effectiveness of any technology depends on factors such as the specific pollutants in the wastewater, plant size, local regulations, and available resources. There are several processes that may be implemented such as - Advanced oxidation process involve using strong oxidants to break down complex organic compounds. Methods like Fenton's reagent (hydrogen peroxide and iron catalyst) and UV/$H_2O_2$ treatment can help in reducing COD through oxidation.

- Electrochemical processes like Electrocoagulation (EC) and Electrooxidation (EO) that involve the application of an electric current to facilitate the removal of pollutants through coagulation, flocculation, and oxidation. These methods can be useful for treating sewage containing various pollutants.

# CHAPTER 10: MARINE WATER QUALITY MONITORING

## 10.1 Marine Water

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

Major water quality concerns at ports include wastewater and leakage of toxic substances from ships, stormwater runoff, etc. This discharge of wastewater, combined with other ship wastes which includes sewage and wastewater from other on-board uses, is a serious threat to the water quality as well as to the marine life. As defined in the scope by DPA, the Marine Water sampling and analysis has to be carried out at a total of eight locations, six at Kandla and two at Vadinar. The marine water sampling has been carried out with the help of Niskin Sampler with a capacity of 5L. The Niskin Sampler is a device used to take water samples at a desired depth without the danger of mixing with water from other depths. Details of the locations to be monitored have been mentioned in **Table 29:**

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

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

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


**Map 16: Locations for Marine Water Monitoring at Kandla**


**Map 17: Locations for Marine Water Monitoring at Vadinar**

## Methodology

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

**Frequency:**

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

**Table 30: List of parameters monitored for Marine Water**

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

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

## 10.2 Result and Discussion

The quality of the Marine water samples collected from the locations of Kandla and Vadinar during the monitoring period has been summarized in the **Table 31**. The said water quality has been represented in comparison with the standard values as stipulated by CPCB for Class SW-IV Waters.

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

| Sr. No. | Parameters | Unit | Primary Water Quality Criteria for Class SW-IV Waters | Kandla | | | | | | Vadinar | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MW-1 | MW-2 | MW-3 | MW-4 | MW-5 | MW-6 | MW-7 | MW-8 |
| 1. | Density | kg/m³ | - | 1.022 | 1.021 | 1.021 | 1.022 | 1.023 | 1.022 | 1.021 | 1.021 |
| 2. | pH | - | 6.5-9.0 | 8.19 | 8.14 | 8.06 | 8.2 | 8.13 | 8.25 | 8.14 | 8.26 |
| 3. | Color | Hazen | No Noticeable | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 4. | EC | µS/cm | - | 51,200 | 52,500 | 51,100 | 51,500 | 52,600 | 51,400 | 53,700 | 54,200 |
| 5. | Turbidity | NTU | - | 94 | 120 | 143.25 | 201 | 136 | 117 | 4.16 | 3.35 |
| 6. | TDS | mg/L | - | 33,568 | 36,245 | 32,568 | 33,145 | 33,586 | 32,589 | 31,542 | 32,513 |
| 7. | TSS | mg/L | - | 338 | 419 | 274 | 372 | 325 | 413 | 129 | 183 |
| 8. | COD | mg/L | - | 33.5 | 31.6 | 30.2 | 33.8 | 31.5 | 32.4 | 48.10 | 50.1 |
| 9. | DO | mg/L | 3.0 mg/L | 5.5 | 6.1 | 5.1 | 5.9 | 6.3 | 5.4 | 6.7 | 5.2 |
| 10. | BOD | mg/L | 5.0 mg/L | 8.21 | 8.26 | 8.34 | 8.77 | 10.26 | 9.83 | 7.40 | 7.11 |
| 11. | Oil & Grease | mg/L | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 12. | Sulphate | mg/L | - | 2145.2 | 2568.4 | 2568.1 | 3149.8 | 2781.6 | 2415.6 | 2781.5 | 3159.6 |
| 13. | Nitrate | mg/L | - | 4.59 | 3.42 | 3.4 | 4.870 | 3.78 | 4.29 | 3.36 | 2.880 |
| 14. | Nitrite | mg/L | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 15. | Phosphate | mg/L | | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 16. | Silica | mg/L | - | 3.13 | 2.66 | 3.27 | 3.10 | 3.78 | 2.64 | 0.86 | 0.71 |
| 17. | Sodium | mg/L | - | 9345 | 9215 | 9874 | 9356 | 9654 | 9412 | 9,845 | 9,523 |
| 18. | Potassium | mg/L | - | 357.00 | 321 | 320.00 | 361 | 342.00 | 286.00 | 435.0 | 402.00 |
| 19. | Hexavalent Chromium | mg/L | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 20. | Odour | - | - | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 21. | Arsenic | mg/L | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 22. | Cadmium | mg/L | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 23. | Copper | mg/L | - | BQL | BQL | BQL | BQL | 6.68 | BQL | BQL | BQL |
| 24. | Iron | mg/L | - | 1.845 | 2.265 | 2.415 | 1.785 | 1.895 | 2.236 | 0.451 | 0.268 |
| 25. | Lead | mg/L | - | 0.003 | 0.003 | 0.002 | 0.002 | 0.002 | 0.003 | 0.0024 | 0.0028 |
| 26. | Manganese | mg/L | - | 0.093 | 0.132 | 0.124 | 0.112 | 0.096 | 0.120 | 0.045 | BQL |
| 27. | Total Chromium | mg/L | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 28. | Zinc | mg/L | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 29. | Mercury | mg/L | - | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 30. | Particulate Organic Carbon | mg/L | - | 1.05 | 0.59 | 0.51 | 0.78 | 0.95 | 1.25 | 0.57 | 0.82 |
| 31. | Total Coliforms | MPN/ 100ml | 500/100 ml | 19 | 14 | 13 | 10 | 17 | 18 | 12 | 20 |

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

## 10.3 Data Interpretation and Conclusion

The Marine water quality of Deendayal Port Harbor waters at Kandla and Vadinar has been monitored for various physico-chemical and biological parameters during the monitoring period. The detailed interpretation of the parameters in comparison to the Class SW-IV for Harbour Waters is as follows:

- **Density** at Kandla was observed in the range of **1.021 to 1.023 kg/m³**, with the average of **1.021 kg/m³.** Whereas for the location of Vadinar, it was observed **1.021 kg/m³** at MW-7 and **1.021 kg/m³** at MW-8, with the average of **1.021 kg/m³**.
- **pH** at Kandla was observed in the range of **8.06 to 8.25**, with the average pH as 8.16. Whereas for the locations of Vadinar, it was observed in the range of be **8.14 to 8.26**, with the average pH as **8.2**. For the monitoring location of both the study areas, pH was found to comply with the norms of 6.5-8.5.
- **Color** range varied from **5 Hazen** at all the monitoring locations in Kandla, and for Vadinar, it found **5 Hazen** for the both of the location.
- **Electrical conductivity (EC)** was observed in the range of **51100 to 52600 µS/cm**, with the average EC as **51716** µS/cm for the locations of Kandla, whereas for the locations of Vadinar, it was observed in the range of **53700 to 54200 µS/cm**, with the average EC as **53950** µS/cm.
- For all monitoring locations of Kandla the value of **Turbidity** was observed in the range of 94 **to 201 NTU**, with average value of **135.20** NTU. For Vadinar it ranges from 4.16 **to 3.35 NTU**, with average of **3.75** NTU. Materials that cause water to be turbid include clay, silt, finely divided organic and inorganic matter, soluble coloured organic compounds, plankton and microscopic organisms. Turbidity affects the amount of light penetrating to the plants for photosynthesis.
- For the monitoring locations at Kandla the value of **Total Dissolved Solids (TDS)** ranged from **32568 to 36245 mg/L**, with an average value of **33616.83** mg/L. Similarly, at Vadinar, the TDS values ranged from **31542 to 32513 mg/L**, with an average value of **32027.5** mg/L.

- **TSS** values in the studied area varied between 274 **to 419 mg/L** at Kandla and **129 to 183 mg/L** at Vadinar, with the average value of **356.83** mg/L and **156** mg/L respectively for Kandla and Vadinar.
- **COD** varied between **30.2 to 33.8 mg/L** at Kandla and **48.10 to 50.1 mg/L** at Vadinar, with the average value as **32.16** mg/L and **49.1** mg/L respectively for Kandla and Vadinar.
- **DO** level in the studied area varied between **5.1 to 6.3 mg/L** at Kandla and **6.7 to 5.2 mg/L** at Vadinar, with the average value of **5.71** mg/L and **5.95** mg/L respectively for Kandla and Vadinar. Which represents that the marine water is suitable for marine life.
- **BOD** observed was observed in the range of **8.21 to 10.26 mg/L**, with average of **8.94** mg/L for the location of Kandla and for the locations of Vadinar, it was observed in the range of 7.40 **to 7.11 mg/L**, with an average value of **7.25** mg/L.
- The elevated Biochemical Oxygen Demand (BOD) values observed in the marine water samples, particularly exceeding 8 mg/L at multiple locations, can be attributed to a combination of anthropogenic activities and hydrodynamic limitations of the creek environment. The sampling points are located within tidal creeks and semi-enclosed water bodies near the Port of Kandla, where reduced water circulation leads to limited dilution and flushing of pollutants. Additionally, the area is subject to intensive industrial and port-related activities, possibly there might be effluent discharges, cargo handling waste, and domestic sewage from nearby settlements. These inputs introduce significant quantities of biodegradable organic matter into the water, which enhances microbial activity and oxygen consumption, thereby raising BOD levels.
- **Sulphate** concentration in the studied area varied between **2145.2 to 3149.8 mg/L** at Kandla and **2781.5 to 3159.6 mg/L** at Vadinar. The average value observed at Kandla was **2604.78** mg/L, whereas **2970.55** mg/L was the average value of Vadinar. Sulphate is naturally formed in inland waters by mineral weathering or the decomposition and combustion of organic matter.
- **Nitrate** in the study area was observed in the range of **3.4 to 4.87 mg/L**, with the average of **4.05** mg/L. Whereas for the Vadinar, recorded value was observed in the range of **3.36 to 2.88 mg/L**, with the average of 3.12 mg/L.
- In the study area of Kandla the concentration of **Potassium** varied between **286 to 361 mg/L** and **435 to 402 mg/L** at Vadinar, with the average value as **331.16** mg/L and **418.5** mg/L respectively for Kandla and Vadinar.
- **Silica** in the studied area varied between **2.64 to 3.78 mg/L**, with the average of **3.09** mg/L, at Kandla. Vadinar, observed value was found to be **0.86** mg/L at location MW-7 and **0.71** mg/L at MS-8 location.
- **Sodium** in the study area varied between **9215 to 9874 mg/L**, with average of **9476** mg/L, at Kandla whereas at Vadinar the sodium concentration value was observed in the range of **9845** to **9523** mg/L, with the average value of **9684** mg/L.
- **Odour** was observed 1 for all locations of Kandla and Vadinar.
- **Copper** at the Kandla and Vadinar location was detected below the quantification limit (BQL)" for the all-sampling location.

- **Iron** in the studied area varied between **1.785 to 2.415 mg/L**, with the average of **2.073** mg/L, at Kandla, and for Vadinar value were recorded **0.451** for location MW-7 and **0.268** mg/L for location MW-8.
- **Lead** concentration varied **0.0023 to 0.0033 mg/L**, with an average of **0.0029** mg/L at Kandla. At Vadinar location MW-7 observed **0.0024** mg/L and MW-8 observed **0.0028** mg/L with an average of **0.0026** mg/L
- **Manganese** in the studied area varied between 0.093 **to 0.13 mg/L**, with the average of **0.11** mg/L, at Kandla. At Vadinar location MW-7 observed **0.045** mg/L and MW-8 observed BQL.
- **Particulate Organic Carbon** in the study area was observed in the range of **0.51 to 1.25**, with the average value of **0.85**. Whereas for the Vadinar, the value observed was **0.57** at MW-7 and 0.82 at MW-8, with the average of **0.69**.
- Oil & Grease, Nitrite, Phosphate, Hexavalent Chromium, Arsenic, Cadmium, Total Chromium, Zinc, Mercury and Floating Material (Oil grease scum, petroleum products) were observed to have concentrations "Below the Quantification Limits (BQL)" for most of the locations of Kandla and Vadinar.
- **Total Coliforms** were detected complying with the specified norm of 500 MPN/100ml for all the locations of Kandla and Vadinar.

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

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

# CHAPTER 11: MARINE SEDIMENT QUALITY MONITORING

## 11.1 Marine Sediment Monitoring

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

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

### Methodology

As defined in the scope by DPA, the Marine Sediment sampling is required to be carried out once in a month at total eight locations, i.e., six at Kandla and two at Vadinar. The sampling of the Marine Sediment is carried out using the Van Veen Grab Sampler (make Holy Scientific Instruments Pvt. Ltd). The Van Veen Grab sampler is an instrument to sample (disturbed) sediment up to a depth of 20-30 cm into the sea bed. While letting the instrument down on the seafloor, sediment can be extracted. The details of locations of Marine Sediment to be monitored under the study are mentioned in **Table 32** as follows:

**Table 32: Details of the sampling locations for Marine Sediment**

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

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


**Map 18: Location of Marine Sediment Monitoring at Kandla**


**Map 19: Locations of Marine Sediment Monitoring at Vadinar**

The list of parameters to be monitored under the projects for the Marine Sediment sampling been mentioned in **Table 33** as follows:

**Table 33: List of parameters to be monitored for Sediments at Kandla and Vadinar**

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

## 11.2 Result and Discussion

The quality of Marine Sediment samples collected from the locations of Kandla and Vadinar during the monitoring period has been summarized in the **Table 34.**

**Table 34: Summarized result of Marine Sediment Quality**

| Sr No. | Parameters | Unit | Kandla | | | | | | Vadinar | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | MS-1 | MS-2 | MS-3 | MS-4 | MS-5 | MS-6 | MS-7 | MS-8 |
| 1. | Inorganic Phosphate | kg/ ha | 3.95 | 10.14 | 21.56 | 8.24 | 14.5 | 13.25 | 3.54 | 2.39 |
| 2. | Phosphate | mg/Kg | 1123.5 | 1785.1 | 1569.2 | 563.4 | 820.9 | 641.8 | 215.6 | 257.8 |
| 3. | Organic Matter | % | 0.78 | 0.33 | 0.21 | 0.48 | 0.71 | 0.38 | 0.58 | 0.77 |
| 4. | Sulphate as $SO^{4-}$ | mg/Kg | 185.62 | 175.26 | 218.45 | 154.78 | 96.58 | 116.52 | 81.56 | 105.49 |
| 5. | Calcium as Ca | mg/Kg | 2045.86 | 2357.14 | 1789.52 | 1458.63 | 1456.37 | 2158.47 | 2345.98 | 2157.42 |
| 6. | Magnesium as Mg | mg/Kg | 1568.34 | 1654.87 | 1785.24 | 1453.28 | 1578.46 | 1125.87 | 1269.47 | 1563.29 |
| 7. | Silica | g/Kg | 578.1 | 456.2 | 478.9 | 315.4 | 248.3 | 336.5 | 287.15 | 415.75 |
| 8. | Nitrite | mg/Kg | 0.25 | 0.35 | 0.39 | 0.45 | 0.41 | 0.55 | 0.21 | 0.33 |
| 9. | Nitrate | mg/Kg | 20.19 | 17.64 | 24.86 | 21.05 | 19.67 | 18.72 | 15.26 | 10.02 |
| 10 | Sodium | mg/Kg | 3481 | 2356 | 2781 | 3125 | 3329 | 2841 | 6028 | 8753 |
| 11 | Potassium | mg/Kg | 2164.2 | 1845.4 | 2745.6 | 3125.9 | 2896.7 | 2541.3 | 2863.1 | 2356.1 |
| 12 | Aluminium | mg/Kg | 2145.8 | 1984.6 | 1356.4 | 2158.4 | 1789.2 | 1456.2 | 1586.4 | 1784.6 |
| 13 | Chromium | mg/Kg | 48.5 | 35.4 | 38.7 | 45.6 | 46.8 | 50.3 | 52.7 | 21.8 |
| 14 | Copper | mg/Kg | 3.21 | 3.45 | 4.15 | 3.86 | 4.87 | 5.1 | 4.26 | 3.67 |
| 15 | Nickel | mg/Kg | 41.58 | 35.41 | 20.45 | 26.94 | 21.56 | 22.35 | 15.86 | 27.46 |
| 16 | Zinc | mg/Kg | 60.23 | 51.27 | 47.67 | 42.68 | 49.82 | 42.51 | 25.64 | 41.29 |
| 17 | Cadmium | mg/Kg | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 18 | Lead | mg/Kg | 4.71 | 5.06 | 3.8 | 5.16 | 4.75 | 4.2 | 4.69 | 5.34 |
| 19 | Arsenic | mg/Kg | 4.29 | 2.51 | 5.15 | 3.36 | 2.56 | 3.54 | 2.74 | 3.25 |
| 20 | Mercury | mg/Kg | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |
| 21 | Texture | - | Sandy loam | Sandy loam | Sandy loam | Sandy loam | Sandy loam | Sandy loam | Sandy Loam | Loam |

## 11.3 Data Interpretation and Conclusion

The Marine sediment quality at Kandla and Vadinar has been monitored for various physico-chemical parameters during the monitoring 2025. The detailed interpretation of the parameters is given below:

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

- The **Organic Matter** for the sampling period was observed in the range of **0.21 to 0.78** % for Kandla with the average value of 0.48 % and for Vadinar the value recorded at location MS-7 and MS-8 was observed 0.58 % & 0.77 % respectively, with average concentration as 0.67 %.
- The concentration of **Sulphate** was observed in the range of **96.58 to 218.45 mg/Kg** for Kandla and for Vadinar the value observed at MS-7 is 81.56 mg/Kg and at MS-8 is 105.49 mg/Kg. For Kandla and Vadinar the average value of Sulphate was observed 157.86 and 93.52 mg/Kg respectively.
- The value of **Calcium** was observed in the range of **1456.37 to 2357.14 mg/Kg** for Kandla and for Vadinar the value observed at MS-7 is 2345.98 mg/Kg and at MS-8, is 2157.42 mg/Kg. The average value of Calcium for the monitoring period was observed 1877.66 mg/Kg and 2251.7 mg/Kg at Kandla and Vadinar, respectively.
- The value of **Magnesium** for the sampling period was observed in the range of **1125.87 to 1785.24 mg/Kg** for Kandla and for Vadinar the value observed at MS-7 is 1269.47 mg/Kg and at MS-8, is 1563.29 mg/Kg. For Kandla and Vadinar the average value of Magnesium was observed 1527.67 mg/Kg and 1416.38 mg/Kg respectively.
- For the sampling period **Silica** was observed in the range of **248.3 to 578.1 mg/Kg** for Kandla with average value 402.23 mg/Kg and for Vadinar the value observed to be 287.15 and 415.75 mg/Kg at MS-7 and MS-8, respectively with average 351.45 mg/Kg.
- The value of **Nitrate** was observed in the range of **17.64 to 24.86 mg/Kg** for Kandla with average value 20.35 mg/Kg and for Vadinar the value observed to be 15.26 and 10.02 mg/Kg at MS-7 and MS-8, respectively with average 12.64 mg/Kg.
- The value of **Nitrite** was observed in the range of **0.25 to 0.55 mg/Kg** for Kandla with average value 0.40 mg/Kg and for Vadinar the value observed to be 0.21 and 0.33 mg/Kg at MS-7 and MS-8, respectively with average 0.27 mg/Kg.
- The value of **Sodium** was observed in the range of 2356 **to 3481 mg/Kg** for Kandla with average value 2985.5 mg/Kg and for Vadinar the value observed to be 6028 and 8753 mg/Kg at MS-7 and MS-8, respectively with average 7390.5 mg/Kg.
- The value of **Potassium** was observed in the range of **1845.4 to 3125.9 mg/Kg** for Kandla with average value 2553.18 mg/Kg and for Vadinar the value observed to be 2863.1 and 2356.1 mg/Kg at MS-7 and MS-8, respectively with average 2609.6 mg/Kg.
- The value of **Aluminium**, was observed in the range of **1356.4 to 2158.4 mg/Kg** for Kandla with average value **1815.1** mg/Kg and for Vadinar the value observed to be **1586.4** and **1784.6** mg/Kg at MS-7 and MS-8, respectively with average **1685.5** mg/Kg.
- The value of **Mercury** was observed "Below the Quantification Limit" at all the eight-monitoring location of Kandla and Vadinar.
- Texture was observed to be "**Sandy Loam**" at location MS-1, MS-2, MS-3, MS-4, MS-5 MS-6 in Kandla. "**Sandy Loam**" at location MS-7 & "**loam"** at location MS-8 in Vadinar during sampling period.

**Heavy Metals**

The sediment quality of Kandla and Vadinar has been compared with respect to the Average Standard guideline applicable for heavy metals in marine sediment specified by EPA have been mentioned in **Table 35.**

**Table 35: Standard Guidelines applicable for heavy metals in sediments**

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

*(Source: G Perin et al. 1997)*

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

| Sr. No. | Parameters | Unit | Kandla | | | | | | Vadinar | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | MS-1 | MS-2 | MS-3 | MS-4 | MS-5 | MS-6 | MS-7 | MS-8 |
| 1. | Arsenic | mg/Kg | 4.29 | 2.51 | 5.15 | 3.36 | 2.56 | 3.54 | 2.74 | 3.25 |
| 2. | Copper | mg/Kg | 3.21 | 3.45 | 4.15 | 3.86 | 4.87 | 5.1 | 4.26 | 3.67 |
| 3. | Chromium | mg/Kg | 48.5 | 35.4 | 38.7 | 45.6 | 46.8 | 50.3 | 52.7 | 21.8 |
| 4. | Nickel | mg/Kg | 41.58 | 35.41 | 20.45 | 26.94 | 21.56 | 22.35 | 15.86 | 27.46 |
| 5. | Lead | mg/Kg | 4.71 | 5.06 | 3.8 | 5.16 | 4.75 | 4.2 | 4.69 | 5.34 |
| 6. | Zinc | mg/Kg | 72.18 | 60.23 | 51.27 | 47.67 | 42.68 | 49.82 | 25.64 | 41.29 |
| 7. | Cadmium | mg/Kg | BQL | BQL | BQL | BQL | BQL | BQL | BQL | BQL |

- **Arsenic** was observed in the range of **2.51 to 5.15 mg/Kg** for Kandla with average value **3.56** mg/Kg and for Vadinar the value observed to be **2.74** and **3.25** mg/Kg at MS-7 and MS-8, respectively with average **2.99** mg/Kg. With reference to the guidelines mentioned in table 35, the sediment quality with respect to arsenic falls in moderately polluted class.
- **Copper** was observed in the range of **3.21 to 5.1 mg/Kg** for Kandla with average value **4.10** mg/Kg and for Vadinar the value observed to be **4.26** and **3.67** mg/Kg at MS-7 and MS-8, respectively with average 3.96 mg/Kg. With reference to the guidelines mentioned in table 35, the sediment quality with respect to copper falls in non-polluted class.
- **Chromium** was observed in the range of **35.4 to 50.3 mg/Kg** for Kandla with average value **44.21** mg/Kg and for Vadinar the value observed to be **52.7** and **21.8** mg/Kg at MS-7 and MS-8, respectively with average **37.25** mg/Kg. With reference to the guidelines mentioned in table 35, the sediment quality with respect to chromium falls in moderately polluted class.
- **Nickel** was observed in the range of **20.45 to 41.58 mg/Kg** for Kandla with average value **28.04** mg/Kg and for Vadinar the value observed to be **15.86** and **27.46** mg/Kg at MS-7 and MS-8, respectively with average **21.66** mg/Kg. With reference to the

guidelines mentioned in table 35, the sediment quality with respect to nickel falls in moderately polluted class.

- **Lead** was observed in the range of **3.8 to 5.16 mg/Kg** for Kandla with average value **4.61** mg/Kg and for Vadinar the value observed to be **4.69** and **5.34** mg/Kg at MS-7 and MS-8, respectively with average **5.01** mg/Kg. With reference to the guidelines mentioned in table 35, the sediment quality with respect to lead falls in non-polluted class.
- **Zinc** was observed in the range of **42.51 to 60.23 mg/Kg** for Kandla with average value 49.03 mg/Kg and for Vadinar the value observed to be **25.64** and **41.29** mg/Kg at MS-7 and MS-8, respectively with average **33.46** mg/Kg. With reference to the guidelines mentioned in table 35, the sediment quality with respect to zinc falls in non-polluted class.
- **Cadmium** was observed BQL for all locations at Kandla and Vadinar during sampling period. With reference to the guidelines mentioned in table 35, the sediment quality with respect to cadmium falls in non-polluted class.

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

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

# CHAPTER 12: MARINE ECOLOGY MONITORING

## 12.1 Marine Ecological Monitoring

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

As defined in the scope by DPA, the Marine Ecological Monitoring is required to be carried out once a month specifically at eight locations, six at Kandla and two at Vadinar. The sampling of the Benthic Invertebrates has been carried out with the help of D-frame nets, whereas the sampling of zooplankton and phytoplankton has been carried out with the help of Plankton Nets (60 micron and 20 micron). The details of the locations of Marine Ecological Monitoring have been mentioned in **Table 37** as follows:

**Table 37: Details of the sampling locations for Marine Ecological**

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

The map depicting the locations of Marine Ecological monitoring in Kandla and Vadinar have been mentioned in **Map 20 and 21** as follows:


**Map 20: Locations of Marine Ecological Monitoring at Kandla**


**Map 21: Locations of Marine Ecological Monitoring at Vadinar**

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

**Table 38: List of parameters to be monitored for Marine Ecological Monitoring**

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

## Methodology

- **Processing for chlorophyll estimation:**

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

- **Phytoplankton Estimation**

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

primary producers that support the pelagic food-chain. The two most prominent groups of phytoplankton are Diatoms (*Bacillariophyceae*) and Dinoflagellates (*Dinophyceae*). Phytoplankton also include numerous and diverse collection of extremely small, motile algae which are termed micro flagellates (naked flagellates) as well as Cyanophytes (Bluegreen algae). Algae are an ecologically important group in most aquatic ecosystems and have been an important component of biological monitoring programs. Algae are ideally suited for water quality assessment because they have rapid reproduction rates and very short life cycles, making them valuable indicators of short-term impacts. Aquatic populations are impacted by anthropogenic stress, resulting in a variety of alterations in the biological integrity of aquatic systems. Algae can serve as an indicator of the degree of deterioration of water quality, and many algal indicators have been used to assess environmental status.

- **Zooplankton Estimation**

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

- **Benthic Organisms Estimation**

Benthic macroinvertebrates are small aquatic animals and the aquatic larval stages of insects. They include dragonfly and stonefly larvae, snails, worms, and beetles. Use of benthic macroinvertebrates has been in vogue as indicator organisms for water quality monitoring since long. Traditional methods of water quality monitoring incorporates mostly monitoring of physicochemical parameters. Benthic macroinvertebrates are majorly insects that dwell on the floor of water bodies. They are found in all water bodies, as they have a wide range of pollution tolerance among various species. The benthic

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

- **Diversity Index**

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

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

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

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

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

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

2. **Simpson's index:**

A reasonably high level of dominance by one or a small number of species is indicated by the range of **0.89 to 0.91**. The general health and stability of the ecosystem may be impacted by this dominance. Community disturbances or modifications that affect the dominant species may be more likely to have an impact. The dominating species

determined by the Simpson's index can have big consequences on how the community is organised and how ecological interactions take place.

The formula for calculating D is presented as:

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

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

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

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

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

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

Where, N = total number of individuals collected

S = No. of taxa or species or genera

**4. Berger-Parker index:**

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

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

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

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

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

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

5. **Evenness index–**

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

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

Where, H= Shannon value

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

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

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

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

## 12.2 Result and Discussion

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

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

| Sr. No. | Parameters | Unit | Kandla | | | | | | Vadinar | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | ME-1 | ME-2 | ME-3 | ME-4 | ME-5 | ME-6 | ME-7 | ME-8 |
| 1. | Biomass | mg/L | 120 | 75 | 62 | 119 | 95 | 91 | 81 | 116 |
| 2. | Net Primary Productivity | mg/L/hr | BQL | BQL | BQL | BQL | 0.91 | BQL | BQL | BQl |
| 3. | Gross Primary Productivity | mg/L/hr | 1.26 | 0.84 | 1.35 | 1.58 | 1.21 | 0.56 | 0.91 | 1.31 |
| 4. | Pheophytin | mg/m$^3$ | BQL | BQL | 0.61 | 1.2 | 1.33 | 0.48 | 1.27 | 1.36 |
| 5. | Chlorophyll-a | mg/m$^3$ | 0.58 | 0.89 | 1.48 | 1.22 | 1.46 | 1.1 | 1.66 | 1.4 |
| 6. | Particulate Oxidisable Organic Carbon | mg/L | 0.7 | 1.16 | 0.61 | 0.75 | 1.32 | 0.85 | 0.73 | 0.81 |
| 7. | Secchi Depth | ft | 0.55 | 0.63 | 0.51 | 0.40 | 0.47 | 0.74 | 1.11 | 1.02 |

- **Biomass:**
  With reference to the **Table 39**, the concentration of **Biomass** reported from location ME-1 to ME-6 in range between **62-120 mg/L** where lowest biomass presents in ME-3 (Near Coal Berth) and highest biomass present in ME-1 (Near Passenger Jetty One) during sampling period. In Vadinar, the value of biomass was observed 81 mg/L at ME-7 (Near SPM) and 116 mg/L in ME-8 (Near Vadinar Jetty) monitoring station.

- **Productivity (Net and Gross)**
  **Gross primary productivity (GPP)** is the rate at which organic matter is synthesised by producers per unit area and time (GPP). The amount of carbon fixed during photosynthesis by all producers in an ecosystem is referred to as gross primary productivity. The monitoring location of Kandla reported GPP value in range between **0.56 to 1.58 mg/L/48 Hr** where the highest value recorded for ME-4 and lowest recorded at ME-6 (Nakti Creek (near NH - 8A)). In Vadinar, the value of **GPP** was observed 0.91 at ME-7 (Near SPM) and 1.31 at ME-8 (Near Vadinar Jetty) monitoring station.

  **Net primary productivity**, is the amount of fixed carbon that is not consumed by plants, and it is this remaining fixed carbon that is made available to various consumers in the ecosystem. The Net primary productivity of the monitoring location at Kandla from (ME-1 to ME-6) has been estimated to be **0.91 mg/L/48 Hr**. While in Vadinar, the value of **NPP** was observed BQL at ME-7 (Near SPM) and ME-8 (Near Vadinar Jetty) monitoring station.

- **Pheophytin**
  The level of Pheophytin was detected in the range from **0.48 to 1.33 mg/m$^3$** where the highest value observed at ME-5 (Nakti Creek (near Tuna Port)) and the lowest value observed at ME-6 (Nakti Creek (near NH - 8A)). While in Vadinar, the value of Pheophytin was observed 1.27 mg/m$^3$ at ME-7 and 1.36 at ME-8 monitoring station.

- **Chlorophyll-a**
  In the sub surface water, the value of Chlorophyll-a reported in range from **0.58 to 1.48 mg/m³**. The highest value observed at ME-3 (Near Coal Berth) while the lowest value observed at ME-1 (Near Passenger Jetty One). In Vadinar, the value of chlorophyll-a was observed 1.66 mg/m³ at ME-7 (Near SPM) and 1.4 mg/m³ in ME-8 (Near Vadinar Jetty) monitoring station.

- **Particulate Oxidisable Organic Carbon**
  During the sampling period, the particulate oxidisable organic carbon falls within the range of **0.61 to 1.32 mg/L** from monitoring location ME-1 to ME-6 at Kandla, whereas for Vadinar, the value of POC observed 0.73 mg/L at ME-7 (Near SPM) and 0.81 mg/L in ME-8 (Near Vadinar Jetty) monitoring station.

- **Secchi Depth**
  In monitoring station of Kandla (ME-1 to ME-6) the level of Secchi Depth was observed between **0.4 to 0.74 ft** whereas at Vadinar, the value recorded at ME-7 i.e. Near SPM is 1.11 ft and in Near Vadinar Jetty is 1.02 ft.

**Ecological Diversity**

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

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

**Table 40: Phytoplankton variations in abundance and diversity in sub surface sampling stations**

| Genera | ME-1 | ME-2 | ME-3 | ME-4 | ME-5 | ME-6 | ME-7 | ME-8 |
|---|---|---|---|---|---|---|---|---|
| *Bacillaria sp.* | - | - | 148 | - | 128 | 269 | - | 168 |
| *Biddulphia sp.* | 159 | 315 | 125 | 125 | 126 | - | 284 | 148 |
| *Chaetoceros sp.* | - | 166 | - | - | - | 248 | 145 | - |
| *Chlamydomonas sp.* | 172 | - | - | 149 | 228 | - | - | 259 |
| *Cyclotella sp.* | 110 | 468 | 168 | - | - | 156 | 350 | 247 |
| *Coscinodiscus sp.* | - | - | - | - | - | - | - | - |
| *Ditylum sp* | - | - | 245 | 165 | 210 | 135 | 267 | - |
| *Fragilaria sp.* | 486 | 174 | - | - | - | - | - | 143 |
| *Bacteriastrum sp.* | 252 | 125 | - | 148 | 114 | 145 | 146 | - |
| *Pleurosigma sp.* | - | - | 241 | - | - | - | 117 | 212 |
| *Navicula sp.* | 147 | - | - | 146 | 196 | 328 | - | 183 |
| *Merismopedia sp.* | - | 147 | 142 | - | - | - | - | - |
| *Synedra sp.* | 178 | - | - | - | - | 157 | 251 | - |
| *Skeletonema sp.* | - | - | - | 249 | 257 | - | - | 144 |
| *Oscillatoria sp.* | - | 256 | - | - | - | 153 | - | - |
| *Thallassiosira* | 187 | - | 158 | - | 175 | 123 | - | 156 |
| *Gomphonema sp.* | - | 187 | - | 178 | - | - | 135 | - |
| **Density-Units/L** | **1691** | **1838** | **1227** | **1160** | **1434** | **1714** | **1695** | **1660** |
| **No. of genera** | **8** | **8** | **7** | **7** | **8** | **9** | **8** | **9** |

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

The density of phytoplankton of the sampling stations from ME-1 to ME-6 (Kandla) varying from **1160 to 1838 units/L,** while for Vadinar its density of phytoplankton observed **1695 units/L at ME-7 and 1660 units/L at ME-8.** During the sampling, phytoplankton communities were dominated, *Cyclotella sp, Biddulphia sp., Bacteriastrum sp, Navicula sp & Thallassiosira, in* Kandla, while *Cyclotella sp.* in Vadinar

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

**Table 41: Species richness Index and Diversity Index in Phytoplankton**

| Indices | ME-1 | ME-2 | ME-3 | ME-4 | ME-5 | ME-6 | ME-7 | ME-8 |
|---|---|---|---|---|---|---|---|---|
| Taxa S | 8 | 8 | 7 | 7 | 8 | 9 | 8 | 9 |
| Individuals | 1691 | 1838 | 1227 | 1160 | 1434 | 1714 | 1695 | 1660 |
| Shannon diversity | 1.97 | 2.06 | 1.62 | 1.58 | 1.87 | 2.15 | 2.01 | 2.15 |
| Simpson 1-D | 0.84 | 0.85 | 0.85 | 0.85 | 0.87 | 0.88 | 0.86 | 0.88 |
| Species Evenness | 0.95 | 0.99 | 0.83 | 0.81 | 0.90 | 0.98 | 0.97 | 0.98 |
| Margalef richness | 0.94 | 0.93 | 0.84 | 0.85 | 0.96 | 1.07 | 0.94 | 1.08 |
| Berger-Parker | 0.29 | 0.25 | 0.20 | 0.21 | 0.18 | 0.19 | 0.21 | 0.16 |
| Relative abundance | 0.47 | 0.44 | 0.57 | 0.60 | 0.56 | 0.53 | 0.47 | 0.54 |

- **Shannon- Wiener's Index (H)** of phytoplankton communities was in the range of **1.58 to 2.15** between selected sampling stations from ME-1 to ME-6 with an average value of 1.88 at Kandla creek and its nearby creeks. While for Vadinar, Shannon Wiener's index of phytoplankton communities recorded to be **2.01** at location ME-7 and **2.15** at ME-8 with an average value of 2.08. The apportionment of the numbers of individuals among the species observed higher stability at all monitoring location of Kandla.

- **Simpson diversity index (1-D)** of phytoplankton communities was ranged between **0.84 to 0.88** at all sampling stations in the Kandla creek and nearby creeks, with an average of 0.86 Similarly, for Vadinar Simpson diversity index (1-D) of phytoplankton communities was 0.86 at location ME-7 and 0.88 at ME-8 with an average of 0.87.

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

- **Berger-Parker Index (d)** of phytoplankton communities was in the range of **0.18 to 0.29** between selected sampling stations from ME-1 to ME-6 with an average value of 0.22 at Kandla creek and nearby creeks. Berger-Parker Index (d) of phytoplankton communities in the sampling stations of Vadinar, was in the range of 0.16 to 0.21 with an average value of 0.19. All the monitoring station signifies a low diversity with an even distribution among the different species.

- The **Species Evenness** is observed in the range of **0.81 to 0.99** for all the six-monitoring station of Kandla and for the Vadinar the species evenness is observed 0.97 at location ME-7 & 0.98 at ME-8 location.

- During the sampling period, **Relative Abundance** of phytoplankton communities was in range of **0.44 to 0.60** between selected sampling stations from ME-1 to ME-6 with an average value of 0.53 at Kandla creek and nearby creeks. Whereas for Vadinar the Index value 0.47 at ME-7 and 0.54 at ME-8 with an average value 0.51, thus it is concluded that the studied species can be stated as neither highly dominant nor rare.

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

**Table 42: Zooplankton variations in abundance and diversity in sub surface sampling stations**

| Genera | ME-1 | ME-2 | ME-3 | ME-4 | ME-5 | ME-6 | ME-7 | ME-8 |
|---|---|---|---|---|---|---|---|---|
| *Acartia sp.* | 1 | - | 2 | 1 | 1 | - | - | 1 |
| *Acrocalanus* | - | 1 | 1 | - | - | - | 1 | - |
| *Amoeba* | 1 | 2 | - | 1 | - | 1 | 1 | 1 |
| *Brachionus sp.* | 1 | 1 | 1 | - | 2 | 1 | - | 1 |
| *Calanus sp.* | - | 1 | 1 | 1 | 1 | 1 | 2 | - |
| *Cladocera sp.* | 2 | - | - | 2 | - | - | 1 | - |
| *Cyclopoid sp.* | 1 | 1 | 1 | - | 1 | 1 | - | 1 |
| *Copepod larvae* | - | 1 | - | 1 | - | 1 | 2 | 1 |
| *Diaptomus sp.* | 2 | - | 1 | - | 1 | - | 1 | - |
| *Eucalanus sp.* | - | 1 | - | 1 | - | 1 | - | 2 |
| *Mysis sp.* | - | - | - | 1 | 1 | 2 | - | 1 |
| *Paracalanus sp.* | 1 | 1 | 1 | - | - | 1 | 1 | - |
| **Density Unit/L** | **9** | **9** | **8** | **8** | **7** | **9** | **9** | **8** |
| **No. of genera** | **7** | **8** | **7** | **7** | **6** | **8** | **7** | **7** |

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

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

**Table 43: Species richness Index and Diversity Index in Zooplankton**

| Indices | ME-1 | ME-2 | ME-3 | ME-4 | ME-5 | ME-6 | ME-7 | ME-8 |
|---|---|---|---|---|---|---|---|---|
| Taxa S | 7 | 8 | 7 | 7 | 6 | 8 | 7 | 7 |
| Individuals | 9 | 9 | 8 | 8 | 7 | 9 | 9 | 8 |
| Shannon diversity | 1.89 | 2.04 | 1.8 | 1.8 | 1.55 | 2.04 | 1.89 | 1.8 |
| Simpson (1-D) | 0.94 | 0.97 | 0.96 | 0.96 | 0.95 | 0.97 | 0.94 | 0.96 |
| Species Evenness | 0.97 | 0.98 | 0.93 | 0.93 | 0.87 | 0.98 | 0.97 | 0.93 |
| Margalef | 2.73 | 3.19 | 2.89 | 2.89 | 2.57 | 3.19 | 2.73 | 2.89 |
| Berger-Parker | 0.22 | 0.22 | 0.25 | 0.25 | 0.29 | 0.22 | 0.22 | 0.25 |
| Relative abundance | 77.78 | 88.89 | 87.5 | 87.5 | 85.71 | 88.89 | 77.78 | 87.5 |

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

zooplankton communities recorded to be 1.89 at ME-7 and 1.8 at ME-8 with an average value of 1.84. The apportionment of the numbers of individuals among the species observed higher stability at all monitoring location of Kandla and Near SPM (Vadinar).

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

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

- **Berger-Parker Index (d)** of zooplankton communities was in the range of **0.22 to 0.29** between selected sampling stations from ME-1 to ME-6 with an average value of 0.24 at Kandla creek and nearby creeks. Berger-Parker Index (d) of zooplankton communities in the sampling stations of Vadinar, was in the 0.22 at ME-7 and 0.25 at ME-8 with an average value of 0.23. All the monitoring station signifies a low diversity with an even distribution among the different species.

- The **Species Evenness** is observed in the range of **0.87 to 0.98** for all the six-monitoring station of Kandla whereas, for the Vadinar the species evenness was observed in the 0.95, during the monitoring month.

- During the sampling period, **Relative Abundance** of zooplankton communities was in range of 77.78 to 88.89 between selected sampling stations from ME-1 to ME-6 with an average value of 86.04 at Kandla creek and nearby creeks. Whereas for Vadinar the Index value 77.78 at ME-7 and 87.5 at ME-8 with an average value 82.64, thus it can be concluded that the studied species is stated as neither highly dominant nor rare.

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

**Table 44: Benthic Fauna variations in abundance and diversity in sub surface sampling**

| Family/Class | ME-1 | ME-2 | ME-3 | ME-4 | ME-5 | ME-6 | ME-7 | ME-8 |
|---|---|---|---|---|---|---|---|---|
| Thiaridae | - | 1 | - | 1 | - | - | - | 1 |
| Mollusca | 1 | - | 1 | - | 1 | - | 1 | - |
| Odonata | - | 2 | - | 1 | - | 2 | 1 | 1 |
| Lymnidae | 2 | 1 | 2 | - | 1 | 1 | 2 | - |
| Planorbidae | 1 | - | - | 2 | - | - | - | 2 |
| Talitridae | - | - | 1 | 1 | 1 | - | 1 | 1 |
| Trochidae | 1 | 1 | - | - | 1 | 1 | - | - |

| Family/Class | ME-1 | ME-2 | ME-3 | ME-4 | ME-5 | ME-6 | ME-7 | ME-8 |
|---|---|---|---|---|---|---|---|---|
| Atydae | 1 | 1 | - | 1 | - | - | 1 | 1 |
| Gammaridae | - | 1 | 1 | - | - | 1 | - | - |
| Portunidae | 1 | - | - | 1 | 2 | 1 | - | - |
| Turbinidae | - | - | 1 | - | - | - | 1 | - |
| Palaemonidae | - | - | 1 | - | - | 1 | - | - |
| **No. of Family** | **7** | **7** | **7** | **7** | **6** | **7** | **7** | **6** |
| **No of Class** | **6** | **6** | **6** | **6** | **5** | **6** | **6** | **5** |

Few benthic organisms were observed in the collected samples using Van-Veen grabs at Deendayal Port (Kandla and Vadinar). The dominant macro-benthic groups included *Mollusca, Lymnidae, Gammaridae and Odonata*, which were present across multiple stations. *Odonata* was observed at all sites (**ME-1 to ME-8**) except **ME-5**, similarly *Thiaridawas* observed at all sites **(ME-1 to ME-8)** except **ME-4**. while *Talitridae* occurred at 6 out of 8 locations, indicating their broad distribution. The number of benthic families/classes varied between 6 to 9 across all stations.

At ME-1, the most dominant groups were *Thiaridae, Planorbidae, Gammariade* and *Odonata*, each with a density of **2 units/L**. The least represented benthic fauna included *Mollusca Sp., atydae, Turbinidae*, which was observed only at ME-1 with a Density of **1 units/L**

The details of Species richness Index and Diversity Index in Benthic Organisms is mentioned in **Table 45.**

**Table 45: Species richness Index and Diversity Index in Benthic Organisms**

| Indices | ME-1 | ME-2 | ME-3 | ME-4 | ME-5 | ME-6 | ME-7 | ME-8 |
|---|---|---|---|---|---|---|---|---|
| Taxa S | 6 | 6 | 6 | 6 | 5 | 6 | 6 | 5 |
| Individuals | 7 | 7 | 7 | 7 | 6 | 7 | 7 | 6 |
| Shannon diversity | 1.75 | 1.75 | 1.75 | 1.75 | 1.47 | 1.75 | 1.75 | 1.47 |
| Simpson 1-D | 0.95 | 0.95 | 0.95 | 0.95 | 0.93 | 0.95 | 0.95 | 0.93 |
| Species Evenness | 0.98 | 0.98 | 0.98 | 0.98 | 0.91 | 0.98 | 0.98 | 0.91 |
| Margalef | 2.57 | 2.57 | 2.57 | 2.57 | 2.23 | 2.57 | 2.57 | 2.23 |
| Berger-Parker | 0.29 | 0.29 | 0.29 | 0.29 | 0.33 | 0.29 | 0.29 | 0.33 |
| Relative abundance | 85.71 | 85.71 | 85.71 | 85.71 | 83.33 | 85.71 | 85.71 | 83.33 |

- **Shannon- Wiener's Index (H)** of benthic organism was in the range of **1.47 to 2.03** between selected sampling stations from ME-1 to ME-6 with an average value of 1.79 at Kandla creek and its nearby creeks. While for Vadinar, Shannon Wiener's index of benthic organism recorded to be 1.75 at ME-7 & 1.47 at ME-8 location with an average value of 1.61. The apportionment of the numbers of individuals among the species observed higher stability at all monitoring location of Kandla and Vadinar.

- **Simpson diversity index (1-D)** of benthic organism was ranged between **0.93 to 0.95** at all sampling stations in the Kandla creek and nearby creeks, with an average of 0.95. Similarly, for Vadinar Simpson diversity index (1-D) of benthic organism was 0.95 at ME-7 and 0.93 at ME-8 location with an average of 0.94.

- **Margalef's diversity index** (Species Richness) of benthic organism in Kandla and nearby creeks sampling stations was varying from **2.23 to 2.89** with an average of 2.62 during the sampling period. While for Vadinar, Margalef's diversity index (Species Richness) of benthic organism observed to be 2.57 at ME-7 and 2.23 at ME-8 location with an average of 2.4.

- **Berger-Parker Index (d)** of benthic organism was in the range of **0.25 to 0.33** between selected sampling stations from ME-1 to ME-6 with an average value of 0.28 at Kandla creek and nearby creeks. Berger-Parker Index (d) of benthic organism in the sampling stations of Vadinar, was observed to be 0.29 at ME-7 and 0.33 at ME-8 location with an average value of 0.31. All the monitoring station signifies a low diversity with an even distribution among the different species.

- The **Species Evenness** is observed in the range of **0.91 to 0.98** for all the six-monitoring station of Kandla and for the Vadinar the species evenness is observed to be 0.98 at ME-7 and 0.91 at ME-8 location with an average of 0.94.

- During the sampling period, **Relative Abundance** of Benthic organisms was in range of **83.33 to 87.5** between selected sampling stations from ME-1 to ME-6 with an average value of 85.91 at Kandla creek and nearby creeks. Whereas for Vadinar the Index value 85.71 at ME-7 and 83.33 at ME-8 location, with an average value 84.52, thus it is concluded that the studied species can be stated as neither highly dominant nor rare.

## Annexure 1: Photographs of the Environmental Monitoring conducted at Kandla

STP Monitoring

Noise Monitoring

Soil Monitoring

Marine Monitoring

Air Monitoring

Drinking Water Monitoring

## Annexure 2: Photographs of the Environmental Monitoring conducted at Vadinar

Air Monitoring

Noise Monitoring

STP Monitoring

Drinking water Monitoring

Marine Monitoring

Soil Monitoring

Source: GEMI

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# Gujarat Environment Management Institute (GEMI)

**(An Autonomous Institute of Government of Gujarat)**

**'An ISO 9001:2015, ISO 14001:2015 & ISO 45001:2018 Certified Institute**


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# ANNEXURE C

Details of Hazardous Waste generated during the financial year 2024-25

# MARINE DEPARTMENT

Sub : Annual Return Showing the collection & disposal of Hazardous and Non-Hazardous Wastes carried out by various parties for the year 04/2024 to 03/2025.

With reference to the above subject, the annual return showing the collection and disposal of Hazardous and Non-Hazardous Wastes carried out by various parties for the period from 01-04-2024 to 31-03-2025 of Marine Department is enclosed herewith.

Encl : As above

Deputy Conservator
Deendayal Port Authority

EMC (I/C)
No. MR/WK/1316/ 427 Date : 13 .05.2025.

## Deendayal Port Authority
## Marine Department

**Statement of Hazardous and Non hazardous Waste disposal from the Vessels at Kandla Port for the Period April 2024 to March 2025 – For the Whole Port Area**

**(PCB ID 28494)**

| Sr.No. | Month | Year | Hazardous Waste Generation in MT | | | Solid Waste Generated in MT |
|---|---|---|---|---|---|---|
| | | | Total Quantity | Used Oil | Waste Residue Containing Oil | |
| 1. | April | 2024 | 1124.53 | 281.13 | 843.40 | 170.96 |
| 2. | May | 2024 | 1004.00 | 251.00 | 753.00 | 265.01 |
| 3. | June | 2024 | 2194.23 | 548.56 | 1645.67 | 174.14 |
| 4. | July | 2024 | 1330.64 | 332.66 | 997.98 | 247.80 |
| 5. | August | 2024 | 2333.80 | 583.45 | 1750.35 | 302.37 |
| 6. | September | 2024 | 2055.17 | 513.79 | 1541.38 | 285.17 |
| 7. | October | 2024 | 2198.00 | 549.50 | 1648.50 | 405.24 |
| 8. | November | 2024 | 1024.58 | 256.15 | 768.44 | 368.41 |
| 9. | December | 2024 | 1283.96 | 320.99 | 962.97 | 404.33 |
| 10. | January | 2025 | 1214.05 | 303.51 | 910.54 | 245.46 |
| 11. | February | 2025 | 1328.61 | 332.15 | 996.46 | 294.38 |
| 12. | March | 2025 | 904.06 | 226.01 | 678.04 | 111.33 |
| Total | | | **17995.63** | **4498.91** | **13496.72** | **3274.60** |

Deputy Conservator
Deendayal Port Authority

# Marine Department

(IN MT)

Statement showing the Collection and disposal of Hazardous and Non-Harardous Wastes carried out by 2024-25

| Sr. No. | Name of Party | Type of Licence | Apr-24 | May-24 | Jun-24 | Jul-24 | Aug-24 | Sep-24 | Oct-24 | Nov-24 | Dec-24 | Jan-25 | Feb-25 | Mar-25 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Alicid Organic Industries Limited | Hazardous | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2 | Amar Hydrocarbon Pvt. Ltd | Hazardous | - | - | - | - | 81.08 | - | - | - | - | - | 62.32 | - | 143.40 |
| 3 | Atlas Organics Pvt. Ltd | Hazardous | - | 17.62 | - | - | - | 62.74 | 33.00 | 72.24 | 32.49 | 96.83 | - | - | 314.92 |
| 4 | Aviation Corporation | Hazardous | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 5 | Mahalaxmi Asphalt Pvt Ltd | Hazardous | 85.73 | 98.06 | 341.38 | 112.90 | 93.29 | 39.25 | 130.21 | 61.47 | 159.73 | 189.88 | 176.28 | 98.08 | 1,586.26 |
| 6 | Priyansi Corporation | Hazardous | - | - | - | | - | - | - | - | - | - | - | - | - |
| 7 | Revolution Petrochem LLP | Hazardous | 736.28 | 721.55 | 1,635.77 | 1,021.52 | 2,033.29 | 1,792.89 | 1,855.24 | 701.58 | 839.45 | 658.23 | 790.31 | 729.14 | 13,515.25 |
| 8 | Shana Oil Process | Hazardous | - | - | - | - | - | - | - | - | - | 88.00 | 132.64 | - | 220.64 |
| 9 | United Shipping Company | Hazardous | 358.75 | 216.97 | 285.83 | 227.57 | 233.45 | 263.05 | 249.85 | 231.88 | 263.26 | 241.81 | 233.49 | 122.04 | 2,927.95 |
| 10 | Kutch Energies Pvt.Ltd. | Hazardous | - | - | 40.96 | 35.18 | 9.38 | - | 39.60 | 8.64 | 53.23 | - | - | - | 186.99 |
| 11 | Pureflow Greens Private Limited | Hazardous | | | | | | | | | | | 44.38 | 156.80 | 201.18 |
| 12 | Jay Ambe Industries, Sanand | Hazardous | | | | | | | | | | | | | |
| 13 | Chitrakut Trading & Industries | Non-Hazardous | 5.65 | 17.52 | 11.44 | 27.20 | 30.02 | 5.56 | 12.11 | 54.50 | 28.00 | - | - | - | 192.00 |
| 14 | Golden Shipping Services | Non-Hazardous | 13.97 | 24.68 | 51.63 | 24.81 | 40.86 | 34.77 | 169.57 | 38.96 | 35.50 | 21.56 | 48.15 | 28.41 | 532.87 |
| 15 | Green Earth Marine Solutions | Non-Hazardous | 5.33 | 12.80 | 3.80 | - | 19.98 | 41.22 | 3.30 | 9.59 | 7.70 | 10.73 | 3.74 | — | 118.19 |
| 16 | Harish A. Pandya | Non-Hazardous | 6.30 | 17.84 | 1.10 | 12.36 | 4.17 | 21.83 | 37.53 | 55.06 | 86.48 | - | - | - | 242.67 |
| 17 | K M Enterprise | Non-Hazardous | 73.16 | 153.62 | 50.10 | 85.46 | 163.77 | 109.71 | 124.14 | 134.78 | 157.50 | 131.16 | 197.01 | - | 1,380.41 |
| 18 | Naaz Shipping Services Ent | Non-Hazardous | - | - | - | 11.00 | - | 8.93 | 4.57 | 3.94 | 4.57 | 4.58 | - | - | 37.59 |
| 19 | New India Marine Works | Non-Hazardous | 21.10 | - | 9.29 | 31.32 | 6.84 | 17.35 | 7.60 | 10.08 | 7.16 | 11.45 | 11.95 | 14.69 | 148.83 |
| 20 | Omega Marine Services | Non-Hazardous | 28.58 | 29.10 | 36.86 | 39.89 | 28.03 | 25.34 | 27.11 | 41.88 | 33.68 | 37.58 | 25.34 | 63.19 | 416.58 |
| 21 | V K Enterprise | Non-Hazardous | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 22 | Vishwa Trade-link Inc. | Non-Hazardous | 16.87 | 9.45 | 9.92 | 15.76 | 8.70 | 15.38 | 12.11 | 14.36 | 34.83 | 18.14 | 8.19 | - | 163.71 |
| 23 | Bhavya Engg.Work & Multi. | Non-Hazardous | - | - | - | - | - | 5.08 | 7.20 | 5.26 | 3.91 | - | - | 5.04 | 31.49 |
| 24 | Shri Ganesh Traders, Anjar | Non-Hazardous | - | - | - | - | - | - | - | - | - | 4.26 | 7.36 | — | 11.62 |
| 25 | Nar Narayan Multiservics | Non-Hazardous | - | - | - | - | - | - | - | - | - | 6.00 | - | 8.50 | 14.50 |
| 26 | Mohanlal & Co, Jamnagar | Non-Hazardous | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 27 | M/s. Kiyara Ship Chandleers & Marine Services, Meghpar- | Non-Hazardous | | | | | | | | | | | | | |
| | | **Hazardous - Total** | **1,180.76** | **1,054.20** | **2,303.94** | **1,397.17** | **2,450.49** | **2,157.93** | **2,307.90** | **1,075.81** | **1,348.16** | **1,274.75** | **1,395.04** | **949.26** | **18,895.41** |
| | | **Non-Hazardous - Total** | **170.96** | **265.01** | **174.14** | **247.80** | **302.37** | **285.17** | **405.24** | **368.41** | **404.33** | **245.46** | **294.38** | **111.33** | **3,274.60** |

**Copy to : GPCB, Gandhidham / Harbour Master**

# ANNEXURE D

Details of domestic waste water generation for 2024-25

## Statement Showing the quantity of Domestic Waste Water Generation (STP - Kandla) for the period from April 2024 to March 2025

| Sr.No. | Month | Average Quantity of Domestic Waste Water Generation in KLD |
|---|---|---|
| 1. | April 2024 | 215 |
| 2. | May 2024 | 210 |
| 3. | June 2024 | 255 |
| 4. | July 2024 | 250 |
| 5. | August 2024 | 240 |
| 6. | September 2024 | 220 |
| 7. | October 2024 | 225 |
| 8. | November 2024 | 210 |
| 9. | December 2024 | 215 |
| 10. | January 2025 | 225 |
| 11. | February 2025 | 220 |
| 12. | March 2025 | 210 |
| **Total** | | 224.58 |

12/05/25

**XEN (Road)**